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ARCOM Declaration:

The papers in these proceedings were double-blind refereed by members of the scientific committee in a process that involved, detailed reading of the papers, reporting of comments to authors, modifications of papers by authors and re-evaluation of re-submitted papers to ensure quality of content.

FOREWORD

Welcome to ARCOM 2018 at Queen's University Belfast.

Ireland is such a wonderful place and it feels so reassuring to bring ARCOM back to Belfast. As we step once again on Irish soil, I feel a sense of pride, as we come together, embracing the debate and further strengthening the supportive nature of our research community.

As the incoming Chair, I wanted a venue that was steeped in industry, with 'real' engaging people. Most importantly, I wanted somewhere devoid of the 'fake' and, without trying, we will trump the 'fake news' brigade. The last time we visited Belfast everyone gave so much to make ARCOM a success and, although the city was not long out of troubled times, there was a spirit of openness and inclusion. While, the divisions of Northern Ireland are often highlighted in the press, the reporters fail to mention the resolve of the people, their ability to confront adversity and their passion and determined spirit to succeed and enjoy life.

Far from the hard political attitudes conveyed through our media, the people of Northern Ireland are friendly and engaging. The difference in the political image and the reality is somewhat akin to construction. The industry, while described as fragmented and perceived as hard, offers a place where people come together from different communities, share good hard working times before moving to the next project. Some of my most favourite memories are from times on sites, bracing against the weather, working with a diverse mixture of people and pushing forward as a team to get the job done. The industry, its culture, the language of the people and attitude to work has always been colourful and enjoyable.

It is diverse, in so many ways and remains one of the largest and most vibrant employment sectors in the world. The industry suits those able to deal with change, being prepared to travel or able to work on different projects. For many of the positions within construction there are few restrictions to entry resulting in an industry that is accessible, rich in difference, regardless of colour and gender. The nature of the work, the quality of the people and the diversity that the industry brings is something to embrace and explore. There are issues that we need to address, but as scholars, with a mind on efficiency and productivity, we should be careful to consider the positive qualities of culture that make construction a wholesome, worthwhile and rewarding experience. The future is both uncertain and exciting, we are going to experience considerable change within the industry and we should be careful how we shape the future.

This year's conference attracted 310 submissions in January 2018. Following three rounds of double-blind peer-review, a total of 131 papers were eventually accepted for presentation at the conference. The depth and diversity of papers submitted has at times been overwhelming and quite a challenge to manage. The process for those submitting and reviewing is a difficult one. It is reassuring that academics are prepared to extend their effort, going above and beyond, to ensure that the quality of contributions and reviews maintains the high ARCOM standard.

The single quality that sets ARCOM aside from other academic conferences is a spirit of community, which is friendly, warm and supportive. ARCOM researchers are also resilient. Our papers are double blind reviewed, with two out of three submissions not making publication. Those papers that are accepted come with critical comments,

where the authors mindfully respond, attempting to retain their preferred direction while respecting the reviewers' comments. Having hit all of the deadlines, many of us require a visa to join the conference. The barriers that face us and the high standards that ARCOM continue to uphold have been overcome and now we are here, we should be proud and must embrace everything that our community and Belfast has to offer.

With Queen University Belfast's Riddel Hall providing our day time venue and evening events at the main campus and the Titanic Belfast, we are set for a packed and cultured conference. This year we are graced with Neill Ryan, CEO of VRM Technology and Professor Graham Ferrier, University of Hull, who are providing our keynote address on Monday. Together they offer insight on how they, industry and academic partners, have actively engaged with the built environment to develop new innovative products through research.

Going beyond our UK boundary, we wanted to explore international research through our rich panel debate benefitting from Professor George Ofori's key contribution. Our productive relationship is not just demonstrated in our main sessions, but with evening entertainment provided by our own Michael Curran and friends, providing a taste of Irish music and dance. At the gala dinner our longstanding Admiral of the Fleet, Dr Joe Gunning is gracing our after dinner speech with 'My Belfast', this year's conference is set to be a titanic event.

I'm looking forwards to meeting all our past friends, making some new and engaging in the hard enjoyable work that is ARCOM. Let us keep the enjoyable supportive nature of ARCOM strong and embrace the music.

A warm welcome to all, and please enjoy the ARCOM 2018 Conference.



Chris Gorse

Conference Chair, ARCOM 2018

August

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The success of the Annual ARCOM Conference depends on the voluntary efforts of the Scientific Committee. We are indebted to the members of the Scientific Committee who, together with the ARCOM Committee members, provided rigour and constructive feedback in the peer-review process.

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A SPECIAL THANK YOU FROM CHRIS GORSE

As Conference Chair, and on behalf of the ARCOM Committee, I would particularly like to thank this year's Track Convenors who have not only submitted a series of interesting and stimulating track proposals, but who subsequently have been so willing to spend time reviewing and evaluating the papers submitted to their tracks.

Track 1: Failure and Learning from Failure

Convenor: Simon Smith, University of Edinburgh

Track 2: Theoretically Informed Research on Digitalization in Construction

Convenors: Henrik Linderöth, Jönköping University; Mattias Jacobsson, Jönköping University; Christoph Merschbrok, Jönköping University; Amany Elbanna, Royal Holloway University London; Martin Löwstedt, Chalmers University

Track 3: Reconceiving Multidisciplinary Collaboration for Managing Design in Construction: Moving Forward from the Fragmentation-Integration Dichotomy

Convenors: Mustafa Çıdık, London South Bank University; David Boyd, Birmingham City University; Vedran Zerjav, University College London

Track 4: Integration and Collaboration for a Sustainable Built Environment

Convenor: Esra Kurul, Oxford Brookes University

Track 5: Keeping Up with the Digital Age: How Construction Companies Use Digital Communication Tools to Build Up Management Processes

Convenors: Tugce Ercan, Yildiz Technical University; Fusun Cizmeci, Yildiz Technical University

Track 6: Mental Health, Stress and Wellbeing in the Construction Industry

Convenor: Dingayo Mzyece

Track 7: Institutionalising Construction Management Research?

Convenors: Paul W Chan, The University of Manchester; Sonja Dragojlovic-Oliveira, University of West of England

Track 8: Infrastructure Investment through Public-Private Partnerships

Convenors: Sharon McClements, Ulster University; Andrew McErlane, Ulster University; Des McKibbin, Northern Ireland Assembly

Track 9: Procurement for Sustainable Innovation in the Built Environment

Convenors: Professor Pernilla Gluch, Chalmers University of Technology; Professor Anna Kadefors, KTH Royal Institute of Technology; Associate Professor Leentje Volker, TU Delft.

Track 10: Walking the Talk: Moving beyond words to create productive communication between academia and industry

Convenors: Professor Christine Räisänen, Chalmers University of Technology; Dr. Paul W Chan, The University of Manchester

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FAILURE AND LEARNING FROM FAILURE

THE MEANING OF FAILURE: ESTABLISHING A TAXONOMY OF FAILURE IN THE CONSTRUCTION INDUSTRY TO IMPROVE ORGANISATIONAL LEARNING

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Despite years of construction accidents and thousands of filed reports, failure is still poorly understood. There seems to be a general disagreement in the field of what constitutes failure. Authors attribute it to, amongst other factors: deficient management; cost and time overruns; design and human error. Developing an understanding of the underlying definitions and links behind failure in construction will allow industry leaders to communicate more effectively about failure and advance industry-wide learning. To better understand the levels of failure in the construction industry, 17 semi-structured interviews were conducted with members of the community across various business aspects and sizes. The aim was to explore the meaning of failure and create a taxonomy which can be used to aid understanding. Thematic analysis revealed a three-level causal relationship between causes, symptoms and consequences of failure. A three-tiered taxonomy of failure was developed, and represented visually in the form of the Failure Taxonomy Tool. It allows for the clear distinction between the three levels of failure and relationships between them, and encourages exploration of both well-known and rare failure paths. The Failure Taxonomy Tool can be used to supplement existing risk analysis methods and encourage forward-thinking. Its applicability in the construction industry and higher engineering education was supported by industry experts via a face validity exercise. Potential applications include, but are not limited to, identifying risks to project success during project inception; becoming a part of graduate programmes to improve commercial awareness; encouraging discussion about popular and unexplored failure paths; as well as serving as an aid to improve students' awareness of failure. Better understanding of failure is the first step to minimising construction project risks and long-term losses.

Keywords: communication, failure, systems engineering, taxonomy

INTRODUCTION

In the light of the Carillion (one of the largest construction companies in the UK) liquidation on 15th January 2018, it is more important than ever to not only understand failure but to also acknowledge it. What appeared to be a huge surprise to thousands of workers, suppliers and the general public appears to have been known within high levels of the company for many months. The reluctance to acknowledge

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and discuss failures might have contributed to the breakdown of the company. Keeping company's issues 'behind closed doors' has definitely proven unsuccessful.

The reluctance to discuss failure is closely associated with the negative connotations it evokes. Despite decades of structurally sound construction, it is precisely the grand structural failures that linger in society's memory (Petroski, 1985): the Tahoma Narrows, the Hyatt Regency, and more recently the Rana Plaza collapse. All these events have diminished the construction industry's authority, and created an unbreakable association between the industry and failure.

Despite years of construction accidents and thousands of filed reports, it is still staggering that failure is poorly understood. There seems to be a general disagreement in the field of what constitutes failure, with authors providing different definitions and attributing it to factors such as deficient management (Sage *et al.*, 2014), cost and time overruns (Sun and Meng, 2009), design (Lopez *et al.*, 2010) and human error (Dekker, 2006). The general absence of failure discussion from the engineering education curriculum further inhibits engineers' understanding of the phenomenon.

By developing a deep understanding of the levels and breadth of types of failure, the construction industry can begin to educate its members and raise awareness about its impact. Using 17 in-depth semi-structured interviews with members of the construction industry, the research presented here explores the different levels of failure and the relationships between them. A three-tiered taxonomy of failure is developed, and represented in a Failure Taxonomy Tool. The aim of this tool is to aid understanding and learning about failure in higher education and industry environments.

APPROACHES TO UNDERSTANDING FAILURE

There is a lack of agreement in literature regarding what constitutes failure. Defining it is often a complicated task (Wantanakorn *et al.*, 1999), with some psychologists claiming that errors are a cognitive product of a person's abilities and do not actually exist (Reason and Hobbs, 2003). Moreover, failure is often referred to as 'error', 'mistake', 'risk' or 'incident', making it increasingly hard to define and understand it. Therefore, there is a need in the industry for a clear appreciation of the complexity of failure as a phenomenon which cannot be simply defined and requires a novel representation.

Most of the research done on failure is from a reactive stance. Using backward analysis, authors have claimed that errors may stem from design (Lopez *et al.*, 2010), a failure to learn (Sage *et al.*, 2014), and lack of adequate health and safety measures (Hinze and Pedersen, 1998). Methods for dealing with failure in the construction industry can also be reactive. For instance, the Root Cause Analysis method was developed as a way to identify the factors that resulted in the harmful outcome of a past event.

More recently, systems engineers have used more active approaches for risk identification and failure prevention. Bow-tie analysis is a risk evaluation method for exploration of the causal relationships in a risk situation. Besides presenting a visual summary of potential accident scenarios for a given hazard, it showcases control measures for controlling and preventing failure (Ferdous *et al.*, 2013). Without explicitly naming it, the method recognises a three- (or five) level relationship: threat- (control measure) - failure - (remedial) - consequence.

The Swiss Cheese model proposed by Reason in 1990 relates to the controls in the bowtie method. According to this metaphor, each level of control has weaknesses, or 'holes', which on a single level are harmless. However, when several holes from different levels align, a hazard can occur, causing failure of the system. Reason (1990) argued that holes are due to a combination of active failures and latent conditions. While active failures such as slips, mistakes and lapses occur due to 'unsafe acts', they are underlain by the invisible latent conditions of the organisation.

While these models attempt to predict failure and prevent it they do not actually classify it despite using categories such as 'threats' and 'consequences'. Failure is a multi-faceted phenomenon, unlikely to be described accurately by a single-level definition. Instead, taxonomy can be used to define failure and showcase the intricate relationships between the different levels of failure. Taxonomy, originally used to classify biological organisms into groups of similar origin, has become an increasingly useful approach to classify concepts and explain the relationships between them (Boulding and Khalil, 2002).

Instead of forming a vocabulary which would not be able to showcase the causes of failure, taxonomy presents an innovative way to examine it. Taxonomy has previously been used to aid understanding of complex systems, primarily in the field of aviation. O'Hare (2000) developed a taxonomic approach to accident investigation, and represented it in his 'Wheel of Misfortune', which summarises the outcomes of many accident investigations. The usefulness of such classification has been recognised and adopted by the New Zealand Civil Aviation Authority as part of their accident analysis system. A similar methodology to the one employed in this research was used by Plant and Stanton (2017), who developed a 28-item taxonomy to describe decision-making in critical aeronautical situations. Their research focuses on understanding systems failure both in terms of structural and human error, and has a potential to improve the aeronautic industry in a similar manner that this research aims to improve the construction industry.

Therefore, taxonomy could be used to aid understanding of failure, which in turn can be increasingly helpful in preventing it, since forensic examination of failure causes can decrease the chance of recurrence (Love *et al.*, 2008).

METHODOLOGY AND METHODS

In order to satisfy the primary aim of the research - to produce a tool for failure understanding which can be used across the construction industry in the UK, realist stance is taken. It is important to acknowledge the role of the researcher in relation to his or her impact on the research being carried out, which is of great importance in qualitative research (Silverman 2007). Lack of bias has been attempted as the researcher is not part of the construction industry at the time of writing, and has limited exposure to the industry itself. This allows taking a scientific, academic stance rather than a role of an active participant in the construction industry.

This research was based on a three-step method. Firstly, data were primarily collected by Baker *et al.*, (2018) in the form of 17 semi-structured interviews with people in various levels and aspects of the construction industry. The interviewees were approached through mutual professional acquaintances. This form of interview was selected as it allows fluidity in discussions, including clarifying questions, while ensuring the relevant topic areas are covered (Harreveld *et al.*, 2016).

Secondly, data was processed using thematic analysis based on the approach outlined by Braun and Clarke (2006) using spatial prevalence to identify themes. The active position of the researcher who determines the 'themes' in thematic analysis needs to be considered. A qualitative data analysis software - NVivo - was used to code the data set. Initially, over 30 'themes' were identified, which were narrowed down to three main ones and transitioned into taxonomy and later into a tool.

Finally, to verify the observed results, six industry experts (different from interview participants) took part in a face validity exercise. This is a non-statistical method to determine the appropriateness or relevance of a given result using experts' opinions (Weiner and Craighead, 2010). The experts were shown the finished tool and asked to discuss the clarity of communication, as well as its usefulness to the industry. Suggestions on how to improve it were implemented and led to the final version of the Failure Taxonomy Tool.

Thematic Analysis Results

Thematic analysis of the 17 interviews revealed that participants recognised the existence of causal relationships in failure. The most commonly mentioned 'failures' were classified as either causes, symptoms or consequences, which became the basis of a three-tiered failure taxonomy. The taxonomy was included into a broader failure lifecycle, presented in Figure 1. It consists of all the elements participants mentioned when discussing failure. Aspects such as learning and prevention of failure, albeit important, are not considered as part of this research - readers are referred to Baker *et al.*, (2018) for more details on learning from failure.

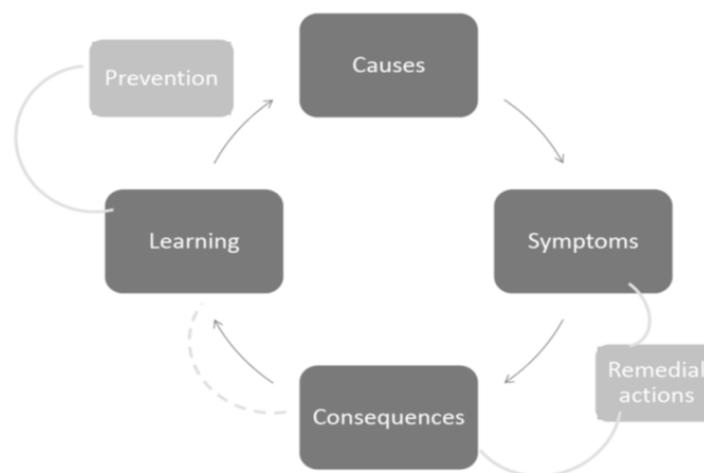


Figure 1: The Failure Life Cycle

In the failure taxonomy, causes are factors which have the potential to result in a failure. They could be due to technical, planning, personal or communication issues, which all fall under the category of 'organisational' causes.

The second level of failure are symptoms. It was decided that failure symptoms are processes that can be observed, similarly to the medical field. They refer to 'lack of project success' in terms of one or more pillars of a successful project (cost, time, quality, environment and safety). These are all actions that are encountered usually before a project is considered complete and usually have a defined 'finish' point.

The third level of the failure taxonomy refers to consequences which are the long-term effects from a failure symptom. They could be tangible (like loss of profit), or intangible, such as loss of reputation.

As the research aims to create a practical tool for understanding failure, the three tiers of the taxonomy were identified, and relationships between them examined. Thematic analysis revealed that research participants recognised 12 common causes of failure, 12 symptoms and 6 long-term consequences. However, it was clear that interviewees did not always recognise nuances in the levels of failure. 7 out of 17 described causes as symptoms, and 6 considered long-term consequences as forms of failure as well. It further confirms the need for clear representation and distinction in the three levels of the taxonomy.

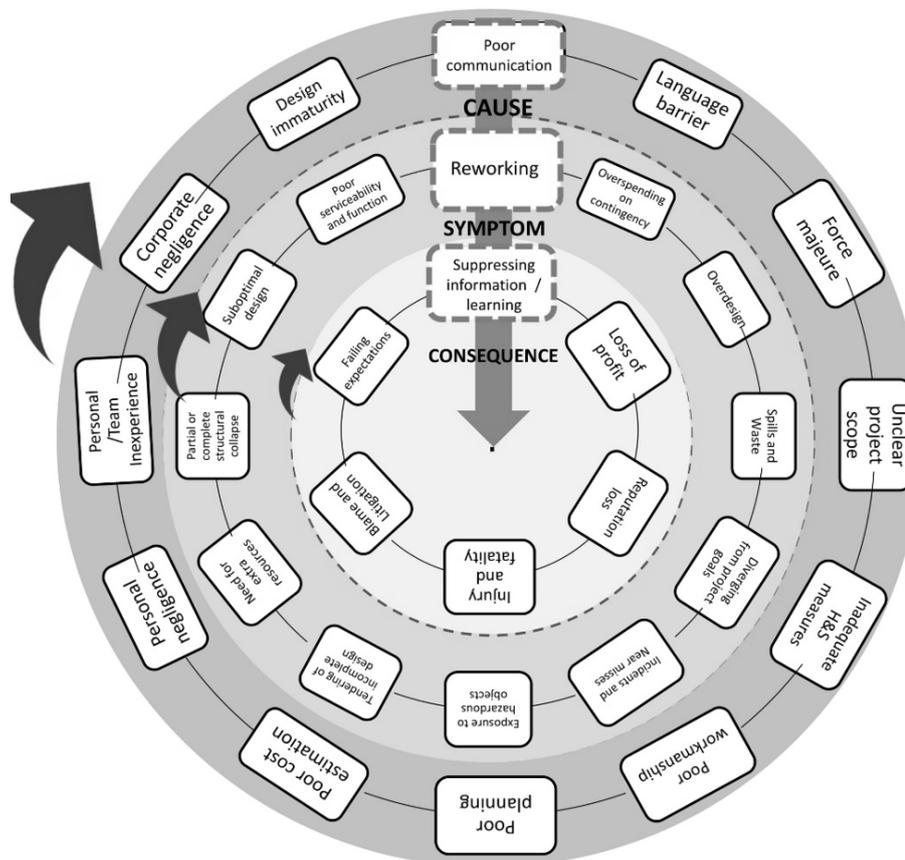


Figure 2: The Failure Taxonomy Tool

Furthermore, it was found that 10 participants related a cause to a symptom, but did not consider further consequences. Only 3 participants recognised a three-level relationship, such as inexperience (cause) -> need for reworking (symptom) -> loss of reputation (consequence). Most didn't recognise relationships between certain causes and symptoms, or symptoms and consequences that were not immediately obvious.

The Failure Taxonomy Tool aims to aid a better understanding of the relationship between the three levels of failure. The tool is presented in Figure 2 and consists of three concentric circles of different size, joined in the centre to form a three-level rotating tool. The circular shape was selected to encourage holistic thinking as part of a systems engineering approach, and to discourage typical engineering behaviours such as linear thinking and 'boxing' of similar items (Dym, *et al.*, 2005). Each circle

contains a different level of the taxonomy, starting from the outermost (causes) to the innermost (consequences).

At the top of each circle, there is a slot cut out of the circle, which allows different causes to take place by simply rotating the first circle. Similarly, the other two levels can be rotated, allowing different symptoms and consequences to be explored. The three cut-outs are joined by a blue arrow, which guides the user into creating a linear failure path of a cause-> symptom -> consequence.

Rotating circles were chosen to allow exploration of various failure paths by lining up different items from each circle. The importance of such an option was underlined at the interview stage, where it was noticeable that participants did not recognise three levels, or could not connect paths besides the well-known ones. Although some links are stronger, classic methods for analysis ignore some relations between causes, symptoms and consequences. Since education is about thinking beyond the immediately obvious, it is important to explore various potential failure paths. It is planned that the Failure Taxonomy Tool is produced in a physical form, which will improve its user-friendliness and ease of understanding.

The Failure Taxonomy Tool can only provide an initial overview of the taxonomy of failure. It does not claim exhaustiveness, and project-specific causes could be added in empty boxes in each level (not shown here for simplicity). This would allow for customisation and help to cater to different engineering branches which may have slightly different needs and modes of failure.

Having produced a version of the tool, the research team consulted with six construction industry experts with experience in both higher education and industry. The aim was to discuss potential benefits to the industry as a practical and educational tool, which are discussed below.

Exploring the Benefits of the Tool through Face Validity

Six experts were consulted to form opinions on the usefulness and benefits of the developed tool. These experts were selected through mutual acquaintance and all had considerable experience of high level of management and leadership in the industry.

When presented with the failure identification tool during a face validity exercise, all six experts expressed interest and overwhelming support for the simplicity of such representation. The use of circles was commended for being easy to grasp, with one expert saying that "unlike common categorisation, it does not just put things in boxes, but allows fluidity". It is believed that by being hands-on, the tool will grab the attention of potential users and encourage them to think about the three levels of failure.

The tool represents the relationships between the levels of the taxonomy, the intention being to make it easier for users to appreciate potential hazards and their manifestation as symptoms and consequences. However, a common criticism of a few of the experts concerned the lack of commercial awareness among recent (civil) engineering. One participant stated that 'understanding risks and the implications of failure is the most useful skill for a graduate engineer' which coincides with the conclusions of King (2009) who discussed in a similar manner the lack of big picture understanding of risks and failure among engineering graduates. Therefore, the tool can aid awareness of potential failure paths, particularly among inexperienced engineers and students.

Industry Applications

It was suggested by one of the consulted experts that the tool could be used during project inception. At the project briefing stage, large and medium sized projects begin with a layout of project aims and objectives, followed by potential health and safety risks, and the environmental impact of the works. In this expert's view, the failure taxonomy and failure analysis in general would fit in perfectly at such an early stage, because they provide a certain level of awareness of what the project risks may be. In addition, the failure taxonomy can directly relate to project goals, such as generating profit, safe construction and sustainability. Therefore, the Failure Taxonomy Tool can be used as a big picture tool to gain an overview of immediate and non-obvious risks that need to be avoided. While it requires an honest discussion, the tool allows all parties to raise their doubts, and facilitates the role of the project manager.

The applicability of the Failure Taxonomy Tool in the construction industry was supported by all six experts during face validity. Participants confirmed that the tool can be useful in preventing failure by exploring different failure paths. While it could be argued that the currently used methods of Bowtie analysis and the Swiss cheese model already fulfil this task, both methods require an initial input of hazards by the analysing engineer. If a young or inexperienced engineer is in charge of analysis, they may not be aware of all potential risks and consequences to a project. Therefore, an important omission of a cause, symptom or consequence can occur, while emphasis may be placed on an unlikely failure path.

The Failure Taxonomy Tool provokes discussion about the likelihood and importance of certain failure paths. For instance, most engineers will certainly correlate poor design with a structural collapse. However, it was argued by the industry experts that in the UK, complete or partial collapse of a structure is in fact rare. More often a project is deemed as a failure when, for example, profit or reputation is lost, or the client takes legal action against the contractor. However, many graduate engineers would be unaware of the commercial or legal consequences an initial error may have. This further confirms the need for the tool, as it allows exploration of various failure modes without putting an emphasis on any single path.

The Failure Taxonomy Tool can provide an extremely beneficial starting point for graduate engineers to think about potential causes of failure, and the long-term consequences of an erroneous assumption or personal negligence. An interview participant said that 'there should be a course on commercial awareness', as most graduate engineers severely lack understanding of the big picture of an engineering project. The intangibility of some consequences makes them harder to identify at an initial stage, therefore causing inexperienced engineers to forget or ignore them. The Failure Taxonomy Tool can serve as both a reminder and a learning opportunity to understand the implications of failure in the construction industry.

Higher Education Applications

The need for graduate engineers to 'think failure to prevent failure' was reiterated by multiple experts during face validity. However, it was suggested that the problem lies in higher education, where failure is not commonly discussed. This leads to lack of experience in areas such as meeting profit targets, or avoiding reputation loss, blame and litigation. Currently, the engineering curriculum in UK higher education is governed by two documents - UK-SPEC and AHEP. While risk analysis is usually touched upon in the learning outcomes provided in the latter, it is rarely in terms of 'risks to project success'. More often, it is referring to immediate physical risks before

laboratories and site visits, therefore leaving out the intangible risks leading to project failure, such as lack of communication or inexperience.

Moreover, it appears that current civil engineering curricula in higher education are primarily focused on codes of practice and standards. Much of the taught content still revolves around limit state design. In areas such as soil and structural mechanics, the Eurocodes provide standardised methods for determining if a structure is safe. The Ultimate Limit State (ULS) concerns avoiding structural failure, while the Serviceability Limit State (SLS) touches on aspects of unacceptable quality, such as deflection or vibrations. Compliance with both limit states is required before a building warrant can be issued for a construction project. Therefore, there is heavy academic focus on these topics, usually ranging from the basic factor of safety in early years, to full design in accordance with the Eurocodes in subsequent years.

However, there is a lack of a commercial limit state, where aspects such as avoiding failure could be introduced. During face validity, most experts claimed that they were not taught about failure in the same sense that they use it during their everyday work. This poses a large gap between what is currently taught in higher education, and what the industry demands. As discussed above, experts reiterated the need for civil engineering graduates to be commercially aware. Therefore, there needs to be a part of the academic curriculum which touches on the commercial targets of a project, which can be represented well by the Failure Taxonomy Tool.

During discussions on the applicability of the tool in an academic setting, there were two main suggestions on how the tool could be implemented in higher education. Firstly, the tool can be used as part of workshops or seminars aimed at raising awareness of failure. For instance, it was suggested that participants could be given one specific symptom, and asked to choose a failure path they consider possible. With 72 combinations possible, it is very likely that in a group of 4-5 people, there will be at least a few different failure paths. In this way, the tool could become the basis of a discussion about those paths, and why people connected the same symptom with different causes and consequences. It would allow participants to see that what may be an obvious failure path for one person may be extremely difficult to conceive for another. Thus, the tool can not only help people 'think failure to prevent failure', but to also highlight the differences in the thought process between engineering students, even ones from seemingly similar backgrounds.

It is anticipated that an inclusion of failure in the higher education engineering curriculum can improve awareness of the topic. Similar to failure, both construction safety in 1980s and sustainability in the early 2000s were novel concepts at their time. Yet, nowadays in the UK occupational health and safety, as well as designing projects to abide to the Environmental and Sustainability Regulations lie at the core of every engineering project. Similarly, in a 10-15 year span, failure analysis could become an inseparable part of engineering design, instead of simply a bureaucratic nuisance.

CONCLUSIONS

This work addresses the concerns raised by some authors on the inability of systems and engineering classification approaches to unify discussions on failure. Using a thematic analysis on 17 semi-structured interviews, three-level taxonomy of failure was created to establish the relationships between causes, failure symptoms and long-term consequences and improve understanding of failure.

The Failure Taxonomy Tool aims to represent the three-tiered taxonomy in a simple, fluid and clear way. By exploring known and unexpected combinations of causes, processes and consequences, engineers can gain a wider understanding of the risks and the implications of failure in the construction industry. The tool can provide a beneficial starting point for graduate engineers to think about potential causes of failure, and the consequences of poor decision-making. Furthermore, the tool can aid commonly used tools for risk analysis in construction projects such as Bowtie analysis or the Swiss cheese method by giving an initial list of potential threats and consequences. Finally, the tool and taxonomy can be included in higher education curriculum in numerous ways to encourage engineering students to think about the commercial implications of failure.

However, the Failure Taxonomy Tool has a few limitations. The language of the tool may need to be adjusted to its audience, since construction workers use different jargon to managing directors. In addition to that, with the globalisation of construction projects in UK, translation may be required for workers not yet fluent in English. Moreover, the tool is not exhaustive. Additional empty boxes could be added to allow for each institution to add project-specific causes and symptoms. However, the long-term consequences are anticipated to stay relatively similar. Finally, the tool is most effective when used hands-on, therefore it may need to be distributed and cause accessibility issues. Nevertheless, it is believed that the tool can provide benefits to the industry, so any limitation can be easily overcome.

In conclusion, although not without its limitations, the failure taxonomy and the tool are novel pieces of work which address the deficiencies of currently employed failure analysis models. Employing the taxonomy and the tool in the construction industry or the higher education engineering curriculum can increase awareness and understanding of failure, which in turn can be the first step to minimising construction project risks and long-term losses. Therefore, the importance of this research cannot be overstated, and further work in developing the Failure Taxonomy Tool beyond this project is encouraged.

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THEORETICALLY- INFORMED RESEARCH ON DIGITALISATION

INFORMATION STANDARDS - A HINDER OR AN ENABLER FOR INNOVATION?

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The potential of cost reduction by efficient digital communication in building processes in Sweden has been investigated to be 15-25% of the building sum. An important part of this potential is by using building information standards, such as Omniclass and IFC. This research has aimed at evaluating the use of building information standards and its impact on innovation. Standards are understood as classification of information and rules for building processes. Selected literature help reveal the multiple character of relevant standardization in building and the effects on innovation. Ten types of effect are identified. Three national longitudinal case studies of hospital projects in Scandinavia were carried out. Many barriers for innovation when using standards were found. The regional public authorities can decide to adopt standards locally and in two out of three cases they did not. For the companies this is a business consideration: In the Norwegian case, the proactive adoption of the architect, meant benefits for the client and contractor. However, other actors did not follow. In the Swedish case, BIM coordination was hampered by incompatible design systems. In the Danish case, the client demanded use of Cuneco Classification System, a Danish information standard, but the classification was done in a reactive manner at a late stage. The Danish and the Norwegian case were innovative, but the Swedish less so. Nine out of ten types of effects were found in the cases. Standard-enabled innovations were mixed with other innovations. The two most remarkable were the Danish reverse innovation, and the Norwegian shift of structural concept. The information standards and BIM are closely intertwined in practice. A common database of coded objects in the Danish case is a strong innovation enabled by standards. The use of TFM, in the Norwegian architect project and its subsequent use in site BIM is remarkable.

Keywords: information standards, hospitals, BIM, Scandinavia

INTRODUCTION

As the digitalization of building processes progresses, the handling of building information becomes increasingly important, both from a societal and business point of view. One way of improving handling of building information is to employ standards to address interoperability and a less redundant internal structure of building information. Building information standards are understood as classification of information and norms and rules for building processes. However, an equally

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important feature of contemporary building processes is the ability to innovate both in terms of product features and processes. There is thus a need for a coexistence in construction management of standards and innovation. This research has aimed at evaluating the use of building information standards and their impact on innovation.

The core empirical material consists of three longitudinal cases of hospital building projects in Norway, Sweden and Denmark, where a large number of building information standards are in play. This includes Industry Foundation Classes (IFC), Cross disciplinary Marking System (TFM), Building Standard BSAB 96, Program for Technical Standard (PTS), Facilities management Information version 2 (Fi2), Cuneco classification system (CCS). Many of these standards claim to build on ISO 12006-2, The ISO standard for building information standards, yet many variants are present. Selected literature is helpful in revealing the multiple character of relevant standardization in building and the effects on innovation. The paper is structured in a classical way commencing with the theoretical conceptualisation moving on to method, three case studies, analysis, discussion and conclusion.

FRAMEWORK OF UNDERSTANDING

In the practitioners' articulated experience (Scholtenhuis and Doree 2017), and in early literature, standards are a nuisance that hinders local creativity and problem solving and innovation (Farrell and Saloner 1985). It can therefore be perceived as an odd coupling to ask what the impact of standards are on innovation as the answer appears given. However, present studies of standards and innovation provide a series of positive impacts. We understand innovation in the usual OECD manner as “the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations.” Some main occupations of innovation studies in construction can be identified: Product improvements, (finalised product, sub systems, components), process improvements, business model innovation and delivery innovations (decommissioning/ facility management). According to the international standard organisation, ISO, standards can be defined as “documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics, to ensure that materials, products, processes and services are fit for their purpose” (Blind 2009). This definition involves two main understandings of standards, that of systematic ordering of information and that of mechanisms of coordination. ISO (2004) distinguishes the following types of standards: terminology, testing, product, process, service, interface, and data. More in particular, building information standards involving classification and/or rules aim to standardise use of information by creating similarity, homogeneity and consistency across time, space and participating actors in the building sector. Some building information standards cover both build products and building processes. This is for example the case of the Danish Cuneco classification system (CCS). CCS and other standards can moreover be characterized as “suites” of many related standards, like the Norwegian NS or Swedish BSAB standards. Many standards refer to the ISO standard ISO 12006-2, which is a standard for standards of building information. Building component standards would usually encompass classification of properties being physical, functional, aesthical, cost, shape or time, and attachment of them to objects. Further classification of objects involves buildings, rooms, systems, resources. Building information standards can also cover the building process, for example through setting rules for information levels in the stages of design and production. Turning to the literature on the relation

between standards and innovation, it does encompass studies that find that standardization is a barrier for innovation. The homogenizing effect of standards by prescribing a common set of rules to be followed, contradicts innovative activities that often require breaking existing (standard) rules.. Nevertheless, most studies find positive mechanisms. Abdelkafi and Makhotin (2014) review the academic literature and organize twelve propositions from the academic literature on how standardization enable innovation. Our study found further four links. These have finally been synthesized into following ten links:

1. link: Standards might indirectly make resources for innovation. In the context of product and process development, there are often resource demanding side activities to the innovation that tend to occupy resources. Standardization of such side activities and sub products lead to reduction of the use of resources and thereby indirectly provides resources for innovation (Sandholtz, 2012).
2. link: Standards can enhance repetitive elements in products that enabled single customer innovation. Standardization can nurture efficient repetition of sub products based on and aimed for recurrent needs of many costumers and simultaneously enable the creation of innovation for single customers (i.e. a mass customisation strategy of product development, (Piller and Tseng, 2010).
3. link: Process standardization stabilizes work activities that create product innovation. In project based environments, design and engineering processes tend to be volatile and difficult to maintain on course. The standardisation of work processes stabilizes work progression and thereby support the creation of an innovative final product as result of these stabilized processes.
4. link: Improved interoperability and interfaces between subsystems enable product innovation. Complex products consist of many sub systems. Product development and product innovation would often encompass embedding new components and subsystems in an existing constellation or structure. Interoperability and interfaces are critical for this. Standards for the interfaces and interoperability can improve and enhance product innovation (Clark and Baldwin, 2000).
5. link: Standardization creates larger markets for products. Standardization of products would overcome use barriers in local markets and thereby create larger markets for products (Schilling, 2008).
6. link: Standardization of product data might provide innovation in customer relations. Complex products are often delivered with a digital product data model, that when standardized can enhance customer related innovation. Standardized data on a building can support process innovation in facility management (Volk, 2014).
7. link: A sector standard can trigger system innovation. A standard that embrace a sector might trigger Innovation system innovation or institutional innovation i.e changes in relations between central actors such as leading companies, educational institutions etc. and thereby innovation in the system itself.
8. link: Standards might enable business model innovation. Standards might enable development of new products and processes that create the basis for business development, i.e. new sold goods, new channels to customer, new revenue. Or in other terms business model innovation (author reference)
9. link: Standardization might trigger paradigmatic innovation. For example from linear to iterative design.

10. link: Standardization of one technology induces new related innovative technologies. Standardization of one (key) technology induces the development of new related technologies

Even if the above list is extensive, it is not comprehensive. Financial innovation and open innovation are not found in standards studies.

Summarizing. The literature of standards and innovation is vast. Many links between standards and innovation are found, but the study also shows that the positive impacts on innovation of standards are not fully explored. There are more imaginable links that might be important. Open innovation and open standards as well as financial and organizational innovation are examples. It is also surprising to find relatively little on portfolios of standards. For example, taking up issues of strong coordination and dependence between standards in a portfolio, i.e. orchestrated standards, which might combine process, product, people and other aspects of a domain, versus loosely juxtaposed portfolios where the standards are largely independent of each other. Standards are often mixed and overlapping in a domain. Few domains using standards exhibit the complete coverage of one standard. Several studies find their domain of studies covered by multiple intersecting standards.

METHOD

The literature study behind this paper was done in two rounds, one early in the research project and one at a later stage. The case reports from Denmark Norway and Sweden are part of the Building Information Standards and Innovation project financed by Nordic Innovation and the participants. The selection of the three cases was done for mundane reasons using the authors contact net in the three countries. Several candidates were approached before succeeding with the three studies. The empirical method is a combination of interviews and documents study complemented with minor on site interaction, participation in meetings etc. The *Danish* case is part of 140.000 m² design of a new regional university hospital, Gødstrup hospital, covering a design of two buildings. The budget is approximately a half billion Euro. The overall design and construction are divided in several overlapping subprojects made by different design teams and companies. 43 interviews were done, 42 over 2016-2017, one in the spring of 2018. The project contains a somatic department, including cancer, neurology and day surgery, a multi-story rectangular building and service functions for the hospital. The *Norwegian* case study is a 22.000 m² transformation and extension of the existing University Hospital, Northern Norway (UNN) in Tromsø, finished January 2018. Total budgeted costs are 170 million Euro. In total 16 interviews are conducted. The A-wing contains polyclinics, test laboratories, day surgical department including operating rooms and day care centres, intensive care department, rehabilitation department, and clinical-medical laboratories. 8.000 m² were demolished and a number of renovations are made in the adjacent parts of the building. The *Swedish* case covers the design of a new building on the Karlskrona campus hospital in Blekinge Landsting (county council). The process followed over 2½ years through 12 interviews. Detailed design is still ongoing, preparing for tendering of contractors. The new building will add 11.000 m² to the hospital complex. A pre-study showed that the renovation required for a necessary relocation of medicine technology, microbiology and other departments within the existing building structure was costly. The option of a new built extension to the existing hospital buildings gained preference. It consists of seven floors. The building is planned to host a nephrology centre, a breast centre, microbiology and

other laboratories, a morgue, an autopsy department, training facilities and technical facilities. The research project has been limited in resources in studying these three building processes.

CASE HOSPITAL DENMARK.

The design of somatic department and service centre commenced with a design brief in January 2014. The construction of the service centre started summer 2016. The design went through a long process of reduction after an early brief estimated cost overrun. The service centre is in operation and the somatic department will be in operation at the beginning of 2020. The client project manager stated from early beginning of the project, that the value of all digital information created during the entire building project should be structured and consistently organized. Furthermore, that the key to a future productive and cost-effective operation and maintenance was the possibility to transmit the data into a Computer-aided Facilities Management (CAFM)-system during the design and construction process for later use of the O&M department. In order to succeed, a common data structure for the entire building project was required and a lot of involvement from the involved teams of the different sub-projects. The client chose one common classification system, CCS, which was able to support classification of all types of design and construction objects. The hospital was the first building project that used CCS aiming to structure all type of information - from drawings, documents and folders to BIM objects and quantities in the tender list etc. The design team of the first and largest sub-project build up a generic object library of Revit objects (rooms and building system and components) structured in accordance to the CCS-systems. The object library contains property information of each type of object and what types of information the contractor should deliver when the building ready to be delivered. The owner purchased a “traditional” CAFM-system, which was able to import the CCS structured BIM data during the design. However, when the O&M-department representative tested the import of the two design team’s CCS-structured BIM data, it was quite clear that the classification was uneven. The cause for this difference was mainly that the teams had different interpretation of CCS, object naming, and information needed in design, tender and construction phases. The client had to invest a common project BIM object library. All later sub-project’s design and construction teams are to use this object library afterwards.

CASE HOSPITAL NORWAY.

The process started in 2009. The outline proposal of the new A-wing was done in 2012 followed by the functional specifications including specification of rooms and design in 2014-2015. The tendering was done in spring 2015. However, the client shifted project manager and contract strategy, moving from the main design project to a design-build contract, mainly to mitigate perceived risks in the project. At that time, the consulting engineer interpreted the design to be about 90% ready. A design-built-contract was signed changing the concept to a double length building and another facade. The design-built contractor received a very detailed material from the architects and engineers, but calculation of material costs still elevated the price, a cost increase at around 36 million Euros. A new approach to the building shell leads to roughly 9 months’ new design. The building site activities commenced in the autumn 2015 and continued in 2016 and 2017. The Lean based TAKT planning means that carpenters, plumbers, electricians, tile setter and painters follow each other. The project was on schedule until it was finished by January 2018 and

inaugurated June 2018. dRofus and the module for room classification and unique numbering of rooms is used in the programming. This is a commercial standard room programming tool used by the national and many regional health authorities. For the outline project, the architects decided to build up a classified BIM model on their own initiative. This was not from start a requirement from the client, which was uninterested in digitalization issues. For the design of the project, different software programs like Archicad, Revit and Autocad were used, put together in a portfolio of building information models managed by a BIM coordinator from the architects. The BIM coordinator did a lot regarding classification for the architectural design on building elements and components. The engineering consultants did not to the same degree, but used the standard of their BIM systems (such as Revit) for classification. For them, use of classification is a change of practice from marking building components on drawings. The client did not express a particularly strong focus on digitalisation during design and construction neither, but focused on the content of the hospital. After the change to a design-build contract, the focus was on the construction. The project did not want to use extra resources on an advanced BIM model. The architects did a modification and simplification of the classification for work drawings and components standards to enable craftsmen's work on site. The BIM model was developed, just to meet the contractors' basic needs without any further attention to the operation and maintenance of the building in use. Two variants of TFM (Cross disciplinary Marking System) was in use, one for architectural design and another for Facilities management.

SWEDISH HOSPITAL CASE

The hospital client first tendered an architect firm to do a program for the building. Then a design organisation consisting of another architect firm and several engineering firms. Further participants were room planners of the client, quality control responsible and work environment responsible. At this design stage, the most important innovations occurred as the architects reconceptualised the outer shape of the building and the light access throughout the building envelope. A returning early theme is the distribution, function and organisation of the rooms. The client demands communicates his demands mainly through the 'room function program' (RFP) developed during summer 2015. The RFP gives prescriptive guidelines for which components should be in each room. The systems design of the architects floor plans were carried out, and the classifying of rooms through running numbers and functional naming. As the architectural design gradually emerged, the structural engineer commenced making concepts for the structure. The distribution of the rooms influenced structural design only at heavy equipment, dangerous chemical or explosive activities. The structural engineer needed to balance the demands from the architect, the electricity and the HVAC. An example of a conflicting demand was observed at the placement of the rooms vis a vis bearing pillars. The RFP, and the design of rooms was almost finished by May 2016. However, further changes demanded by client, impacted on RFP and the design. From the end of the conceptual system design phase, an increase in IT based review and coordination work occurred, using IFC and Solibri. Collision control continued through the detailed design phase and towards the end it obtained more time, as tendering for construction was postponed. The constellation of IT systems was three different CAD systems; MagiCad, Revit, and Autocad. In addition a document system, "byggnett". The way of working is a mixed IT/paper method where also several less interoperable IT

systems have been involved. To transform 3D BIM models to 2D pdfs has involved considerable extra work

ANALYSIS

The Danish case showed that a classification system is not enough to ensure well-structured and consistent data across different sub-projects. One common BIM object library is necessary for fulfilling the project managers statement that data created in early design and construction should be an applicable and productive foundation for the future operation and maintenance of the hospital. The different design teams tend to define and structure BIM objects differently, even if they structure the objects in accordance to a comprehensive classification system, like CCS. The designer's interpretation of needed types of objects was clearly reflected in the use of design phase and the needed level of information. The owner invested in a common project object library for the whole hospital project to ensure that the CAFM-system did not contain redundant objects definition. The benefit of a common project object library will probably give the O&M-department a consistent tool for managing their future operation and maintenance work, as the digital content represent the real physical components and technical systems, even though the components and technical systems where designed and constructed by different teams in different sub-projects. Another benefit is the re-use of object definitions. In the following sub-projects, the design and construction teams had to use the predefined project object library. In the *Norwegian case*, we see a need for a much stronger involvement and commitment from the client to lead the process and define the relevant level of standardization and classification. The client organization and the engineers in the building project is relatively passive in the digitalization issues. The BIM coordinator from the architect company is here the driver behind digitalization initiatives such as proactive use of building information standards and BIM. However, this does not cover the building projects fully. The new strategy of Sykehusbygg represents a possible stronger common development of standards in the future. However, the regional public authorities that build hospitals still decide adoption locally. The proactive adoption of the architect in the design phase meant that the client and contractor actually achieved benefits from the standardization. There are several national systems for standardization and classification partly used. The use of TFM supports use of an app BIM system, BIMx, which provided updated BIM models for the site managers and workers. The use of dRofus and TFM with standardisation of room categories, numbering of rooms and functions and components have given a certain process stability in the basis for the design and construction. However, the potential for a stronger and more consistent information capturing and flow throughout the whole process has not been fully utilized. The use of TFM by UNN and other hospital organisations in Norway is a possible platform for a common standardisation support new built and facilities management. The practice is, however, limited to local variants of TFM. The recent investment in a FM system is not directly integrated or communicating with the other systems due to a lack of unified interfaces. In the *Swedish* process, several standards have been used: The client's room classification, Fi2, BSAB 96 (AMA), PTS and IFC standards. Also, the CCS building component standard have been offered yet less visible. It supports a BSAB coding that can be entered in Revit models. However, in six out of eight main design areas the use of Magicad made the CCS function suboptimal as they are not interoperable unless IFC is used. There are few examples of actual innovation not related to the use of classification standards. The redesign of the daylight access to the building is the

most important. Here the architects did benefit by their BIM systems and the embedded standards. However, this was not directly experienced as such by the architects. The use of the PTS and Fi2 standards enables the diffusion of innovations among hospital projects. The limited use of BIM and limited attempts to integrate the IT architecture have multiple explanations. The constellation of IT systems and way of working in the Karlskrona project use three different CAD systems, where integration between Magicad and Revit was a particular barrier. However, it is central that the clients do not demand integrated BIM design. This is exhibited by a low priority of IT demands in contracting, low priority of BIM by strategic management and project management. No IT agreement has been accorded upon. Adding to this, large parts of the design consultancy team operated a low level of BIM integration. This in turn created barriers for integration of classifications and standardisations beyond the above-mentioned standards (Blekinge Landsting-s room classification, Fi2, and AMA). To assure occasional, monthly, coordination of models, during detailed design, IFC was used.

CROSSCUTTING ANALYSIS OF INNOVATIONS

Below the enabling links between standards and innovation are discussed one by one. However, no. 10, was not found, and therefore only nine of ten are discussed here:

1. link: standards might indirectly make resources for innovation. In the Danish case the use of standards did create cost cutting and potentially available resources, but this effect was outweighed by a needed cost cutting during the design phase. When it came to contractors bidding, the offers were lower than expected, which created a new buffer. In the Swedish case, use of IFC saved resources through proactive collision control. In addition, the interoperability between different modelling software's would lead to indirect efficiency gains. The Norwegian case had more limited benefits of the use of IFC and collision control, due to the changes in contract form.
2. link: Standards can enhance repetitive elements in products enabling single customer innovation. The client in the Danish case created a repetition of coding used from phase 1 of the project, provided as a database and supported by the tool Spine. This created an option for the client to use this structured library later.
3. link: Process standardisation stabilizes work activities that create product innovation. In the Norwegian case the use of dRofus and TFM with standardisation of room categories, numbering of rooms and functions and components have given a certain process stability in the basis for the design and construction. However, the potential for a stronger and more consistent information capturing and flow throughout the whole process has not been fully utilized.
4. link: Improved interoperability and interfaces between subsystems enable product innovation. Hospital buildings are complex products with many intersecting subsystems. The Danish case had an interface between two complex system, the phase 1 building system and the phase 3 building system (the present case). The client aimed for coding in CCS in both, including technical installations directly interfaced between the two systems. This standardization first meant reductions in the development of descriptions for the somatic building and better information handling.
5. link: Standardisation creates larger markets for products. In all three cases the participating architects, consulting engineers and contractors participated in several hospital projects before, in parallel or after. One architect company did develop an object library for use across hospital projects containing illustrations of equipment,

furniture etc. The use of PTS and the related competences would similarly tend to favour building companies which are skilled in using it. The common hospital use of TFM in Norway for facilities management appear to create larger markets for FM.

6. link: Standardization of product data might provide innovation in customer relations. Architects used BIM for visualization purposes in their interaction with clients/customers. In early phases, visualization is often changed and it is probably instrumental for their use that they are not classified. Later, the delivery of information to the future operations and facility management played a role in all three cases. We did not find innovations in customer relations.

7. link: A sector standard can trigger system innovation. In the Swedish case the client Blekinge Landsting adopted fi2 and PTS. Fi2 was used for room classification and the client shared their developed room classification. PTS is a technical standard for hospital projects and was here followed during the design, which was a smooth process. Both examples have the potential of contributing to the further development of the health innovation system in Sweden and the community innovation around fi2/BIM alliance. In the Norwegian case, the use of TFM signifies a possible common platform. In Denmark, there were weak links between the case companies and the building sector innovation system.

8. link: Standards might enable business model innovation. In all three cases, standardization enabled small software companies to develop their product, services and business model. In Denmark this include Project-spine, dRofus, Sigma and Likan. Projectspine had a platform in the Swedish project for developing its product for the Swedish market. However, the limited use of Spine prevented it to develop into a genuine reference case, but at least the Project-spine organisation gained important experience. In the Norwegian Case, Unizite got an opportunity to expand to a second reference customer for their system for onsite monitoring of progress.

9. link: Standardisation might trigger paradigmatic innovation. The potential for this effect is definitely there, yet many elements including design and engineering processes in the three case projects stayed relatively mainstream. The BIM use was on a par with the respective sectors. There was therefore no sign of paradigmatic shifts.

DISCUSSION AND CONCLUSION

The aim here has been to evaluate the use of building information standards and their impact on innovation. Through selected literature, a framework of understanding was established on possible positive impact of standards on innovation. In the empirical work, many barriers for innovation using standards are found. Apart from demands of IFC, there is not a rigorous legal demand for standards, so the regional public clients decide. Two out of three clients did not adopt standards. The participating companies have a business approach to standards. The proactive adoption of the Norwegian architect meant that the client and contractor achieved benefits, but other actors did not follow. In the Swedish case, the barriers of innovation also include the position of the client. As six out of eight design areas used MagiCAD, BIM coordination were hampered. In the Danish case the client demanded CCS, but the CCS classification was done at a late stage of the design and was therefore not influential on the most important innovation, the reverse innovation. A systematic internal IT-strategy of the companies building up families of objects was in an early stage. The Danish and the Norwegian case were innovative, the Swedish less so. Seven out of the ten links

between standards and innovations were found, but they are mixed with other innovations. The three most remarkable were the Danish CAFM database innovation, the Norwegian shift of structural concept, and the Swedish improved daylight access. Only a few types of information standards, i.e. rooms, components and descriptions, is in use, compared to the portfolio of building information standards available. The standards used internally in the cases are both complementary and overlapping. This mirrors a fragmented set of national level responsible institutions/bodies, which coordinate and develop suites of standards. But these are only partially implemented corresponding to the literature review finding. Especially standards for the process of design and its information levels, or design/detail levels and the production process is not in use. Several standard studies find domains covered by multiple intersecting standards. This has implications for managing building information with standards. A given standard will develop in versions and only be relevant for some time. The implementation barriers found here, thus risk to reflect a condition of constant transition of one set of standards to another.

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INSTITUTIONAL FOUNDATIONS OF CONSTRUCTION ICT: A VIEW FROM THE WEST MIDLANDS OF ENGLAND

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Construction industry is of strategic importance to economic development and growth within any region and nation. However, the industry is confronted by many challenges including poor labour productivity. Part of the explanation frequently provided in literature is that the industry has been slow to adopt and institutionalize useful information and communication technologies (ICT). The research questions asked in this article are: What are the institutional foundations for West-Midlands construction firms to deliver their projects based on ICT and how can these be strengthened? These questions are asked for two reasons. The first is to understand the reasons behind slow ICT adoption and second, to inquire into what can be done about it. The article provides an overview of projects using advanced ICT in the region and presents the results of a focus group discussion undertaken with six industry experts. Scott's pillars of institutions were used for understanding how the foundations for ICT adaption in the region can be strengthened. Findings are that present regulations, incentives and perceptions of ICT can be further strengthened. While ICT adoption appears to accelerate in large projects, many practitioners remain sceptical as to whether the excessive costs associated with ICT adoptions are justified. The regulative pressures exerted by government in support of ICT adoption do not seem to have fully materialised in industrial practice. However, it is apparent that the normative and cultural cognitive pressures are rendered weak in the region with using advanced ICT being viewed as extraordinary rather than standard industrial practice.

Keywords: institutional theory, ICT, West-Midlands

INTRODUCTION

The construction industry suffers from poor labour productivity when compared to other sectors of the economy. Farmer (2016) states that the construction industry and its labour model is at a critical crossroads in terms of its long-term health. Whilst the diagnosis points to a deep-seated market failure, there are certain industry trends and wider societal changes happening now that represent both unprecedented risk and opportunity for the industry and its clients. If the opportunities are not harnessed, the risks may become overwhelming. The report suggested the industry to 'modernise or

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die' in order to safeguard its future. The productivity in the UK construction industry has been fundamentally flat since 1994 (DDCM&S 2017). One way to modernize the construction industry is to embrace the adoption of emerging information and communication technology (ICT) solutions that promote efficiency in communication, firm performance and driving innovation (Baxter and Berente 2010; Eastman *et al.*, 2011; Francom and El Asmar 2015, Froese 2010, Azhar 2011).

Recognizing the potential of ICT, the UK government has initiated major programs such as Digital Built Britain to contribute to further digitalising the industry. Consequently, there is a growing body of research focussing on ICT diffusion and adoption in construction. Cao *et al.*, (2014) argue that project adoption is a complexly socialized activity that is not only motivated by participants' rational needs to proactively address internal process problems, but also driven by external isomorphic pressures related to the acquisition of institutional legitimacy. Review of literature show that there is little research that examines institutional foundation for ICT-based work in West Midland. Doing this will assist in understanding reasons behind slow ICT adoption in the region and subsequently, it allows for an understanding of what can be done about it. The research question asked in this paper is: What are the institutional foundations for West-Midlands construction firms to deliver their projects based on ICT and how can these be strengthened?

Scott's pillars of institutions theoretical framework allows for understanding the authoritative guidelines for social behaviour (Scott 2001). The social behaviour at the core of this research study is ICT adoption in the construction industry. Institutional theory has proven its value for studying how innovations become adopted and how they can be made to stick in industrial practice. Data was collected through one focus group interview with six subject experts from the Midlands region and from assessing documents related to ICT-based work in construction projects. The paper is structured as follows, first an overview of recent ICT solutions for the construction industry is presented, second Scott's pillars of institutions as theoretical view are explicated, third the methodology is presented and fourth the findings of both the document study and the focus group interviews are presented. Last, the findings are discussed and conclusions is drawn.

Emerging ICT in the UK Construction industry

Construction organisations increasingly view ICT as a strategic asset driving business performance and generating competitive advantage (Underwood and Khosrowshahi 2012). ICT comprises of computer software, hardware and communication devices that allow easy communication at local and international level (Forbes and Ahmed 2011). Construction projects planning and site work require extensive information and personnel at all stages, starting from the front-end planning through to completion. In 2011, UK Government mandated the use of level 2 Building Information Modelling (BIM) on all public-sector projects by 2016. BIM is considered the most promising development to construction industry for its ability to produce accurate virtual models (Eastman *et al.*, 2011). The realistic visual produced ignite construction clients to understand the design and construction process better when compared to 2D drawings. These emerging technologies are recognized as main source of improvement and competitive advantage to construction firms and as critical solution to shortage of skilled labour, safety for construction workers and boost to productivity (Ho and Liu 2003). Digital technologies are electronic resources, tools, systems and devices with the capacity to store, generate and process data. An

overview of the emerging ICT and their applications in construction industry is provided in Table 1. The technologies listed below represent the artefacts placed at the core of both document analysis and the focus group discussion.

Table 1: Details of emerging ICT in Construction.

Emerging Technology in ICT	Application in construction
Software, online platform, mobile devices and the cloud	For communication, reporting, collaboration and enhancement of decision-making.
Big data, Artificial Intelligence (AI) and Advance Analytics	Analyse big data for decision making. Provide users real-time information for maintenance and decision making.
Project management and digital collaboration	Enhance collaboration, assign tasks and assists contractor with administration and compliance with regulations and safety on site. Allows for transparency and enable data-mining in large scale.
Building Information Modelling (BIM)	3D modelling of design allows virtual twinning of the structures, speed decision making process, manage changes and enable workers to run various scenarios. 3D, 4D, 5D, 6D and 7D BIM is for visualization, construction sequencing, estimation, facility management and materials/objects tracking respectively.
Sensors and Internet of Things (IoT)	IoT is connectivity of many intelligent devices with the ability to communicate with one another and humans. Sensors measure operational variables such as identification of individuals, tools, materials, speed, telecommunication devices, infra-red, body temperature, fatigue and environmental conditions.
Spatial measurement, tracking and geolocation	Helps information to be transmitted wirelessly from workers, tools, materials, vehicles and equipment to a designated server for display, process and analyses. Geolocation technologies are used for personnel safety, site security, fraud detection, and project management.
Augmented Reality (AR) and Virtual Reality (VR)	Enable construction clients to interact and understand the unbuilt structure. Allow a live direct and indirect view of real-world, physical environment

Theoretical Lens

Institutional theory suggests that organisations are primarily stimulated by the motivations of seeking social legitimacy (Scott 2001). Oliver (1991) reckons that institutional theory is capable of explaining nonchoice behaviour in the context of taken-for granted norms and beliefs and suggested that attention should be given to ways in which organisations strategically respond to institutional pressures. In Three Pillars of Institutions (Scott 2014) points out that organisations could be persuaded not only by the regulatory coercive pressures but also compelling influences from other competitors and external isomorphic pressures. Institutional theory is organisational change theory, with relatively established theoretical perspectives capable enough to explain the connection between organisational activities and institutional environments.

Explaining innovation diffusion process, Westphal *et al.*, (1997) argued that social and economic motivations in innovation implementation by an organisation substitute for each other instead of working in a parallel sense. Also, Tolbert and Zucker (1983) strongly support the idea that adoption of new innovations by organisations is importantly determined by the law or gradual legitimacy. Institutional theory however has been criticised by researchers. For instance, Martinez and Dacin (1999) observed

the theory ignored the place of organisation economic considerations and overemphasising the social legitimacy Lounsbury (2007). Also, leveraging on institutional theory contended that economic and social legitimacy motivation for innovation diffusion should not be decoupled from broader institutional beliefs. Cao *et al.*, (2016) affirmed that construction project participants such as clients may strongly advocate the use of BIM. Cao *et al.*, (2016), using questionnaire survey and construction professionals’ interviews, established that impacts of isomorphic pressures will probably be not completely isolated from the motivations to seek economic performance improvement.

Institutionalisation is the action of establishing something as a convention or norm in an organisation or culture. Institutional theory stresses that institutional environments are crucial in shaping organisational structure and actions (Scott 2001). The theory claims that organisations are likely to be wooed to adopt ICT because of external isomorphic pressures from the government, competitors and customers rather than deliberate internally driven decision. Organisation’s actions and decision are not only driven by sensible goals of efficiency and increase productivity but also by social and cultural factors and concerns for legitimacy (Oliveira and Martins 2011). Cao *et al.*, (2016) summarised from literatures three categories of factors catalysing firms to implement ICT. One, decisions that are informed by external entities like trade partners and industry professionals. Two, innovation implementations that are not primarily influenced by external requirements but by imitative motivations and three, organisation implementation of innovations based on proactive decision by internal economic motivations hinged on desire to improve communication and reduce cost and not necessarily based on significant environmental factors or practice of other competitors.

Scott (1995) defined institutions as regulative, normative and cognitive structures and activities that provide stability and meaning for social behaviour. Institutionalisation theory is a powerful tool to explain individual and organisational behaviours in technology adoption (Lounsbury 2008). The regulative institutional pillar is established system of rules that is backed by surveillance and sanction such as formal institution of laws.

Table 2: Three pillars of institutions (Scott 2014).

	Regulative	Normative	Cultural - cognitive
Basis of compliance	Expedience	Social obligation	Taken for granted
Mechanism	Coercive	Normative	Mimetic
Logic	Instrumentality	Appropriateness	Orthodoxy
Indicators	Rules, laws, sanctions	Certification, accreditation	Prevalence, isomorphism
Basis of legitimacy	Legally sanctioned	Morally governed	Culturally supported, conceptually correct

The behaviour of institutional regulative actors are based on consequential logic but also seek to maximize their investment strategically. The normative pillar is centred on norms and values in explaining actions and behaviour. Institutionalisation in normative context is viewed as internalized moral beliefs of logic of appropriateness and forces of social patterns that influence behaviour. The cognitive pillar is built on

share conceptions of social reality and ways by which meaning is made. Institutional actors react to external stimulus by imitating others through various templates such as mere conceptions, pattern of action and routines. Cognitive paradigm stress that socially structured meaning determines how people are treated and on how rules are set in the society. In nutshell, the three pillars are interrelated, vital and mutually reinforced institutions.

METHODOLOGY

The overall strategy used for the collection of the data were in twofold. First, an overview of the industrial context and the projects using emerging technology in the West Midlands was generated based on web searches. Examples for keywords used in the searches include the names of the emerging technologies in Table 1, construction, project and West Midlands. While we claim that these searches did return data helpful for understanding the present state of construction ICT adoption in the region we cannot claim that the overview is complete. This is so because not all projects announce their ICT usage on the web. However, we double-checked our findings with the focus group experts and thus argue that this data serves well for providing an initial understanding of ICT adoption. Secondly, to understand how current regulations, incentives and perceptions in the region motivate how firms institutionalise new innovations in construction management and process, a focus group interview with six industry experts from the region discussing the institutionalisation of ICT innovations was conducted. The combined intention of document analysis and focus group interview focused on gaining an in-depth understanding of the foundations for institutionalisation of ICT in construction projects in West-Midlands region of England and how can this process be improved.

The purpose of the focus group interview to gain in depth understanding on issue of ICT institutionalisation complementing our findings from the web searches. Ten industry professionals from construction company and academics in the region were contacted through personal visits and email to explain why a focus group interview is been conducted. Only six out of ten construction experts contacted confirmed their availability and willingness to take part in the interview. The professionals that participated in this interview were one mechanical engineer, two quantity surveyors, a digital designer, a building surveyor and a site manager. All expert interviewed had over 20 years of industrial experience in the construction industry expect for one quantity surveyor. The meeting was held on Monday the 19th of March 2018 at John Laing Building, faculty of engineering, Coventry University between 15.00 and 16.30. Four simple and short questions around the research enquiry were drawn up but not made known to the participants prior the meeting. These questions formed the bases of discussion alongside with findings from the document analysis in Table 3. Proceedings of the meeting were recorded, transcribed and processed using Nvivo 12 qualitative data analysis. Signed informed consent was obtained from all participants.

FINDINGS AND DISCUSSIONS

The West-Midlands Industrial context

At regional level there are several notable initiatives focusing on ICT implementation. BIM in Birmingham initiative started in 2017 in West-Midland, it is a collaboration event between the Association of Academic Educators (AAE) and the Royal Institute of British Architects (RIBA). The event is aimed at educating, informing and to showcase the work of talented BIM managers across the region so as to promote

adoption, diffusion and career opportunities locally. The event this year welcomed over 500 students from the UK and South America alongside professionals from construction industry. BIM west midland (BIMwm) is another initiative in the region. BIMwm is a collaboration effort of three construction stakeholders in the region namely: Sandwell Council, Sandwell College and the University of Wolverhampton. The group established a technology and skills development suite with computer workstations, BIM viewing software, e-learning platforms, to assist West-Midlands construction firms and to encourage small and medium sized enterprises (SMEs) in West-Midlands to acquire necessary skills to adopt and implement necessary software and remain competitive in business. Over 2,000 users ranging from clients, architects, buyers, suppliers and other support service providers have registered to use the facility.

Analysis from archive documents from recently completed and ongoing project across the region is presented in Table 3. Project selection is based on table 1, projects that adopt BIM and other ICT at different phases of delivery were selected randomly. Analysis reveals BIM is gaining awareness in the region and that adoption of emerging ICT is gradually increasing on mainly public-funded projects. Archive document search for privately funded construction projects implementing emerging ICT did not yield any result. However, other emerging technologies in ICT such as Augmented Reality and Virtual Reality, the cloud, big data are not widely use in Mid-Westland region. Some of the twenty-one projects reviewed are award winning projects and first of its kind in the region and some on national level. Educational buildings dominate project samples in Table 3. ICT adoption in construction projects in the region is not limited to new construction projects entirely, some of the projects considered are refurbishment and redevelopment works on existing structures.

Table 3: Sample projects adopting emerging ICT in the West-Midlands (2015-2018).

Project Cost range	Educatio n	Industrial	Office	Leisure	Mixed Residential/commercial	Health
£5-10m	-	-	1	-	-	1
£10-20m	7	-	-	1	-	-
£20-30m	2	1	-	-	-	-
£30-40m	1	-	-	-	1	-
Over 40m	3	1	-	1	-	1

The Three Pillars of Institutions

Findings from the focus group discussion with the industry experts are presented along the three pillars of institutions as proposed by Scott (2014). The progressive collaboration between businesses and academic institutions in the region is a promising indication that the UK construction industry can realise its potentials and tackle poor labour productivity and other illustrious challenges confronting the industry.

Regulative pillar: The regulative pillar may be viewed as coercive because of its formal power affirmation by constituted authority. The focus group experts acknowledged that the UK government mandate, which enforced BIM level 2 on all public sector procured projects has played an important role through legislative strategy to inspire institutionalisation and uptake of emerging ICT in the region. For

example, interviewees were asked to express their view concerning the impact of government mandate enforcing BIM level 2 on implementation of BIM in the region. Some textual excerpts from the interview transcribed are as follows:

I think with most things in construction, it all comes down to the law and the penalty. We change or comply when we are told to do so (Site manager).

I definitely think the law has made impact in implementation of new technologies (Quantity Surveyor).

I believe the uptake is mainly because of government policy and competitive advantage but it is a gradual process, we still have a long way to go (Senior Quantity Surveyor).

The enforcement of the mandate was criticised by some participants, from their viewpoint, the mandate favours the large construction companies in neglect of the SMEs because of high capital investment required for adoption. In practice, subcontractors are mandated to acquire mobile gadget like tablets for use on construction site to enable them paired with main contractor on collaboration platform where useful information needed for their work could be retrieved. The focus group discussion indicates that regulative forces play a significant role when it comes to the institutionalisation of new technologies in the industrial context of the West Midlands. However, it became apparent that coercive impact of regulative force may limit institutionalisation, noting that some construction firms may limit their ICT adoption to the minimum level/requirement as specified in the law without aspiring to go beyond.

Normative pillar: The normative pillar is centred on norms and values in explaining actions and behaviour. BIM was considered as a ‘fashionable’ technology by one participant of the focus groups meeting alluding that main contractors on construction projects are only willing to partner with subcontractors who can implement new technologies, therefore it would appear that using emerging ICT is becoming a social obligation in construction project team selection. To understand the institutionalisation of emerging technologies in the region participants were probed further on reasons for adoption of new ICT on construction projects based on the outcome of document analysis in table 3, their answers are presented below:

When people say they use BIM, it does not necessary mean that they are digitally literate; perhaps they use 3D, probably they used 3D AutoCAD for design, but people think it is fashionable to associate with BIM and therefore equate everything to BIM (Digital Designer).

Years down the line, it is becoming less viable to use old equipment, you wait till ten years’ time. I won’t say it is the government law but people think it is not good enough to give client 2D drawings. Adoption is more than the government law or for competitive advantage, it is what more and more people are expecting. No one is expecting the shoddy 2D drawings anymore (Site Manager).

Probably the software is becoming cheaper, more people are getting interested but implementation is combination of many factors (Building Surveyor).

Acceptance will take time, it is a slow process ..., it will gradually circulate, [and] West Midland region is behind London (Mechanical Engineer).

Although the imposition of the level 2 mandate influenced institutionalisation of BIM in the region, there are other factors contributing to adoption according to the quotes above. These factors may include the intent of the project, how acceptable a technology is being perceived, the affordability of the software and clients demand. While some participants opine that the initial cost of adoption especially for SMEs, is

enormous, other experts reckon that software subscriptions are becoming cheaper and affordable. However, there is gradual adoption in the region.

Cultural-cognitive pillar: The cultural-cognitive pillar recognises the importance of making meaning of an innovation in a cognitive and cultural way. The cultural-cognitive element in implementation of new technology in the region is attributed to the number of ongoing activities and events aimed at showcasing the impact of BIM in the region. These activities and initiatives reflect a community seeking to create value and provide a culture of learning to influence adoption and institutionalisation. The cultural-cognitive pillar may not be popularly reported in construction management research, but it is a valuable deeper process of institutionalisation. One of the interviewees gave cogent insight into gradual adoption and institutionalisation of useful information and communication technologies in the region by this quote:

I train people locally on how to use Revit software, the initiative is funded by Coventry University and European Development Fund. The problem is that many senior people in construction business are old and can't be bothered with new technologies (Digital designer).

Decision of top executives in construction organisation is vital to adoption and institutionalisation of new ICT. Laggard decision makers will need to be enlightened to speed up rate of adoption and stimulate institutionalisation in the region. While ICT adoption appears to accelerate in large projects, top practitioners and construction firm's executives in the region remain sceptical as to whether the excessive costs associated with ICT adoptions are justified.

Institutionalisation Challenges and Barriers

Based on the outcome of strategy used for the data collection, some challenges and barriers hindering adoption and institutionalisation of ICT in the region were identified. Initial cost of procuring ICT by most SMEs is a challenge despite the availability of the laudable initiatives for training in the region. A thinkable solution to stimulate institutionalisation could be to form industry clusters where firms could share their experiences. There is more to learn from construction cluster organisation in many parts of Europe with the main aim of improving domestic and international competitiveness of its member firms through commercial cooperation and networking, training, education, research and development activities. Educational buildings dominate project samples in Table 3, it is apparent that the normative and cultural cognitive pressures are rendered weak in the region with using advanced ICT being viewed as extraordinary rather than standard industrial practice. Implementation of ICT is key to institutionalisation, role of ICT in project delivery in the region should be further strengthened especially among the top executives of construction firm. UK construction industry is faced with challenge of recruiting experts to meet the demands for emerging ICT application. While ICT technologies such as BIM, diverse software and project management platform are being adopted increasingly by large construction firms emerging ICT such as Sensors and Internet of Things (IoT) and Augmented Reality (AR) and Virtual Reality (VR) within the region are being utilised as training facilities. An example is UK's first construction training simulation centre in Coventry University, Solihull College and University Centre Virtual Reality (VR) and Robotics Development Centre among others.

CONCLUSIONS

A clear deduction from the study is that institutional foundation required for the West Midlands construction firms to deliver their projects based on ICT is to tackle

resistance to new technologies through quality training of companies' chief executives. The regulative pressures exerted by government in support of ICT adoption has started to materialise in industrial practice. However, most of the identified use cases of emerging ICT (Table 3) were found in public sector projects and the interviewees stressed that firms limited the use of advanced ICT unless otherwise demanded by their clients. One thinkable avenue for extending the outreach of regulative pressures to other types of projects could be for planning permission authorities to demand model-based designs or simulations as part of the approval criteria. In this way, other non-public sector projects would be compelled and hence increase ICT adoption. Moreover, there is an increasing ICT uptake in large projects, but general adoption among SMEs in the area remains a concern. It appears that many construction executives remain hesitant and sceptical as to whether high capital investments in ICT are justified. To tackle the risk averseness and resistance to new technologies and lack of 'innovativeness' among top executive in the region, new initiatives that target top executives should be considered. This would then strengthen the normative and cultural cognitive pressures. Dossick and Neff (2010) argued that even as technological advances such as BIM that enable collaboration and better information exchange, decision-making power in building projects is often divided organisationally. People make or break change, hence successful institutionalisation of emerging ICT is dependent on decisions of enthusiastic top executives of construction firms and stakeholders to embrace new technologies.

Application of the findings is peculiar to the region, this may limit the transferability of the results and recommendations given. Further research using qualitative and quantitative approaches could complement this work. From the perspective of institutional theory, assessment of institutionalisation of information and communication technologies in West Midlands was carried out. The existing initiatives towards construction practitioners and the SMEs are important for industry development. The normative and cultural cognitive pressures are rendered weak in the region as emerging ICT is viewed as extraordinary rather than standard industrial practice. The impact of non-regulative pressures in the region needs to be strengthened for progressive adoption that will lead to eventual institutionalisation.

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POTENTIALITY OF EMERGING TECHNOLOGIES TO MINIMISE LATE-PAYMENTS QUANDARY IN CONSTRUCTION

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Globally, late payments to contractors remain a persistent issue in the construction industry. Recent studies in UK reveal substantial rise of 27% cases of late-payments; with over £30 billion of unpaid invoices to construction contractors. Yet, there is little empirical study concerning the role of emerging digital technologies such as Agresso Unit 4, 5D-BIM and Automated Payment Systems (APS) in alleviating chronic late-payment quandary in the construction industry. What are the potentiality (likely quality that can be developed) via use of emerging technologies to minimise late-payment in the construction industry? The study adopts a sequential explanatory type of mixed methods design strategies; in addition to use of five case studies to investigate potentiality of emerging technologies in minimising late-payments. Representative population sample that includes digital technology experts and construction professionals in the UK participated in the study; for better understanding of the research problem. The findings show that implementation of emerging technologies at the right level has potential to significantly minimise late payments menace in the construction industry. In specific terms, emerging technologies have potentials to leverage deep rooted administrative payment glitches, cultural and technical problems associated late-payment problems in construction. Other findings are presented in the conclusion section of the study. The study is part of on-going PhD study that seek to develop of a smart valuation and cash flow systems that will help minimise late-payment predicaments to construction contractors.

Keywords: emerging technologies, late-payments, construction industry

INTRODUCTION

Globally, the issue of late-payment to construction contractors remain a reoccurring problem. In the UK, dilemma of late-payment seems to have defied various contractual, government and private initiatives designed to curb the menace. Stallons (2017) claim that “late-payment is a huge and debilitating problem for most businesses in the UK”. The Euler (2015) report assert that there has been substantial increase from 18% to 27% in number of late-payment cases in the UK construction industry; with over £30 billion of unpaid invoices to Small and Medium Enterprises (SMEs) contractors. Certainly, late-payment predicament is not peculiar to SMEs alone; major contractors in the industry also experience similar problems. Construction Excellence (2016) confirm that on average large construction companies

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spends 130 hours per year; with approximated cost of £1,500 per business chasing late-payment. Indeed, the issue of late-payment in construction is truly a deep-rooted problem; that requires holistic approach including government interventions; clients/contractors' charters, legislative initiatives, awareness of stakeholders, et cetera. Desjardins-Proulx *et al.*, (2017) assert that there is no gainsaying that emerging digital technologies such as Agresso Unit 4, 5D-Building Information Modelling (BIM), Automated Payment Systems (APS), Smart contracts and Artificial Intelligence (AI) systems are moulding business landscape, dramatically reduces delinquencies, enhances reliability and changes pattern of work.

Yet, there is little empirical study concerning how these modern technologies can be used to alleviate chronic late-payment problem in the construction industry. Therefore, the study seeks to investigate potentiality (i.e. likely quality that can be developed) via the use of emerging technologies in minimising late-payment quandary in construction.

LITERATURE SURVEY

Emerging Technologies and Their Leverage on Construction

A report from the Department for Digital, Culture, Media and Sport entitled "A Digital Strategy for a Digital Economy" (DDCM&S (2017) claims that use of emerging technologies especially smart systems has potentials to boost business transparency, create platforms for better connectivity to businesses; save time, money, dramatically reduces delinquencies, enhances reliability and changing work practices that are unproductive. However, there is little literature concerning the role of emerging technologies in minimising late-payment to construction contractors. Thus, there is need for thorough understanding of literature, theories, and dynamics about likely quality that can be developed via use of emerging technologies (such as 5D-BIM, Automated Payment Systems (APS), Smart contracts, Agresso Unit 4, and Artificial Intelligence) in minimising late-payment quandary in construction.

For example, BIM level 1 to 3 have grew to become useful tool in solving problems in the construction industry. The Associated General Contractors of America (AGCA, 2006) define BIM as "a data-rich, object-oriented, intelligent and parametric digital representation of a facility" that enables users to extract comprehensive and accurate information that can be used to improve processes and making decision on a facility throughout its lifecycle. Yet, development of 5D-BIM is even a "data-rich" objects that support the function of cost modelling; assemblies of cost components; added either by incorporating cost data in the model itself or "live-linking" to estimating software tools (Boon and Prigg 2012).

Kamardeen (2010) and Forgues *et al.*, (2012) affirm that the benefits of 5D BIM includes value engineering, cost certainty, effective design, time savings in take-off of quantities, estimation; transparency and increased control and predictability to project stakeholders. Moreover, efficacy of 5D is predicated on dynamic link to information model that forms a foundation of living cost plan (Mitchell, 2012). Foundation living cost referred to by Mitchell (2012) is an updated estimation model that changes simultaneously with finance, funding, budget variances, cost forecasting, investment decisions as well as negotiations with contractors. Besides that, 5D BIM information model allows extraction and modification of cost information on BIM framework by creating relationship between elements, specifications and properties of individual

elements and objects that generate cost related data for a project (Eastman *et al.*, 2011).

Moreover, other contemporary digital technologies have been proven to have great leverage over construction process. Barber (2012) posit that digital devices such Automated Payment Systems (APS), Smart contracts and Agresso Unit 4 provide opportunity for instant and timely payments practices that are accurate, efficiency and easily interrogated within project base organisation. These devices have dynamic link on modelled information that allows for easy recompilation of quantities that enhance progress payment calculations visible to supply chain.

Mitchell (2012) is of the view that these technologies are likely to minimise dependence on cost consultant or quantity surveyors concerning valuation of works at project level together with associated administration costs. However, numerous factors such as lack of investment, cultural resistance, setup costs, lack of government interventions and professional capabilities are likely to hinder smooth implementation of these technologies. Regardless, of acclaimed benefits of emerging technologies on construction; their influence on minimising late-payment remain unsubstantiated.

Overview of Late-Payment in the Construction Industry

The phrase “late payment” or “delay payment” are often used interchangeably to mean payment not received at as when due. Ramachandra and Rotimi (2015) expound that the phrases are often used to denote the same thing. However, UK government report titled “Late Payment and Grossly Unfair Terms and Practices” consistently used the word “late-payment” to illustrate a contract situation where a party fails to reciprocate payment to another party upon satisfactory completion of assignment based on pre-agree contract payment terms. Harris and McCaffer (2003) define late payment as failure of paymaster to pay within the period of honouring of certificates as provided in the contract. Late payments normally occur when there is delay between the duration and the agreed stipulated time frame for receiving payments.

Failure to pay complete invoice on time has many negative effects on construction; particularly contractors’ financial ability to execute projects, negative cash flow and profitability problems (Jiang, 2014). Salder (2015) asserts that more than one-third of main contractors are paid more than 60 days after issuing invoices. Recent survey conducted by Federation of Small Business (FSB, 2016) claim that on average 15% of SMEs contractors’ turnover are tied up due to late payments bottleneck.

Judi and Rashid (2010) acknowledged that late-payment to construction contractor is a universal problem caused by host of factors. Ye and Rahman (2010) argued that clients’ inability to rise sufficient funds, poor administrative acumen on the part of contractors, contractual misunderstanding and system failures are major causes of late-payment in the construction industry. Besides, Rotimi *et al.*, (2010); Pettigrew (2005); Abdul-Rahman (2009) and Abdul Rahman *et al.*, (2010) all argued that typical construction payment syndrome that encourages “execution of work by contractors and get paid later” is the main reason for deep-rooted deferred payment problem in the industry. Other authors such as Ansah (2011); Ramachandra (2013) and Danuri *et al.*, (2006) argued that poor financial management, inadequate funds and the use of “pay-when-paid” tactics by major contractors all contributes to chronic late payments dilemma in the industry. Hindsight of corrupt activities often associated with the industry is also a likely factor (Arewa and Farrell, 2016). The Australian Procurement and Construction Council (1996); Pettigrew (2005) and Ramachandra and Rotimi (2011) are of the view that existence of multi-tiered hierarchical structure, together

with cascade payment obligations makes the industry susceptible to unavoidable late-payment dilemma.

In essence, prevailing payment mechanisms in construction, long supply chain, delays in approval of works, errors in submitting claims/valuations for work done, client failure to implement good governance in business, administrative errors, contractors delaying submission of claims/invoices, inadequate supporting documents, cascade payment obligations, multi-tiered hierarchical structure of contractual framework; paymaster withholding of payments, client poor financial management, insufficient financial resources and disputes over payment claims all contribute to lingering late-payment problems (Judi, 2010; Pettigrew, 2005; Ramachandra and Rotimi, 2011).

Government and Private Initiatives to Curb Late-Payment in Construction

The UK government acknowledged the problem of late payment in construction; and reactively put forward various legislations and contractual measures to curb the menace. For example, the Housing Grants Construction and Regeneration Act (HGCRA 1996) made clear payment provisions for any construction contracts. The Act stipulate 28 days payment timeline to contractors; with total delay period of 45 days afterwards interest on delayed payment will apply. In addition, the Local Democracy, Economic Development and Construction Act (2009) is believed to have stringent penalties concerning delay payment to contractors. The Scheme of Construction Contract Act 1998, the Late Payment of Commercial Debts Regulation (2013) and the Construction Supply Chain Payment Charter are all initiatives employed by government to checkmate chronic late-payment matter in construction.

Arguably, the issue of late-payment in construction appears to defy various contractual and private initiatives. For example, various Standard Forms of Contract such as the Joint Contract Tribunal (JCT 2016), New Engineering Contract NEC 4, the International Federation of Consulting (FIDIC), etc. all have standard payment guidelines. The Construction Leadership Council (CLC) payment charter backed by the UK government in 2014; is an initiative of major contractors, SMEs and other private clients. The Council agreed to pay all contractors under its umbrella within 30 days. However, these Acts, charters and initiatives though designed to provide security of payment to contractors seem to be ineffective for various reasons. Perhaps, due to factors such as client care consideration, administrative lapses, lack of political will and varying economic situation of clients.

Recent study reveals that over 62% of late-payment issues in construction relates to technical, managerial and contractual issues (FSB, 2017). The Department for Digital, Culture, Media and Sport's 'Digital Strategy for a Digital Economy' stresses that emerging technologies have potential to minimise profound industry problems, cultural practices, human and legislative factors that are difficulty to resolve by mere human tendencies (DDCM&S 2017). But, it is myopic to assume that emerging technologies alone, will solve persistent late-payment delinquent considering the scale and other cultural issues that exist in construction.

RESEARCH APPROACH

The study methodology is hinged on pragmatic paradigm; because the research focuses on practicality i.e. potentiality of emerging technologies to minimise late-payment quandary in the UK construction industry. The choice of pragmatic research paradigm is predicated upon the fact that it provides an underlying philosophical framework for mixed-methods research (Teddlie, and Tashakkori, 2003).

The multi-methods research design used QUAL-QUAN concept (Creswell, 2003); meaning that qualitative method is the lead data collection instrument, while quantitative data are used to support and validate the qualitative findings. The study used sequential explanatory type of mixed methods design strategies; for better description of the research theme; as illustrated in interview and discussion sections. Research ethics approval was sought from Coventry University Research Ethics Committee and it was granted, see attached ethics certificate attached as appendix A. The study research method design considered data collection techniques, location of the study and data analysis as illustrated in the succeeding sections.

Study Location, Population Sample and Data Collection Technique

Data collected relates to potentiality of emerging technologies to minimise late-payment to contractors in the construction industry. The study quantitative and qualitative data targeted a population sample that comprises seasoned digital technology experts and construction professionals such as Architects, Construction Managers, Clients, and Quantity Surveyors. The study data were collected in various locations in England.

The study data collection and analysis are divided into three stages. Phase 1: questionnaires data to ascertain contemporary factors that influences late-payment to contractors. Phase 2: interviews data designed to tease out potentiality of emerging technologies to minimise late-payment and Phase3: used of archive data to ascertain likely quality of emerging technologies in alleviating problem of late-payment.

Phase 1: entailed design of questionnaire, data collection, and analysis using SPSS. Factors that influences late-payment to contractors identified in the study literature were used to design the questionnaire to ascertain contemporary factors that influences late-payment to contractors. These factors were then ranked using Relative Importance Index (RII) as illustrated in Table 1 below. See discussion section for findings concerning table 1.

Table 1: Relative Importance Index (RII) of Factors that Influences Late-payment to Contractors

Ranking of factors that influences late-payment to contractors	RII	RANK
Delay to approving work done	0.705	1
Insufficient financial resources	0.698	2
Inadequate supporting documents	0.677	3
Contractors delaying submission of claims /invoices	0.621	4
Client failure to implement good governance in business	0.547	5
Disputes over payment claims and responses	0.464	6
Administrative errors	0.422	7
Cascade payment obligations	0.402	8
Errors in submitting claims and valuation for work done	0.391	9
Paymaster withholding of payments	0.365	10
Multi-tiered hierarchical structure of contractual framework	0.344	11
Other factors	0.321	12

Phase II: Interview Data

History of Qualitative Research Reveals Endless Theoretical Arguments about Validity and Credibility; Often Referred to As “Truth and Integrity of Qualitative Research” (Kvale 1996; Gaskell and Bauer, 2000). to Avoid Philosophical Arguments about Validity of Qualitative Research; the Authors Accepted Standpoint of Kuzmanić (2009) Who Asserted That “There is a Pure ‘Form of Truth’ Somewhere Out There, Which Can Be Discovered Through (Construct, External and Internal Validity) Use of Appropriate and Valid Research Methods. Credibility and Validity of the Study Were Upheld in Three Fundamental Areas Namely: Production (Design of Interview Questions, Interview Process and Recording of the Data), Presentation (Replicability, Valid Inference and Arrangement of the Data) and Interpretation (Meaningful Discussion of Data). the Interview Data Were Analysed Using Content Analysis for Easy Inferences to Antecedents of Interviewees’ Discussions; Concerning the Study Subject Matter. for Example, Interviewees Were Asked to Evaluate and Express Their Views Concerning Potentiality of Emerging Technologies in Minimising Late-Payment to Contractors in the UK Construction Industry. Textual Contents of the Interview Data Were Transcribed into Manuscript, Inputted into Nvivo 10 Software; and Coded Using Key Study Themes. Subsequently, the Key Themes Were Trimmed for Better Understanding and Spontaneity of the Interaction Between Study Participants and the Researchers. Some Textual Excerpts Are Expressed Verbatim; As Illustrated Below for Better Understanding of Interviewees’ Thoughts.

...Late Payment to Contractors Remains Emotive Issue, Uncertainties Exist Within Payment Terms Stipulated in Contracts ... It is Doubtful Whether Technologies Can Be Used to Leverage Deep Rooted Human Attitudes about Late-Payments (Contractor - Birmingham UK)

... At this Point in the History of Construction ... Digital Technologies Have Potentials to Interpolate Contract, Cost, and Payment Data ... Their Latent Qualities Will Certainly Reduce Administrative, Human and Technical Errors That Influences Late Payments (Software Design Engineers - London).

However, When Participants Were Probed Further on Potentiality of Specific Emerging Technologies Such As BIM and Digitalisation of Payment Processes to Alleviate Chronic Late-Payment to Contractors; Their Answers Were Wide-Ranging. Some Participants’ Responses Are Presented Thus:

...Currently Design Features in BIM Do Not Tackle Late-Payment Peril; ...But Its Digital Potential Can Be Reconfigured to Ease Out Technical and Contractual Errors Associated with Payment Processed Such As Delay and Valuation Errors (BIM Coordinator, London UK).

...Certainly, Digital Technologies Such As Agresso Unit 4 Version 5.6 and Automated Payment Systems (APS) ... Have Potentials to Enhances Payment Practices and Minimise Scepticism Surrounding Administrative Errors, Delay in Approving Work Done and Other Human/Cultural Risks Linked to Late-Payment ... Unfortunately Only Few Businesses Have Invested in Such Technologies (Project Manager, Norway)

Phase III: Archive Data

Table 2 Illustrates Summary of Average Time-Line Between Manual and Use of Digital Payments Systems in Various Construction Companies. the Captured Data Consist of Five Case Studies in the UK Construction Industry; Scrutinised to Ascertain Payment Time-Frame Between Manual and Automated Payment Systems.

FINDINGS

The study quantitative inquiry summarised in table 1 above show that “Delay to approving work done”; “insufficient financial resources”, “inadequate supporting documents” and “contractors delaying submission of invoices” ranked 0.705, 0.698, 0.677 and 0.621 respectively in RII test. The ranking in table 1 illustrates important index factors that influences late payment in the construction industry. The study qualitative inquiry suggest clearly that digital technologies have potentials to interpolate contract, cost, and payment data; with latent qualities to reduce bureaucratic and technical errors that are hallmark of late payments. Table 2 findings demonstrate that automated payment systems provide adherence to stipulated contract payment time-frame.

Table 2: Summary of average time-frame between manual and automated payment systems

Nature contractors; clients; Value of project and country	Payment process technique	Contract Stipulated time- line for payment (in days) from the day of receiving invoice	Average number of days professed by contractors to receive payment from clients
1. Nature of project: roof work; Contractor: SMEs. Project value £32,345; Client: Large construction company. Turnover: over £121M. Country: UK	Traditional value and manual invoice system	28 days	32 days
2. Nature of project: Refurbishment and construction of new classroom; Project value: £3.7M. Contractor: Large construction company; Client: Local Government Council. Country: UK	Traditional value and manual invoice system	28 days	41 - 45 days
3. Nature of project: painting and road marking; Contractor: SME Project value: £11,504; Client: Large Local Government Council Country: UK	Traditional value and manual invoice system	28 days	28 - 45 days
4. Nature of project: construction of water channel. Contractor: Local SME; Project value: £92,870; Client: Local Airport Authority. Country: UK	Automated systems	28 days	26 - 28 days
5. Nature of project: Framework agreement for plumbing work. Contractor: M&E SME contractor. Project value: varies depending on number of call-out. Client: Utility company with average annual turnover above £607M. Country: UK	Automated systems	14 days	14 days

DISCUSSIONS

A common deduction from the three set of data analysed reveal that late-payment to contractor’s remains a deep-rooted problem within the UK construction industry. The study quantitative findings summarised in table 1 identified host of factors that influences late-payment to contractors; with “delay to approving work done” ranked most common factors. Thorough examination of these factors suggests combination of both administrative and technical failure. Indeed, emerging technologies places significant role in dynamic interoperability and modelling of information that allows for easy recompilation of quantities that enhance calculation of progress payment and

transparency. Moreover, analysis of archive data in table 2; show that organisations that uses emerging technologies or automated payment systems are more likely to adhere to contract payment stipulated time-frame compared to traditional valuation payment system. Most interviewees consent that emerging technologies have potentials to minimise late payment. An interviewee particularly mentioned that "... certainly, digital technologies such as Agresso Unit 4, BIM level 4 and Automated Payment Systems (APS) if adopted properly have potentials to enhances payment practices and minimise scepticism surrounding administrative errors, delay in approving work done and other human/cultural risks linked to late-payment. However, some study participants appear to exhibit element of doubt on whether emerging technologies can be used to leverage deep rooted human attitudes and contractual culture that exist in the construction industry.

CONCLUSION

The aim of the study is to identify potentiality of emerging technologies in minimising late-payment dilemma in the UK construction industry. The study literature suggest that late-payment remains a serious problem to both large and SMEs contractors. Key deduction from the study show that emerging technologies such as Automated Payment Systems (APS), Smart contracts and Agresso Unit 4 have potentials via interoperability of contract, cost, processing of work done and invoice data for timely payments practices that are accurate and efficiency. Moreover, emerging technologies have potentials for in-depth scrutiny and interrogation of checkered history of late payment that is commonplace in the construction industry. However, there are number of drawback that may hinder businesses from using these emerging technologies; such as lack of willingness to invest, scepticism about return on investment and huge initial costs involved in the procurement and installation of these technologies.

Besides, there are insinuations that practitioners in the construction industry are not yearning or doing enough to promote the use of emerging technologies. The construction industry is generally deemed to be slow in adopting new technologies compared to other industries. But there is need to harness interoperability potentials of emerging technologies to reduce administrative, human and technical errors that influences late payments. From professional standpoint, emerging technologies have latent qualities to minimise dependence on cost consultant or quantity surveyors concerning valuation of works at project level together with associated administrative costs. Many, experts are of the view that advancement in smart contracts and Artificial Intelligence (AI) systems if syntactically interpolated into BIM framework have potentials to expedite payment process and offer greater transparency to all supply chain.

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AN ALTERNATIVE PROJECT-BASED LEARNING MODEL FOR BUILDING INFORMATION MODELLING-USING TEAMS

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Adopting Building Information Modelling (BIM) is a radical challenge for Small and Medium-sized construction enterprises (construction SMEs). Inadequate individual BIM competencies in BIM-using teams are among key challenges, while Project-Based Learning (PBL) could form a potential solution. An alternative PBL model that conceptualises relations between knowledge practices exercised and project influencing attributes is presented to be used further in improving BIM learning mechanisms of teams. It contains three dimensions which are: 1) project knowledge stocks; 2) project knowledge practices; and 3) project influencing attributes. A Systematic Literature Review (SLR) is performed to qualitatively synthesise attributes found from relevant literature from management and construction innovation. The model serves as a framework for future studies and investigations on how project knowledge practices and their influencing attributes in projects can assist BIM learning in construction SMEs and BIM-using teams.

Keywords: BIM, innovation, Project-Based Learning (PBL), project knowledge

INTRODUCTION

Adopting Building Information Modelling (BIM) is a radical challenge for Small and Medium-sized construction Enterprises (construction SMEs) (Dainty *et al.*, 2017; Tulenheimo, 2015). BIM changes existing paradigms of construction by politically, technologically, and procedurally (Migilinskas *et al.*, 2013; Puolitaival and Forsythe, 2016) incorporates geometrical and functional properties of facilities for stakeholders throughout the building lifecycle (Ding *et al.*, 2014; Miettinen and Paavola, 2014). Inadequate individual BIM competencies in BIM-using teams is the major issue (Dainty *et al.*, 2017; Succar and Sher, 2014), while Project-Based Learning (PBL) is a potential solution (Bartsch *et al.*, 2013; Hartmann and Dorée, 2015).

PBL values project-based knowledge and focuses on learning to improve organisational performance and innovation adoption (Ashok *et al.*, 2016; Gopalakrishnan *et al.*, 1999; Hartmann and Dorée, 2015). It answers to the temporal nature of construction (Bakker *et al.*, 2011; Davis *et al.*, 2016), where innovations are constantly co-developed among team members (Aouad *et al.*, 2010; Lloyd-Walker *et al.*, 2014). PBL features the sender/receiver and social learning approaches (Bresnen *et al.*, 2003; Hartmann and Dorée, 2015). The former directs on knowledge practices

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and attributes affecting individual learning. The latter examines influencing attributes of project context to learning. Additionally, relations between knowledge practices used in teams and influencing attributes of projects can be studied to understand BIM learning mechanisms in teams and advance individual BIM learning. The integration of both approaches in literature of PBL is scarce.

The paper presents an alternative PBL model that conceptualises knowledge practices in projects and influencing attributes of projects for future studies and practical implementation. A Systematic Literature Review (SLR) is conducted to synthesise attributes found. The structure of the paper is as follows. The background section discusses PBL and BIM theories. PBL models and frameworks section investigates background of related literature. Next, the research approach section clarifies the methodology. Then, an alternative PBL framework is proposed. Ensuring sections analyse the framework against literature and conclude this study.

BIM Adoption and Project-Based Learning

Building Information Modelling (BIM) Innovation Adoption

BIM is the common construction innovation (Bryde *et al.*, 2013; Succar and Sher, 2014), the solution to fragmentation in construction (Chen *et al.*, 2017; Ghaffarianhoseini *et al.*, 2017; Puolitaival and Forsythe, 2016). It emerges from the current geometric oriented Computer Aided Design (CAD) program (Ghaffarianhoseini *et al.*, 2017). BIM politically, technologically, and procedurally integrates facility-related geometries and functional properties for project actors throughout the building lifecycle (Miettinen and Paavola, 2014; Puolitaival and Forsythe, 2016). Adopting BIM is a systematic innovation for organisations (Murguia *et al.*, 2017; Papadonikolaki, 2017), however, it is a radical process innovation for construction SMEs (Dainty *et al.*, 2017; Tulenheimo, 2015) as they contain insufficient resources of expertise and skills compared to large firms. Adopting BIM will revolutionarily replace existing working paradigms. This complication is referred to as inadequate individual BIM competencies (Succar and Sher, 2014). Gained through BIM learning, individual BIM competencies are personal capacities to perform or deliver BIM-related activities and outcomes (Succar and Sher, 2014). Foci to advance this have been shifted to KBV of firms and PBL as valuable knowledge in parts of a firm is unequally dispersed (Prencipe and Tell, 2001; Szulanski, 2000) and learning is highly intensive in projects (Egbu, 2004; Hartmann and Dorée, 2015).

Knowledge-Based View (KBV) of Firms

KBV of firms perceives knowledge as a strategic resource (Nonaka and von Krogh, 2009). Knowledge is defined as individual capabilities acquired through dynamic human processes of justifying personal perceptions towards truth (Nonaka, 1994; Prencipe and Tell, 2001). Nonaka (1994) distinguished knowledge into explicit and tacit. Explicit knowledge can be accessed through consciousness, codified, and externalised, while tacit knowledge is intuitive, un-codifiable, and personal (Nonaka, 1994; Seidler de Alwis and Hartmann, 2008). For knowledge-intensive and project-based organisations such as constructions (Egbu, 2004; Prencipe and Tell, 2001), learning from projects is crucial to innovation adoption (Aouad *et al.*, 2010).

Project-Based Learning (PBL)

PBL highlights the management of project-based knowledge to maximise individual learning (Hartmann and Dorée, 2015; Prencipe and Tell, 2001; Yun *et al.*, 2011). Constructions are organised around projects (Gann and Salter, 2000; Tatum, 1987), an innovative environment where specialists constantly explore and learn (Aouad *et al.*,

2010; Bartsch *et al.*, 2013; Davis *et al.*, 2016). Lindner and Wald (2011) classified project-based knowledge into: 1) project knowledge that denotes an overview of an organisational landscape; 2) intra-project knowledge within a project; 3) knowledge between upstream and downstream projects; 4) knowledge between parallel projects; and 5) knowledge between projects and their parent organisations. Zhao *et al.*, (2015) added 6) knowledge between two projects with different completion time.

Individual learning occurs when routines are recreated and maintained in new settings (Hartmann and Dorée, 2015). Learning in projects is categorised into the sender/receiver and social learning approaches (Bresnen *et al.*, 2003). The former expresses learning from processes of storing, retrieving, and transferring explicit knowledge that can be reverted to transmission channels such as electronics and document-based repositories (Bresnen *et al.*, 2003; Hartmann and Dorée, 2015). Referred as the 'cognitive approach', it is suitable for product innovation, where learning is based on codifiable knowledge (Bresnen *et al.*, 2003). The latter focuses more on tacit knowledge transfer and prioritises attributes promoting a fertile environment, a context that facilitate learning (Szulanski, 2000) and innovation from collaboration mechanism in teams (Bresnen *et al.*, 2003; Hartmann and Dorée, 2015). Described as the 'community approach', it is advisable for process innovation as knowledge learned is mostly un-codifiable (Bresnen *et al.*, 2005).

Project-Based Learning Models and Frameworks

PBL models and frameworks can be classified into the sender/receiver and social learning approaches (Bresnen *et al.*, 2003). Within the sender/receiver approach, Prencipe and Tell (2001) suggested a learning landscape framework in analysing learning abilities of project-based firms. Prencipe and Tell (2001) argued for attentions upon processes of learning and the articulation of codifiable knowledge. Szulanski (2000) presented a process model of knowledge transfer between individuals and highlighted transfer barriers on each process. Built on Szulanski (2000), Tan *et al.*, (2006) introduced a model in live-capturing and sharing of explicit knowledge among project members. Tan *et al.*, (2006) stressed workflows and knowledge practices as major attributes to individual learning of codifiable knowledge. Knowledge practices were mentioned in Reich *et al.*, (2012) to help generate desired business outcomes when aligned with knowledge stocks and enabling environment dimensions. Duffield and Whitty (2015) accentuated this by proposing the Systematic lessons learned knowledge (Syllk) model, encouraging the alignment of organisational elements such as people, practices, culture, and so forth.

For the social learning approach, Bresnen *et al.*, (2005) proposed a framework of structural, relational, and cognitive dimensions of social capital in PBL. Chen and Huang (2007) argued for less formalisation, more decentralisation, and high individual integration structure and climate. Bakker *et al.*, (2011) presented temporal dimension instead of the structural dimension, stressing influences the temporal nature of constructions have to learning. Bakker *et al.*, (2011) also highlighted absorptive capacities and motivations of individuals as major contributors to project learning. Respectively to the cognitive, relational, and temporal dimensions, Lindner and Wald (2011) posed three supporting attributes of culture and leadership, organisation and process, and technological system. Bartsch *et al.*, (2013) investigated the relational dimension further and suggested advocating attributes of social ties and shared system of meanings among colleagues. Additionally, Hartmann and Dorée (2015) linked individual learning to social and organisational context in which projects are formed.

Zhao *et al.*, (2015) re-classified project influential attributes into transfer capabilities, relationships, context, and task context of project teams.

RESEARCH APPROACH

The theoretical body of the sender/receiver approach explores upon processes and knowledge practices in learning codifiable knowledge in projects. The knowledge body of the social learning approach accentuates learning of un-codifiable knowledge and influencing attributes of a fertile project. Additionally, relations between knowledge practices and influencing attributes of a fertile project can be challenged to advance individual BIM learning. Their affiliations in BIM-using teams can be formulated to understand BIM learning mechanisms in teams to advance individual BIM learning. The paper addresses the research question of "how can relations between project knowledge in practices and their influencing attributes be conceptualised to advance individual BIM learning in teams?"

This research exercises a constructivist ontology and an interpretive epistemology of PBL and BIM adoption in construction SMEs. It suggests that the integration of both theoretical bodies potentially yield a new perspective to the practical problem of BIM adoption in construction SMEs and therefore needs to be interpreted or formulated. The research proposes a model that conceptualises knowledge practices used by project members and influencing attributes to a fertile project. The model advances from the SLR of PBL, project knowledge transfer, and construction innovation adoption. SLR is known to be efficient for identifying and evaluating extensive literature (Crossan and Apaydin, 2010; Tranfield *et al.*, 2003). This paper starts by determining relevant keywords to the research question. Searches are made through academic sources such as the International Journal of Project Management, Journal of Knowledge Management, Journal of Management Studies, Construction Innovation Journal, Automation in Construction Journal, Building Research and Information Journal, and Proceedings of ARCOM (Association of Researchers in Construction Management) Annual Conferences. Qualitatively, insights from the secondary data are synthesised and built upon one another through an inductive approach.

An Alternative Project-Based Learning Model

This alternative PBL model incorporates several insights from the SLR and includes three dimensions which are: 1) project knowledge stocks; 2) project knowledge practices; and 3) project influencing attributes.

Project knowledge stocks

Similar to Reich *et al.*, (2012), project knowledge stocks represent individuals with cognitive capacities and potentials to increase such knowledge. The project knowledge stocks sort individuals into a sender and a receiver. Referring to Lindner and Wald (2011) and Zhao *et al.*, (2015), the sender and receiver can be two different individuals within a project, between upstream and downstream projects among parallel projects, and between two projects within different completion time. The receiver can also be the sender, learning from previous projects.

Project knowledge practices

Project knowledge practices are activities exercised to learn (Reich *et al.*, 2012). They act as mechanisms to translate, transfer, and share knowledge from one entity to another (Liyanage *et al.*, 2009). Attributing practices from the SLR are classified into: 1) codifiable approach; 2) un-codifiable approach; and 3) mixed approach in Table 1 as follows.

Table 1: Approaches of project knowledge practices and their attributing practices.

Approaches	Attributing practices	Cited references
Codifiable approach (concerns explicit knowledge)	External knowledge sources	Tan <i>et al.</i> , (2006)
	Project documentations	Hartmann and Dorée (2015)
	Research and development	Tan <i>et al.</i> , (2006)
	Standardised operations and manuals	Tan <i>et al.</i> , (2006)
	Shared knowledge repositories	Egbu (2004) and Tan <i>et al.</i> , (2006)
Un-codifiable approach (concerns tacit knowledge)	Creation of a knowledge team	Egbu (2004) and Tan <i>et al.</i> , (2006)
	Incentive schemes	Duffield and Whitty (2015) and Egbu (2004)
	Informal meetings	Duffield and Whitty (2015) and Tan <i>et al.</i> , (2006)
	Mentoring	Duffield and Whitty (2015) and Egbu (2004)
	Partnership	Tan <i>et al.</i> , (2006)
Mixed approach (concerns both explicit and tacit knowledge)	Recruitment and reassignment of project members	Tan <i>et al.</i> , (2006)
	Assignment of knowledge management personnel	Duffield and Whitty (2015)
	Post project reviews	Hartmann and Dorée (2015) and Tan <i>et al.</i> , (2006)
	Professional networks	Egbu (2004) and Tan <i>et al.</i> , (2006)
	Promotion of knowledge sharing culture	Duffield and Whitty (2015)
	Trainings and workshops	Tan <i>et al.</i> , (2006)

Project influencing attributes

Project influencing attributes incorporate both technological and social aspects of PBL. They can be enabling and hindering attributes to a fertile project, based on perceptions of teams. Project influencing attributes facilitate project knowledge practices and form a unique learning mechanism in teams. Attributes found are classified into topics, then categorised into different themes which are: 1) qualities of a sender; 2) qualities of a receiver; 3) project team relationships; 4) project team context; and 5) project operational context presented in Table 2.

Table 2: Themes and topics of project influencing attributes and their supporting attributes

Themes	Topics	Supporting attributes
Qualities of a sender	Transferring capacities	Existing abilities of an individual to realise values and purposes of knowledge, as well as take opportunities to accurately document and store such knowledge (Bresnen <i>et al.</i> , 2003; Hartmann and Dorée, 2015; Tan <i>et al.</i> , 2006)
	Willingness to share	Resources such as time in capturing knowledge (Hartmann and Dorée, 2015), workloads of the sender, and legal issues associated to knowledge captured (Tan <i>et al.</i> , 2006).

Qualities of a receiver	Absorptive capacities	Abilities to identify the value of new knowledge, assimilate it with existing knowledge, and apply it to commercial ends (Bakker <i>et al.</i> , 2011; Bartsch <i>et al.</i> , 2013; Bresnen <i>et al.</i> , 2003; Lloyd-Walker <i>et al.</i> , 2014).
	Knowledge quality	Usefulness (Hartmann and Dorée, 2015), expiration, and fragmentation of captured knowledge (Zhao <i>et al.</i> , 2015).
	Motivation to absorb	Resources such as time in learning (Hartmann and Dorée, 2015), workloads of the sender, and legal issues associated to knowledge captured (Tan <i>et al.</i> , 2006).
Project team relationships	Cognitive aspects	Shared representations, interpretation, and system of meanings among team members (Bakker <i>et al.</i> , 2011; Bartsch <i>et al.</i> , 2013; Bresnen <i>et al.</i> , 2005).
	Relational aspects	Network ties with current and former project team members based on trust, cooperation, and communication (Bakker <i>et al.</i> , 2011; Bartsch <i>et al.</i> , 2013; Chen and Huang, 2007)
	Temporal aspects	Disruptive experience and connection of team members from previous projects (Bakker <i>et al.</i> , 2011; Bresnen <i>et al.</i> , 2005).
Project team context	Project climate	Senior management support, knowledge sharing culture, and no-blame culture where social barriers in learning are blurred (Duffield and Whitty, 2015; Lloyd-Walker <i>et al.</i> , 2014) and learning in projects is structured (Duffield and Whitty, 2015; Egbu, 2004; Lindner and Wald, 2011).
	Project resources	Costs and investment made by a project to capture and transfer knowledge, and modify existing business processes (Lloyd-Walker <i>et al.</i> , 2014; Tan <i>et al.</i> , 2006).
	Project structure	Formalisation, centralisation, integration, and stratification of a project (Chen and Huang, 2007; Egbu, 2004) and clearly defined roles and responsibilities (Bresnen <i>et al.</i> , 2003).
Project operational context	Project similarities	Similarities of projects, tasks, and problems found (Zhao <i>et al.</i> , 2015).
	Time urgencies	Differences in timescale of projects, tasks, and urgencies of problems encountered (Duffield and Whitty, 2015; Zhao <i>et al.</i> , 2015).

The alternative Project-Based Learning (PBL) model

Inductive approach allows attributes found to be developed into a model (Figure 1). The project knowledge practices are means through which the receiver learns from the sender.

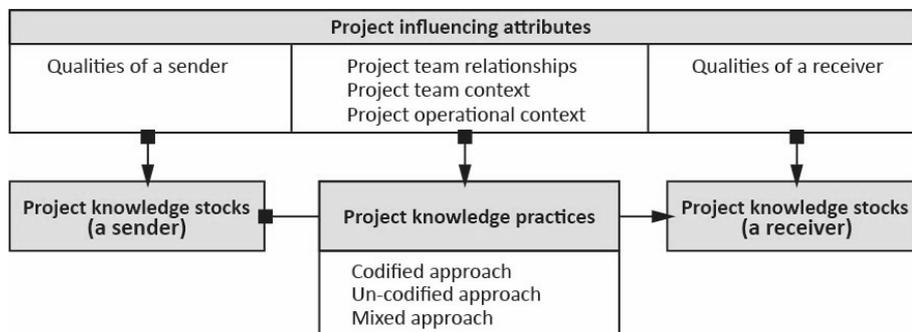


Figure 1: The alternative Project-Based Learning (PBL) model

A project can contain several attributing practices from different approaches of the project knowledge practices. The project team relationships, project team context, and project operational context directly influence the project knowledge practices and

form the learning mechanism of a team. The qualities of senders and receivers respectively affect each project knowledge stocks in learning.

DISCUSSION

The model resonated with theories about knowledge as a strategic resource (Nonaka and von Krogh, 2009), highlighted the importance of individual knowledge and competencies (Nonaka and von Krogh, 2009; Seidler de Alwis and Hartmann, 2008), and addressed relations of knowledge practices and their influencing attributes to individual BIM learning in teams.

The dimensions in the proposed model were developed from knowledge practices, knowledge stocks, and enabling environment dimensions of Reich *et al.*, (2012). The project knowledge stocks were categorised based on different types of project-based knowledge in Lindner and Wald (2011) and Zhao *et al.*, (2015). The codifiable and un-codifiable approaches of the project knowledge practices were based on knowledge types focused in the sender/receiver and social learning approaches (Bresnen *et al.*, 2003; Hartmann and Dorée, 2015), as well as the general classification of knowledge in Nonaka (1994). The mixed approach was proposed based on how some knowledge practices practically include the learning of both types of knowledge. Themes of project influencing attributes were extended from Zhao *et al.*, (2015). The transfer capabilities of individuals from Zhao *et al.*, (2015) were sorted into the qualities of senders and receivers to match the project knowledge stocks dimension. The project team relationships include the temporal, relational, and cognitive aspects from Bakker *et al.*, (2011). This contradicted to Bresnen *et al.*, (2005), who presented the structural aspect together with the relational and cognitive aspects in assessing the social capital of firms. This paper classified the structural aspect with project climate (Chen and Huang, 2007) and project resources (Tan *et al.*, 2006) as they are significant in forming a fertile project team context. The project operational context held affinities to task context of a project in Tan *et al.*, (2006) as it contained task similarities and time urgencies.

Practically, construction SMEs adopting BIM and BIM-using teams can employ this model to reflect, assist, and improve upon existing BIM learning mechanisms and advance individual BIM competencies. It allows construction SMEs and BIM-using teams to select best practices to suit their existing project context or alter their context to fit practices exercised in the firm. It also fosters greater understanding on managerial challenges in construction innovation adoption and offers opportunities to challenge such issue.

Theoretically, with the constructivist ontology and interpretivist epistemology, this model consolidates related literature, question the current theoretical body of PBL, and additionally suggests a new perspective of the under-studied relations between project knowledge practices and project influencing attributes to advance individual BIM learning and BIM adoption in construction SMEs. It combines and builds on current theories of PBL with different rationale from project knowledge transfer and construction innovation adoption literature. Further studies and practical implementations are needed in exploring, refining, and validating the alternative perspective presented and the proposed model, as well as populating with empirical data.

CONCLUSIONS

BIM adoption is a radical innovation for construction SMEs due to the lack of individuals with adequate BIM competencies in BIM-using teams. PBL is suggested as potential solution. This paper challenges current theories of PBL by presenting an alternative PBL model that conceptualises relations between knowledge practices and influencing attributes of projects. The model formulates from attributes synthesised from the SLR of PBL, project knowledge transfer, and construction innovation adoption. It contains three dimensions which are: 1) project knowledge stocks; 2) project knowledge practices; and 3) project influencing attributes. The model allows construction SMEs and BIM-using teams to evaluate and improve their learning mechanisms to advance BIM learning. This paper consolidates existing literature and introduced an alternative approach to PBL to support BIM and innovation adoption in general. Future studies are needed to refine all variables and investigate how project knowledge practices and project influencing attributes can assist BIM adoption in construction SMEs and individual BIM learning in BIM-using teams.

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**RECONCEIVING
MULTIDISCIPLINARY
COLLABORATION FOR
MANAGING DESIGN**

A GESTALT PERSPECTIVE ON CO-CREATION: ACTION RESEARCH IN ARCHITECTURAL PRACTICE

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Co-creation is an emerging trend in construction management research and architectural transdisciplinary practice. With action research in architectural practice, a new perspective on the act of co-creating together in the design process, was explored in the architectural design phase. Co-creation through the lens of gestalt-theory brought other solutions than the traditional design process. Findings illustrate how the Gestalt-approach to co-creation in architectural practice is different in the way that the relational is in focus. Gestalt brought a systemic perspective on forces of resistance of change, which led to the creation of a new digital tool for participatory design. The Gestalt approach was also found to be supportive of bridging fragmented knowledge perspectives into a meaningful whole and integrated design. Further, it challenged the role of the architect and the power distribution when creating. The contribution to practice was twofold: 1) an innovative design solution for urban resilience; 2) the invention of a new digital tool supporting participatory design processes. In conclusion, it was found that by engaging in transdisciplinary research, and thus changing the way we do things, we allow for different ideas and solutions to emerge. However, the paper offers only one in-depth case-study, but still provide design practice and construction management research, with insights on how to co-create in the early 'fuzzy' phase of design.

Keywords: co-creation, action research, gestalt, design practice

INTRODUCTION

Co-creation is an emerging trend in construction management research. However, one could argue that all co-creation is a collaborative practice and the interest in collaborative practices is not new. Construction management research has shown a long interest in understanding the development of collaborative practices (Walker and Jacobsson, 2014) and collaboration is encouraged across multiple disciplines as a prerequisite for sustainability. To achieve sustainability for the built environment, effective co-creation is important in the early phase as environmental sustainability thinking and planning must be incorporated in the project idea before the design is conceptualized (Ding, 2006). However, there are several challenges in order for design-teams to achieve sustainable designs: for example, interorganizational collaboration between specialists with diverse knowledges (Ding, 2006) and interprofessional engagement and communication when combining competences and professionals (Keys *et al.*, 2016). This puts pressure on the early design phase to develop and apply methods for engaging in collaboration, as collaboration and communication of the various spheres of influencers are essential to achieve

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sustainable frameworks in the designs (Shelbourn *et al.*, 2007); as well as new collaborative practices that deal with the fragmentation between disciplines, lack of shared frameworks, and power-struggles (Räisänen *et al.*, 2014).

The early phase: Architectural practice

In architectural practice, collaboration is a deeply embedded work method and the increased demand for sustainability asks for new methods and tools which are now rapidly transforming contemporary architecture practice (Nilsson, 2016). There is an increased emphasis by architects in the early stage, i.e. the fuzzy front end, see figure 1. Considerations of many natures come together in this increasingly critical phase: e.g. understanding of users and contexts of use; and exploration and selection of technological opportunities such as new materials and information technologies, etc. (Stappers, 2006). The multiple perspectives and competences that need to be coordinated and integrated in the early front end puts pressure on new collaborative practices of co-creating an integrated solution.

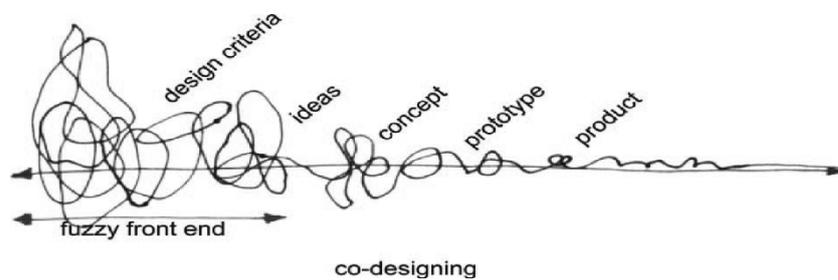


Figure 1. The front end of the design process has been growing as designers move closer to the future users of what they design (Sanders and Stappers, 2008).

The terms co-creation and co-design are often confused and/or treated synonymously with one another (Sanders and Stappers, 2008). In this paper, co-creation is used in the broader sense to refer to the creativity of designers and people not trained in design working together in the design development process, or as described in the Journal of co-design: The practice of collective creativity in the design process. Co-design and participatory design are more commonly used in architecture to describe a collective collaborative practice with a user centred design approach. Some of the key components of participatory- and co-design in architectural research are briefly described in section; Co-creation in architectural practice. 'Design Participation' in architectural practice is however not new. It was introduced as a concept in 1971 (at the Design Research Society conference in England). The need for new design approaches was already emphasized; There is certainly a need for new approaches to design if we are to arrest the escalating problems of the man-made world, and citizen participation in decision making could possibly provide a necessary reorientation. (Conference book edited by Nigel Cross, 11). The application of participatory design practices to very large scale problems has since then been growing and is projected to change design and may change the world (Sanders *et al.*, 2008). Nevertheless, there is also an implicit assumption that co-creation is inherently a good thing. There is, for instance, a growing body of scholarships in e.g. the service marketing literature that suggests that co-creation can also destroy value.

The aim of this study is to explore a new perspective on co-creation in early design phases - the process to collectively create together in the early design phase in architectural practice. What new approach to co-creation, tools and methods, can be applied in the design process? What effect can it have on the design outputs? What values are created that are relevant to practice?

Practice-based research: New perspective on co-creation

The changing shape of practice is not only in regard to new design processes with emphasis on the fuzzy front end. Currently, more research initiatives are embedded in architectural practice around Europe. (Nilsson, 2016; Nordic Built, 2018). Indeed, there are several practice-based-research initiatives for urban transformation and knowledge clusters, for example cross-sector university collaborations, 'Co-creation for sustainability', which is also driving sustainable urban transformations (Trencher *et al.*, 2012). The designer as researcher, or the researcher as facilitator of design processes, has in co-design research been highlighted as of extra importance. Such co-designing should be a close collaboration between all the stakeholders in the design development process together with a variety of professionals having hybrid design/research skills (Sanders *et al.*, 2008).

Although research has been done in architectural practice on BIM and computational design, there are less studies on the multi-disciplinary co-creation process with focus on the activities in the workshops and its correlation to the design output. There are even fewer studies with an action research approach, which is notable considering the increasing number of practice-based research and especially, the demand for new methods, tools and approaches.

Action research (AR) is a collaborative and practice-based approach, aiming at achieving relevant change in practice. Such change, or output, comes from increased and shared awareness of a problem, co-created in the AR-process. The AR process consists of iterations of activities with researcher and practitioners, co-creating knowledge. The activities are lined up in iterations with structured documentation and self-reflection to provide rigour. This research approach is in this way different to traditional research approaches and has shown to give novel results, especially relevant to practice. There is a wide recognition that no single actor or organisation possesses the knowledge, resources or capacity to solve complex, interwoven sustainability problems on their own (Klein *et al.*, 2001; Sehested, 2003). At the core of action research is the co-creation of knowledge in action.

With AR, a new perspective to co-creation was explored in early design. A return to the origins of AR (and organization) - Gestalt management tools and methods were applied to the co-creation of a city innovation project. The findings in this paper are analysed through the lens of Gestalt theory and discussed in relevance to practice. Table 2 shows three essential gestalt features that has been applied in the design process and as theoretical framework: 1) The relational focus, 2) Figure and ground, 3) and the inter-relational field of forces for change and resistance to change within a group (Lewin, 1946).

Co-Creation in Architectural Practice and Gestalt

Architectural practice: Dialogue and user-centric design

New methods and tools are currently emerging and changing the shape of architectural practice (Nilsson, 2016). One such example is how new digital tools, e.g. BIM, simulations and computational design processes, informs design processes (Nordic Built, 2018). Another change is the use of dialogue processes (Ranhagen *et al.*, 2017), where digital tools have been more scarcely used, but are now starting to emerge, e.g. to support dialogue in collaborative workshops (Grosse and Karrbom Gustavsson, 2017). Main features of these emerging practices are that they are collaborative, iterative and process-based and described as a creative and trustful collaboration, often among many stakeholders (Ranhagen *et al.*, 2017).

The term Participatory design incorporates a larger spectrum of participants into the design process, and have different levels of participation (Arnstein, 2007). The DIAD-theory (Innes and Booher, 2010) conditions for a collaborative planning process in a design-driven dialogue. First, a diversity of independent stakeholders must be allowed to participate in planning. Secondly, authentic dialogue characterized by reciprocity, relationships, learning and creativity and a shared understanding, gradually building knowledge through own reflections (i.e. new heuristics), cultivating innovation and innovative thinking.

The focus on dialogue is not entirely new, but steadily growing in Scandinavian architectural practice, especially in terms of sustainability in city planning. Current academic examples are transdisciplinary initiatives such as: SGBC Action Lab; Design Dialogen (Ranhagen *et al.*,) Södertörnsmodellerna (Vinnova), The Royal Seaport development (NDS), Mistra Urban Futures (Chalmers) and several Living Labs. These initiatives have focused on the need to collaborate across multiple disciplines, and often with triple/quadruple helix stakeholders.

The Gestalt Framework: Co-Creating Meaning through Dialogue

The systemic relational focus and 'figure and ground' formation.

As mentioned in the introduction, co-creation of knowledge is at the core of AR. Kurt Lewin, who first used the term AR (1946), was a social-psychologist and Gestalt practitioner. Lewin has much influenced theory on group-dynamics and organizational studies. According to Lewin and Gestalt, a group, i.e. human system, consists of relationships. To understand a human system, a sociogram - map of inter-relationships within the human system, is a powerful tool to understand the group. Further, a practice-based research approach is required where knowledge is generated together with practitioners, in the setting where change should occur.

In Gestalt, this notion of co-creating knowledge goes even further and has an existential approach to humans and co-creation, linking it intimately with dialogue. Martin Buber, the famous Gestalt philosopher describes how we experience our true humanity when we co-create meaning through authentic dialogue with one another (Ich and Du, 1923). Humans constantly create and re-create a meaningful whole (a gestalt or figure) in the interaction with others to organize ourselves in the world. In the 1920-ties, Wertheimer, Köhler and Koffka - the founders of Gestalt psychology, discovered this unconscious process called the 'figure-ground' organization; we visually and psychologically attempt to make order out of chaos and look for meaning based on context and on our background references. We add to disconnected bits of information into a whole, i.e. 'gestalt', to create harmony or structure (Malmgren, 2014). When a gestalt is clear, it serves both as a 'roadmap' for how we can navigate and as a source of energy that motivates further actions (the Gestalt formation or energy-cycle) and so humans collaborate and self-organize beyond management of control and command. This insight, that order can emerge in systems without anyone controlling the parts, is outside the Gestalt community fairly recent. It first became part of established knowledge during the 1980's when chaos theory or complexity theory was developed (Malmgren, 2014). Further, Gestalt theory on visual perception has gained a newly waken interest in neuro-science, design practices such as interactive media design and screen design where Gestalt factors influence the responses of the user.

Field theory rule

Kurt Lewin's field theory rule (1946) helps scholarly practitioners of organisational development and change to 'start the analysis with the situation as a whole'. Using the field theory rule displays the psychological field of forces and counter forces in the social system. Patterns of forces helping or hindering a goal, illustrate points of intervention. Thus, increased awareness of existing forces offer possibilities to counteract repetitive solutions that don't work. In table 1, the Gestalt framework and how it was applied in the design process, is presented.

METHOD

The Action Research Empirical Arena

In the context of understanding and improving the transfer and diffusion of academic knowledge in practice, an AR methodology was applied. This aims at adapting and integrating AR in design management to ensure rigor and relevance of research. The AR builds on previous work done by the researcher (ARCOM, 2017) of doing action research in the own organization (Coghlan and Brannick, 2000, 2004, 2009, 2014) and builds on the general AR cycle of; planning; acting, observing and reflecting (Coghlan *et al.*, 2010). The empirical arena is a large Scandinavian architecture office where the action researcher works as an architect and sustainability advisor, facilitating processes to increase sustainability in projects. The AR cycles evolves mainly around collaborative workshops, se figure 2.

Background: The Eco-canopy case

The study is conducted around a single case: The eco-canopy concept as city-innovation in Linköping. The case had received R&D funding aimed at increasing innovation of advanced systems and techniques for sustainable city-innovation. The project was in 'fuzzy end' of design practice, in which a multitude of actors from different disciplines got involved and co-created a solution. The case had a trans-disciplinary approach with quadruple helix actors, adapting learnings from each cycle.

Data collection and validation

Gestalt management tools and methods was applied to the co-creation process, se figure 2 and table 1. Reflection-in-action (Schön, 1991) were ongoing and challenged with feedback from project-participants, which was collected after each session verbally and through digital inquiry. The experiences and outcomes of the sessions (learnings) and further planning of next iteration (action) were analysed through the support of a Gestalt management-group. The Gestalt management-sessions ran parallel to the design process, and thus impacted the design process, se figure 2. In the final analysis session, the process with the learnings and outcomes, was illustrated in text as well as a 6m long drawing and reflected upon together with the gestalt specialists. The case findings are described and analysed through the framework of gestalt theory, and the compromised findings are presented in figure 2 and table 1. Semi-constructed interviews with the core-project participants were recorded around the final workshop and transcribed to insure relevance of the findings. Questions addressed issues like: Their experience of the process of co-creation; how they experienced the process compared to other projects; their reflection on engagement; and on fragmentation of knowledge perspectives; weather an innovative and sustainable design solution was achieved. Further, in a research seminar with 7 industrial peer scholars at the architectural firm, the definition of co-creation and how it might be different to collaboration was addressed. Finally, the conclusions and

implications for further research will be reflected upon in a real-time co-creation experiment at the ARCOM conference (if accepted).

FINDINGS

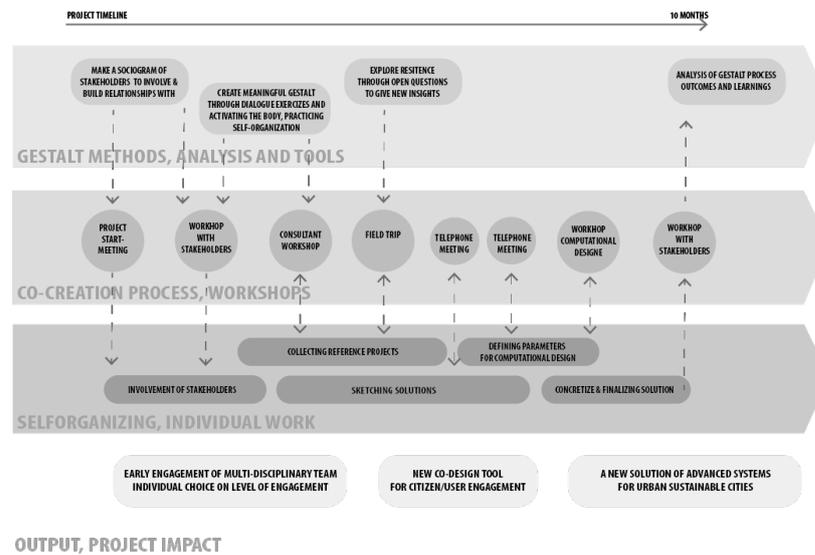


Figure 2: The main co-creation activities and the self-organized work in the design process. The Gestalt management-sessions ran parallel to the design process and thus impacted the design process in mainly three ways.

In conclusion, the solution was presented to the real-estate owner group (consisting of genitors, business developers, communicators and project leaders). 9 out of 10 voted for the concept to happen in real, and 1 voted maybe. Further, exploring the feeling of resistance, through dialogue and open questions, led to the invention of the new digital participatory-design tool.

Table 1. The main theoretical features and how it was applied in the design process

Theoretical features of Gestalt	How it was applied in the design process
<p><i>The relational focus</i> Humans are social. A group consist mainly of relationships. To understand it, one needs to actively take part in changing it. It is in the authentic inter-relational activities that we can fully experience our humanity. (Buber, M.)</p>	<p>Sociogram - the mapping of relationships in different human systems (design group, consultant group, stakeholder group and stakeholder organizations). Active participation in meaningful meetings with genuine dialogue. Establish a receptive context, accepting and exploring different modes of thinking.</p>
<p><i>Figure and ground</i> We constantly interpret and co-create meaning, influenced by our life experiences. We add meaning to fragmented pieces to create a meaningful whole. We are functions of our experiences and our interpretations. (Life space, Lewin)</p>	<p>Co-creating a shared understanding between actors by sharing individual experiences and perspectives for example on reference projects. Through dialogue, open questioning and continuously reflecting on the process, a common understanding and vision of the task and context can be co-created and shared.</p>
<p><i>Field theory rule</i> Groups are social systems in a power field with forces for change and its equivalent counter-forces (Lewin, K). Only when we become aware and accept the forces, change can come. (the paradoxal theory of change, X)</p>	<p>By reflecting on the process and our experiences, we gain insight and can move forward. By exploring our 'resistance', for example through coaching open questioning, we can become aware of the underlying forces, for change or counter-change and gain insights and can find new resolutions.</p>

DISCUSSION

This paper articulates that when we change the way we do things, we allow for different ideas and solutions to emerge. Through AR, new approaches to co-creation was explored and analysed with a Gestalt framework. The feedback below is extracted from semi-conducted interviews with the core participant group and the peer-research group, around the time of the final workshop.

There are several learnings drawn from this AR. First, the relational focus and the use of a sociogram, helped pin-point the necessary stakeholder-group and supported the

engagement of the right organizations and competences from early on (Ding, 2006). "In other projects, there is only the common consultants, such as; plumbing, energy and architect. Not like in this project where we have specialists in very special areas such as Björn (aquaponics specialist) and the IT-AI specialist" (HVAC consultant). The sociogram also created awareness of existing or non-existing relationships. For example, the urgency of establishing contact with the building regulation plan official at the municipality. Second, time and resources were invested to cultivate the relationships and communication amongst the multi-disciplinary stakeholder group in collaborative workshops (Grosse *et al.*, 2017). A considerable amount of time was spent on 'figure/ground', creating a meaningful gestalt through activating the body, sketching, field-trip, dialogue exercises and open-ended questions. This supported the interprofessional communication and engagement (Keys *et al.*, 2016) illustrated in the interviews; "The meetings we had and how we discussed, and study visits were very interesting, and it is very rare in regular projects. (In meetings) usually a project leader keeps track of various points we talk about, which is not the same as here. It has been a lot more fun to attend these meetings... "I've been engaged all the time and trying to get what I think is important, wrote so much and shown pictures and tried to make them understand the difference in operating energy" (HVAC consultant)". The shared understanding and gradually building knowledge through own and group reflection, is also highlighted in the literature (Innes and Booher, 2010; Shelbourn *et al.*, 2007) and relates to notions of 'sense-making', 'shared frameworks' and 'boundary objects' translating meaning in inter-disciplinary collaboration.

Third, although chaos and fuzziness were experienced in the process, the final output was a surprisingly well integrated and new design solution "I was very surprised how it all fit together so nicely at the end" (handling architect), incorporating an advanced system based on the multi-disciplinary competences and experiences of the stakeholder group. "In collaboration projects we have our solutions here, the other consultant has theirs. Here (the eco-canopy project) we (consultants) have been much earlier involved. Nobody knew what it would look like before we sat down and talked about it. And we get a different solution from the traditional" (HVAC Consultant). The co-creation process helped bridge fragmented knowledges and perspectives "Most often, the architect comes with a draft and we should project the ventilation. In this case, we are very early (meeting all the consultants) and we had quite different views on how the results would look". Addressing issues of fragmentation in the interviews the topic of innovation came up; "(Innovation) is based on contact with other people who are not just like ourselves, it (innovation) does not happen very much when you have the same world view." (Eco-system specialist). "Innovation is difficult to do without creating together. But if you are doing, for example maintenance, were there is an exciting system that is already in play and working, maybe it is better to collaborate" (Computational design, Architect, LIC.). The integrated design solution that came out of the project was a new urban sustainable typology. "If we can pull through with what we propose, it will be very innovative and interesting." (HVAC Consultant). The new solution gained acceptance not only in the client-group. The process evoked engagement reaching outside the project-group through the new participatory-design tool and attracted another client to engage with the eco-canopy concept in another city planning. However, the case had R&D funding. If a project is funded entirely by the client, it can be difficult to convince the client to make a larger investment in the fuzzy early phase, as clients tend to want to minimize cost in the early phases. The fifth and essential learning was how the Gestalt perspective challenged the role of the architects as the omnipotent designers. With AR, and

especially with a Gestalt perspective on co-creation, the distribution of power was essential. This can feel frustrating and requires the architect in charge to have faith in the process.

The difference between collaboration and co-creation addressed the distribution of power and responsibility? "Co-creation is a more flat organization. Collaboration is more of a hierarchy with a project leader who says; do this assignment and deliver it in 3 weeks. In co-creation we would meet, talk and work in an iterative process, sharing responsibility" (Computational design, Architect, LIC.) "In co-creation the architects share this power (to create) and invite others to participate in the act of creation. You share the responsibility." (Head of R&D, Architect, Ph.D.). Usually we are not there to create something new, just to accomplish, to follow these rules in the shortest possible time for no cost. This (eco-canopy project) has been a completely different process and it has been very interesting" (HVAC Consultant).

Other comments connected engagement to the ability to impact solutions "it is a condition for engagement, not just to give your input and ideas and somebody else does the creation." (Head of R&D, Ph.D.), emphasizing the different levels of participation (Arnstein, 2007). One participant said that his engagement was pre-conditioned in the concept of the eco-canopy "but your facilitation was protecting us as a guiding spirit" (Eco-system specialist). The stresses the crucial role of the facilitator/researcher-designer (Sanders *et al.*, 2008) which was one and the same throughout the process and limits the generalizing of results. Further, the study only provides one in-depth case which is another limitation. Sixth, the level of engagement was also much self-regulated.

An exercise in the first stakeholder workshop, where participants chose their individual level of engagement visible and in relation to whole group. A reflection-in-action was that this self-regulated approach was fruitful for long-term engagement, because it was voluntarily chosen on the individual level. In between sessions, the participants self-organized their work, taking responsibility of the whole content, instead of just fragmented aspects of project deliverables. "Here, the eco-canopy project has discussed all disciplines and done the work of the architect. When we collaborate in a project, normally we just add to what has already been created." (HVAC consultant). Seventh, exploring the feeling of resistance, through dialogue and open questions, led to the invention of a new digital participatory-design tool used to create a wider engagement with possible future users. How digital tools can be designed to support the co-creative process is an area of great possibilities and raises questions of democracy and power distribution. The application of participatory design practices to very large-scale problems will change design and may change the world (Sanders *et al.*, 2008).

These findings are in line with the current trends in architectural practice and policies for urban sustainable development in the Scandinavian context. However, in the hunt for efficiency and the increased belief in measurability, companies today are often governed by a 'control and command' philosophy where employers are seen as human resources rather than human beings (made to collaborate and co-create meaning). What if much of the inefficiency we have in organizations today is due to ineffective collaboration and bad conversational cultures that have their root in the lack of trust for one another and 'the battle' between different competences? If we can identify the rules or guidelines that help us to self-organize, we might accomplish three things: First, allow for people to take more responsibility for their own work as well as for the

common goal; secondly, create more integrated and holistic solutions; and third, have effective organizations in the knowledge-economy that are fulfilling places to work in as employers co-create meaning and value.

CONCLUSIONS

In the context of understanding and improving the transfer and diffusion of academic knowledge in practice, an Action Research methodology was applied. The aim was to explore co-creation in early design phase from a new perspective. This paper presents the findings from one case study, exploring co-creation through a Gestalt framework. Three Gestalt-tools/approaches are in focus; 1. The relational focus; 2. Figure and ground; 3. The field theory rule, and the study aimed to combine their strengths with the design process. Findings illustrate how co-creation from a Gestalt perspective challenges the power distribution and adds the relational focus to the process. This supported the early engagement of key stakeholders and competences. Using Gestalt tools, the architect had to resign from the omnipotent designer role in favour of facilitating collectively creative process (Sanders *et al.*, 2008).

Team members collectively created a shared framework, hence a meaningful gestalt ('figure and ground'), through dialogue exercises in collaborative workshops (Grosse *et al.*, 2017). Field theory (Lewin, 1946) - the investigation of 'resistance', led to the creation of a new digital participatory-design tool. The output was an integrated design of a new urban sustainable solution which was positively rated by the clients. Indeed, the solution even attracted a new client to use the eco-canopy concept. Findings illustrate how a Gestalt framework; can bridge fragmentation of different competences, achieving an integrated design solution. Findings also support engagement and self-organization. However, even though co-creation with a Gestalt approach offered better possibilities for engagement, more factors are in play, such as timing, funding and personal values regards to definition of task. The study also has limitations. The paper only provides one in-depth case-study from a Swedish context. The presented and experienced methodology can provide design- and construction management practice and research, with insights on how to co-create.

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FACILITATION OF INTERORGANIZATIONAL TEAMS: AN EXPLORATORY LITERATURE REVIEW

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Collaboration is important in a project-based industry like construction. The deterministic approach to project management implies the possibility of planning, managing and controlling the construction project phenomena and project actors' roles. This belief is dominant in the industry and the practice of collaboration will be influenced by it. The need to improve collaboration and move the project forward can be addressed a facilitation, however, it is unclear how facilitation takes place in inter-organizational project teams. This study is part of a larger project, which aims to address the skills and competencies needed for professionals in the industry to encourage collaboration and co-configuration between the actors to minimize the effect of the fragmentation within the industry. An earlier study in a Danish school setting suggests that the deterministic approach towards project management contradicts with the need for disruptive breaks from routines, which encourages co-configuration as seen in knotworking. The deterministic approach demands a certain mind-set among the actors, when delivering a known product in a known production process with a known division of labour, while the mind-set of co-configuration entails upsetting these relationships. It is possible to organize the breaks from the deterministic approach and it has previously been demonstrated, how a facilitator can help making the switch between the two mind-sets. A literature review is carried out to investigate which perspectives facilitation theory can bring to improving collaboration in the construction project. The literature presents a belief in facilitation as a way to improve collaboration although no single unified recipe for facilitation was found. A further investigation into how to approach facilitation of collaboration so focus can become on how to share critical resources for project efficiency as well as learning is recommended.

Keywords: facilitation, literature review, project management

INTRODUCTION

Collaboration is important in the mainly project-based construction industry, which depends on the collaboration from many actors. Collaboration can be perceived as a strategic process of sharing critical knowledge or as a process to create learning and produce synergistic solution argues Hardy et al., (2003) and stresses that little attention has been paid to the relationship between the two different perspectives.

From an organizational perspective construction projects “are multi-actor projects in which a broad range of actors with different competences and specialties are

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involved" (Eriksen 2013: 336). The actors in the projects are each performing their unique set of activities although ideally these activities should become integrated with each other to generate optimal value. However, Baiden et al., (2006) find that full integration is challenged by the traditional drivers for project success as well as project culture, the need for behavioural change and the lack of measurement of integration.

The traditional drivers for project delivery are cost, time and quality. They are used to measure how well projects performed. This form of evaluation is part of the deterministic approach to projects (Padalkar and Gopinath 2016). They found in their review of project management that the deterministic approach is the dominant view of the project management. It leads to an underlying belief that project phenomena can be planned, scheduled and controlled. The primary object of the deterministic project management approach is to plan and control the project and the project processes (Padalkar and Gopinath 2016). A finding supported by Blomquist et al., (2010). The deterministic approach also argues for a need for clear roles and responsibilities to ensure efficiency in the project, reports Gustavsson (2015).

However, Tuckman's (1965) team development model suggests that a team must go through the phases forming, storming, norming before it can enter the performing stage. In the storming phase, the actors will challenge each other on how to perform the tasks as well as each other's authorities. This seems contradictory to the primary objective of the deterministic project management perspective's belief in defining a plan for the collaboration including how to use the actor's resources. The plan will encourage the team to perform their task in the 'usual manner', which in turn can create a static situation. The use of facilitation may assist the team in performing their duties while developing as a team. The objective of facilitation is dependent on the context. Rasmussen (2011: 389) finds that "the primary objective of facilitation [for change] is to support participants to transcend 'business as usual' conventions", which in turn may lead to the existing structures and routines being questioned to ensure a continuous development and avoid a stand-still situation.

The contradiction between the challenges of the storming phase and the planning of project management is successfully overcome in knotworking, a new form of collaboration which shows promising results (Kerosuo 2015, Buhl et al., 2017). The participating actors form what is called 'a knot'. The knot is formed as a way to reach an object. An object can be defined as 'the raw material' or 'problem space' at which "activity is directed" (Engeström and Sannino 2010: 6). Knots are thus formed spontaneously and dissolved in a similar way when an object arises. In this way knots differ from teams as knots do not necessarily collaborate over a longer time period. Teams are also characterised by having well defined roles which can be defined by contracts, another major difference to knots. Collaboration within the knot is of "vital importance, yet it takes shape without rigid, predetermined rules or a fixed central authority" (Engeström 2008: 20). However, the actors may find this form of collaboration difficult, so in our previous study, we introduced the use of a facilitator to functions as a catalyst helping the actors to achieve full integration and collaboration (Klitgaard 2017). The study showed that it is possible to help the actors to move away from old routines and enter into a questioning stage of the old routines. It became clear that the existing way of doing things was a barrier to questioning the existing way of doing things - but with the use of a facilitator, these questions could be addressed.

The unwillingness to question the existing can be explained by practice theories. There are no unified practice theory traits and so no unified definition (Nicolini 2012). For the purposes of this study, we will follow Gherardi's (2012: 03) definition "Practice is [...] a practiced, habitual, taught and learned activity that constitutes the job and requires expertise", where knowing is not separate from doing. However, all the practice theories have common traits. One of these is the assumption that a practitioner will be absorbed in or being absorbed in a practice and this "implies certain norms of correctness (what is right and wrong)" Nicolini (2012: 5). This means that once an actor becomes engaged in the project, he will also become absorbed in a practice of project management. In the industry, it seems that the deterministic project management approach is dominant and so this becomes the "right way" of doing things and the actors become less likely to challenge it with questions.

The move to consider the project from a practice-based understanding is recognized by Blomquist et al., (2010: 9), who considers that "it will contribute to a more reflexive, mature and contextualized understanding of project management". Bygballe and Jahre (2009: 702) supports this and call for a shift in the focus on "economic or production-oriented perspective" towards a focus on "handling different types of interdependencies". An example of a practice-based approach is Boyd's (2013: 1145) work on knowledge management, where he identifies the importance of "supporting people to act better in practice" rather than "to think better about practice". Inspired by these approaches, we set out to investigate if the two different approaches also are evident in the facilitation literature; we call them the deterministic approach and the contextual approach. The deterministic facilitation approach we define as having a strategic perspective on collaboration with a focus on the critical distribution of resources. The contextual approach we define as having a learning perspective on collaboration with focus on learning and synergetic problem solving.

On this background, we carried out a provisoric literature review to discover the role of facilitation in an inter-organizational project. We ask the questions:

How are the deterministic approach and the contextual approach to facilitation represented in the literature?

How have these approaches developed since the turn of the century?

Furthermore, we investigate:

What is the relationship between the approach to facilitation and the objective for the facilitation?

What is the relationship between the approach to facilitation and the method of facilitation?

What is the relationship between the objective for facilitation and the method of facilitation?

This paper is organized as follows. In the next section the method is described including a description of how the sample was generated. It is followed by a section with the findings of the study, where the above questions are addressed. In the final section with concluding remarks the implications and limitations of the study can be found.

METHOD

To determine from which approach or perspective the facilitation literature has been written, we set out to investigate the literature on facilitation. Inspired by Kokkonen

and Alin (2015: 516), who use their review to “make sense of a set of extant research in a meaningful way”, we review the literature and present it in a meaningful way, although we due to time constraint only investigate literature from the turn of the century to the present day.

Generating the sample

We conducted a literature search in the EBSCO database Business Source Complete, which covers all disciplines of business. It is the intention of the researchers to complement the database search with a snowballing search back and forth from one of the articles identified in the database search. The article chosen is Ludwig Bstieler and Martin Hemmert’s “Increasing Learning and Time Efficiency in Interorganizational New Product Development Teams” from 2010, which puts emphasis on the adverse relation between learning/creativity and time efficiency. This problematic relationship is facing many construction projects; although it may be reduced by facilitation. Unfortunately, this snowball search hasn't been conducted at the present stage due to time constraints.

A search of four blocks for 'free text' was conducted, see table 1.

Table 1. Four block literature search

Phenomena of interest	Objective	Desired Result	Context
to achieve	for	in a	
Facilitation	Collaborat*	Practice Development	Project Team
OR	OR	OR	OR
Intervention	Learn	Product Development OR Innovation	Inter-organizational

The first block sets out the phenomena of interest, the second block is the objective of the phenomena, the third block is the desired result of the objective while the fourth block sets out the context of the phenomena. The results were limited to articles from the turn of the century, peer-reviewed articles in English and full-length articles. The Phenomena of interest block was created by using the search words: facilitate* or intervention and gave 132.609 hits. The Objective block included the words: collaborat* OR learn and gave 181.672 hits. The third block, the Desired Result consisted of the words: practice development or product development or innovation and gave 409.041 hits. The Context block included the search words: Project team or Inter-orga+ational or interorgni?ational or construction and gave 99.796 hits. The four blocks were combined with and, this gave 91 hits. By limiting the articles from the turn of the century and full-text peer-reviewed articles the number of articles was reduced to 33 articles. Six articles were deemed irrelevant. The rest of the articles contained some element of facilitation although it may not be the main topic of the article.

The articles were read and categorized after their approach. Furthermore, the objective and method of facilitation were noted of each article was noted. These were later sorted into categories with similar characteristics. The findings are presented in the next section. The articles have been entered into table 1. The articles written in

bold are under influence from the deterministic approach and the rest are influenced by the contextual approach.

FINDINGS

At first, we set out to discover, how the deterministic approach and the contextual approach to facilitation is represented in the literature.

Out of the total of 28 articles, the deterministic perspective was clear in 13, while the contextual approach was apparent in 15 articles. This level distribution might be explained by the second block of the search, where the words ‘collaborate’ and ‘learn’ are present. By including 'learn' in block two the search may have found literature about facilitating for learning rather than only about collaboration. Hardy et al., (2003) argues that in strategic literature collaboration is viewed as a way of sharing critical resources and facilitation used to enable knowledge transfer; while in learning literature collaboration is viewed as a way to transfer knowledge, but also facilitates the creation of new knowledge and produce synergistic solutions. Using the original search and combining it with NOT to a fifth block containing the word ‘Learn’, the search was limited to 18 articles. In this way, the block searching for the objective was reduced from 'collaboration and 'learning' to only include 'collaboration'. In this search, the division between deterministic and contextual approach is 8 under the deterministic approach and 10 under the contextual approach, which still is a level distribution between the two approaches. It appears that in facilitation literature the deterministic and the contextual approach is both represented and in almost level proportions.

The next step was to investigate if a trend towards one or the other approach is clear over time. The articles’ approach was entered into a timeline, see table 2. We find that the two approaches carry the same interest over time since the beginning of the century.

Although the number of articles in the sample is very limited it appears that both approaches have attracted the same interest over the investigated time period. The researchers wondered if this level pattern also applies for facilitation within the construction industry. Of the 28 articles, ten articles clearly identified the researched industry as construction. Out of these 10 articles, seven were written from the deterministic approach and 3 from the contextual. It seems that the construction industry favours the deterministic approach, although it is difficult to conclude on such a limited number of articles.

Table 2: Timeline over the use of the two approaches

Approach	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Deterministic	x	x					x		x			x	xx	xx		x	xx	x
Contextual				xx		x	x			xxx	xx		x	x		x	xx	x

Furthermore, we would set out to investigate the relationship between the approach to facilitation and the objective for the facilitation. We use table 3 to investigate as the columns represent the objective of facilitation, while bold lettering for the authors' names indicate the deterministic approach and normal lettering indicate contextual approach.

Table 3: Findings

Method for facilitation	Objective of facilitation						
	Knowledge sharing/ transfer/ Communication	Organisational redesign/ procurement	Innovation	Improving performance of project	Improving performance of teams/ Self-sustaining	Interorganisational collaboration (firms)	Learning/ Creation of knowledge
IT system	Rehm et al (2017) Senescu et al (2013) El Ghazail et al (2012)	Otte-Trojel (2017)				Wang et al (2006)	Scott (2000)
Social system (Trust)	Mabey, Zhao (2017)						
Radical flank						Truelove, Kellogg (2016)	
Boundary spanner/ object	Lawson et al (2009)		Harty (2005) Holmes, Smart (2009)	Blake, Foster (2016)		Soeparman et al (2009)	
Spatial Proximity					Dettmann et al (2015)		
Conveners						Dorado, Vaz (2003)	
Strategic management/ formal function	Mathur (2008)	Bowles, Morgan (2016)	Cui, O'Conner (2012)	Davis, Love (2011)			
Theory design			Tanskanen et al (2015)				
Management intervention/ actions		Rosenkopf et al (2001)	Peansupap, Walker (2006)		Thamhain (2013)		
Using metaphors as catalyst	Shelley (2012)						
Newcomers			Skilton, Dooley (2010)				
Procurement			Ozorhon (2013)				
Interorganisational collaboration / facilitating knowledge creation							Hardy et al (2003)
Problem solving etc.					Bstieler, Hemmert (2010)		

It appears that facilitation with the objective for organizational design is mainly performed under the deterministic approach. This can be explained by the deterministic approach implied belief in clear role and responsibilities. Facilitation with the objective of knowledge transfer and communication is considered from both the deterministic and the contextual approach. Facilitation for improving team performance is considered from the contextual approach. It is difficult to make a general conclusion, other than the objective of facilitation can be many; and the same objective can be viewed from both the deterministic and contextual perspective.

The relationship between the approach to facilitation and the method of facilitation was also investigated. This time, the results are read from table 3 using the rows for method and the bold/normal lettering for the approaches. There is a clear correlation between the use of IT systems/databases for facilitation and a deterministic approach. This may be due to the deterministic belief in planning, managing and controlling the process. The use of boundary object/spanners is mainly approached from a contextual perspective, which indicates how the use of boundary objects/spanner demands regard of the context.

Finally, we investigate the relationship between the objective for facilitation and the method of facilitation. Facilitation for the objective of innovation seems to be approached by a range of different method. However, if the objective is to facilitate communication and knowledge transfer the preferred method seems to be the use of IT tools.

CONCLUDING REMARKS

In this literature review, we set out to investigate the role of facilitation in literature, although the limited number of articles reviewed put some limitation on the value of the review. We intend to continue with the study using the snowball search method to generate a larger article sample.

In the facilitation literature, we discovered the same deterministic approach as in the project management literature although it is not as dominant. Furthermore, we discovered that facilitation is a wide concept used for many different collaboration objectives and in many different ways.

The literature presents a belief in facilitation as a way to improve collaboration although there no single unified recipe for facilitation was found. The amount of research from the contextual approach also indicate an accept from much of the literature that such a recipe cannot ever be created, which contrasts to the deterministic belief in planning all events and processes at an early stage of project followed by managing and controlling these as close as possible to the original plan.

In this way, we discovered an acceptance in the facilitation literature of both the deterministic and the contextual approach. We consider that facilitation may be the key to introduce new collaboration forms, like knotworking in the construction industry. We would like to investigate this further as we expect that awareness of both approaches towards facilitation of collaboration will generate collaboration with focus on both sharing critical resources to gain project efficiency as well as learning during the project. Practice Theory can generate an understanding of facilitation and how it influence different practices. We expect that the project management practice in particular will be influenced by the facilitation practice.

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UNDERSTANDING THE DYNAMICS OF CONSTRUCTION DESIGN TEAM MEETINGS THROUGH JOINT LAUGHTER

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Joint laughter in meetings is an all too familiar occurrence; yet, it has received little attention to try and understand its underlying meaning. The role and effect of joint or collective laughter are examined in the context of the design team meetings for a case study construction project. Such meetings, which are standard practice in the UK construction industry, are the face-to-face communication mechanism for group decision-making involving the client, design, and construction teams during the design development phase of contractor design-led projects. The importance of the design phase to the overall success of a project is well-documented. Design team meetings provide a venue to facilitate successful group collaboration and promote the integration of ideas between sub-teams. The social and task-related interactions of the group dynamic need to be recognised, understood, and evaluated for meetings to be directed productively. A 360° panoramic video-recording camera was used to gather data from three consecutive design team meetings during a live construction project when adopting a non-participant observation technique. Computer-assisted qualitative data analysis software was used to structure and interpret packets of rich data focused on critical incidents (involving joint laughter) that occurred during the design team meetings. Results show that instances of laughter do not happen at random but at specific times in meetings when they perform distinct functions. These functions include, amongst other things, the building of an effective team-working environment. Ultimately, group collaboration and integration may be improved if team leaders and members recognise the importance of joint laughter and the part it plays to create an inclusive working environment, foster collegiality, and improve decision-making. Acknowledging that mutual laughter is an essential aspect of team dynamics that can improve social and task-related performance will inevitably result in better performing teams and the realisation of successful projects.

Keywords: collaboration, construction design, group dynamics, laughter

INTRODUCTION

During the past 40 years, the construction industry has been criticised for being fragmented and adversarial (Latham 1994; Egan 1998, 2002), pointing to a need to improve its delivery of value to clients and society by realising improvements in areas

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such as teamwork, collaboration, and integration, particularly at the interface between the design and construction sub-processes.

The increase in popularity of contractor-led procurement routes has led to prime or main contractors taking increased responsibility for design (Gray and Hughes, 2001); this has resulted in those who traditionally led the design process now finding themselves as sub-contractors participating in multi-disciplinary teams (Male, *et al.*, 2007; Greenwood *et al.*, 2008). The effect of these new procurement routes means main contractors are often contractually responsible for, and thus need to manage, the entire design process.

As noted by Tjell and Bosch-Sijtsema, (2015), the design process accounts for a relatively small proportion of the overall project cost but has a significant impact on the characteristics and future construction and running costs of a project: therefore, its management is critically important to the overall success of a construction project.

Design process complexity is influenced by decentralised decision-making and financial control (Dubois and Gadde, 2002), leaving the fiscal responsibility and authority with the project team, rather than senior management. The combined effect of unique and possibly uncertain site conditions and decentralised decision-making increases the need for effective management, particularly concerning the design.

Construction projects use design team meetings (DTM) as standard practice in the UK construction industry. DTMs are the face-to-face mechanism for group decision-making between the client, design, and construction teams during the design development phase of contractor design-led projects. The purpose of such meetings is to provide the project team with a collaborative forum for problem-solving and decision-making about the design. Due to the participants' involvement in the meeting (designers, constructors and client stakeholders are customarily represented), the integration of ideas can be facilitated across the entire team. While the recent uptake of new technologies (such as BIM, virtual reality, and augmented reality) has aided collaborative dialogue between project stakeholders, there remains a need for them to interact both on task and social, i.e. inter-personal, issues by meeting face-to-face (physically or sometimes virtually) as a team. The three principal stakeholder groups involved with the design process and therefore present at DTMs are the design, construction, and client teams. Research has revealed that these groups need collaborative interaction for different reasons. Morris (1972) has shown that, due to the uncertainty and complexity of construction projects, the most critical inter-relationship within a site-specific, project-based organisational structure is the dynamic and challenging relationship that exists between design and construction. This relationship must be a priority when striving for better project outcomes; a view that is supported by other writers (see Emmitt and Ruikar, 2013).

A further crucial inter-relationship that exists during the realisation of a construction project, in connection with the design process, lies at the client ↔ contractor (designers and constructors) interface. Vrijhoef and Koskela (2005) have recommended focus be placed on the client as the primary driver for the project at this boundary. However, Cox and Thompson (1997) suggest that few clients can afford to be 'repeat clients' over an extended period, which means they tend to be uninformed and new to the design process. The inclusion of an unfamiliar client during the design development phase can result in the creation of a unique, bespoke supply chain, i.e. a 'quasi-supply chain', which can contribute to the magnification of cost inefficiencies as the team attempts to realise and deliver a unique project. The relationship between

the client and the rest of the project team needs to be carefully managed to reduce these cost inefficiencies, particularly during the design development phase, when the client's requirements are captured and incorporated. This intervention will require meaningful conversations involving the client and both the designers and constructors of a project. DTMs provide the opportunity to have such significant conversations on a regular basis; thus, giving further emphasis to the importance of these meetings.

In summary, although the many different phases of a construction project need to be managed efficiently and effectively, a priority is the design phase. Bearing in mind the heavy burden of financial responsibility the design holds if not successfully executed, it is clear to see why DTMs need to be effectively managed for the overall project to be a success.

Group Dynamics

The work of Kurt Lewin and his followers (see Lewin, 1951) marks the emergence of group dynamics as a socio-psychological research area. Its focus is the examination of how people work and interact in small groups, and amongst its applications is the drive to improve the effectiveness and efficiency of how teams operate.

From the early work of Lewin (1951), group dynamics theory has developed into an established body of knowledge. Hackman (1987) defines three primary areas upon which a team needs to focus to be successful:

- Completing a task
- Developing social relations
- Benefitting the individual

Developing social relations is particularly relevant for this research project. Levi (2017) stresses the importance for the team in developing good social relations among its members to be able to work effectively and complete the necessary tasks. Skills necessary for good social relations include cohesion through collegiality and excellent communication. Cohesion comes from the emotional ties that team members have with one another. Effective communication is not a straightforward process, but essential elements such as understanding and trust can contribute to a constructive working environment. The benefit of productive social relations within a group tends to be the creation of clear and effective communication, which can influence the team's ability to operate successfully and, therefore, accomplish the task.

Humour and Laughter in the Workplace

The development of research into the role of laughter in work-related meetings has been inhibited by two commonly-held but incorrect assumptions. The first of these is that historically, emotion was considered to be the antithesis of rationality and, therefore, of less critical importance within organisational settings. This perspective has changed with the work of writers such as Ashforth and Humphrey (1995), who now accept that emotion is best considered as intertwined with rationality and, therefore worthy of investigation. Emotion within organisations is now supposed to be an inseparable (and sometimes inaugural) part of emotional life and, therefore, critically important to understand in relation to organisational performance, specifically about motivation, leadership, and group dynamics.

The second traditional assumption is that laughter is inextricably linked to humour. Authors such as Rogerson-Revell (2007) have shown that this is not necessarily the

case. Furthermore, Greatbatch and Clark (2003) postulate that laughter can manipulate relationships between individuals and groups. A review of empirical work on laughter in work-group settings reveals that it serves five primary functions:

Collegiality: to create and maintain social cohesion and group solidarity (Meyer 1997, 2000)

Superiority: to attack others in a socially acceptable way and enhance self-esteem at the expense of others (Rodrigues and Collinson, 1995)

Support: to gain the approval of others (Meyer 1997, 2000)

Relief: to manage embarrassment fear or stress in threatening situations

Conflict: to express opposition, resistance, and dissent (Rodrigues and Collinson 1995; Mulkay, 1998)

Greatbatch and Clark (2003) criticise many of these studies, pointing out that they do not take into account that laughter can occur during natural interactions. Similar to studies of laughter within organisational settings are rare (exceptions being Holmes, 2000 and Kangasharju and Nikko, 2009) and none currently exist that are specific to the construction industry.

Holmes (2000) highlights both the positive and negative impact of joint laughter in workplace meetings in relation to organisational goals. Positive functions include solidarity and good relationships with fellow workers, improvements in job performance, increased employee satisfaction, encouraging creativity, and diffusing conflict among employees (Holmes, 2000).

Further positive effects of joint laughter during workplace meetings are investigated by Kangasharju and Nikko (2009). Applying conversational analysis, the authors linked joint laughter to:

the opening phase of a meeting

a topic-closing device

reducing tension in challenging situations

The importance of the opening phase of a meeting is well established (Ashforth and Humphrey, 1995). The behaviour of the group leader, as well as the behaviour of the participants, during this phase, determines the general character and atmosphere of the encounter, including the acceptable nature and discourse of formal or informal group interactions. Ashforth and Humphrey (1995) claim that it is the primary task of the leader to create and sustain solidarity within a group, which creates 'fellow-feeling' and aids members of the organisation to proceed in the same direction. An adverse effect of laughter during the meetings reviewed by Kangasharju and Nikko (2009) was its use in manipulating the proceedings of a meeting. An example of a specific negative function, as highlighted by Holmes (2000), is the manipulation of the meeting when participants deliberately changed the dialogue from formal to informal, which can include some participants in the conversation but exclude others - sometimes intentionally. (It should be noted that this outcome only occurred in the data collected during a cross-cultural disagreement between the Swedish and Finnish participants, while all participants contributed to a Swedish 'round-the-table' procedure that is not standard practice within UK DTMs.)

Research that investigates the emotional behaviour -- witnessed through joint laughter -- that exists between participants in the unique, temporary, fragmented, complicated and, sometimes, adversarial nature of construction DTMs, does not currently exist. This project aims to address this gap.

DATA COLLECTION AND ANALYSIS

Data Collection

The data for this study were collected as part of a pilot study for a broader project that looks at the function and social interactions between participants during DTMs.

Three consecutive DTMs on a single project were observed. The specific project is a new-build educational building in the North East of England, selected because it is a contractor design-led procured project and, therefore, the contractor holds the design responsibility. Because data collected by interviews lacks authenticity, an ethnographic research strategy was used to capture the occurrence of joint laughter taking place in its natural setting and to enhance the understanding of the setting.

The dataset for this research project consists of 3 hours of 360° panoramic video recordings, which capture not only the narrative of the meetings but also the ability to allocate individual participants to the narrative and allow for what Symon and Cassell (2012) call 'meaning-making'. Permission was sought and given by all participants for the use of the data for this investigation. The time during the meetings when joint laughter occurred was explicitly noted; these occurrences form the critical events which are the focus of the analysis. Joint laughter was defined as when the majority of the participants were engaging in laughter at the same time.

The length of the meetings varied between 50 and 75 minutes. The number of participants ranged from 7 to 10, and the same individuals took part in more than one meeting. The prime purpose of the meetings was the sharing of information and decision-making about the design of the project. The three stakeholder sub-groups, i.e. design team, construction team, and client team, were represented at each meeting.

Data Analysis

The process used to structure and analyse the data follows that of Powell *et al.*, (2003), specially developed for video-recorded data. This involved: (1) attentively viewing the video data; (2) describing the video data; (3) identifying critical events; (4) transcribing; (5) coding the results; (6) constructing a storyline; and (7) composing the narrative (see Powell, Francisco and Maher, 2003, p. 413). Each critical event, i.e. where joint laughter occurred, was structured using NVivo software, and thematically analysed to (i) consider its functions; (ii) to understand its contribution to group dynamics; and (iii) to acknowledge its contribution to future strategic behaviour about improving collaboration and integration. The basis of the thematic analysis derived from the five primary functions of laughter according to Greatbatch and Clark (2003), namely: collegiality, superiority, support, relief, and conflict. The analysis of the joint laughter critical events focuses on the verbal interactions of each meeting's participants. Non-verbal forms of communication lie outside the scope of the investigation.

Results of the Analysis

Occurrences of joint laughter were observed in connection to social relationships and conversational humour during the three DTMs. Joint laughter occurred that was linked to both principal meeting activities, i.e. the clarification of information and decision-making. Joint laughter also occurred that was linked to both interpersonal and intra-organisational group interactions. The two most prominent functions of joint laughter about successful group collaboration included joint laughter during the opening phase of a meeting to create a good working environment and joint laughter

as an aid to fostering collegiality. These two areas will be the focus of the following discussion of the findings.

Joint Laughter in the Opening Phase of a Meeting

All three of the DTMs observed contained joint laughter during the opening phase of the meeting. During each meeting, the 'Chair', (who was also the leader), took the time to lighten the atmosphere using the device of informal yet explanatory conversation; thus, ensuring that all the participants understood the overall aim of the meeting and their role. The dialogue was friendly and inclusive. Interestingly, the joint laughter that consistently occurred during this phase was not instigated by the Chair but by one of the participants. The Chair's reaction to the joint laughter was to participate actively; this appeared to create an atmosphere of solidarity and cohesion amongst the group during the first five minutes of the meeting. The data might suggest that this role can be undertaken by any group member as well as by the leader and the same benefits result, provided the team leader supports it. See Extract 1.

Extract 1: The opening phase of a meeting

P1 Thank you everyone for attending. We will do a quick round the table with introductions, it Sarah's* first meeting this one. You have done design team stuff before, so we don't need to introduce that. You know me, Fred*. Which way round should we go? ...

(...everyone introduces themselves)

P1 Thank you for that ...

P2 And you are ... (Laughter)

P1 I said first ... (Laughter)

*Pseudonyms and numeric references are used to maintain anonymity.

Following on from the opening phase, the atmosphere throughout each meeting remained relatively inclusive (from the observer's perspective) with a total number of 25 joint laughter critical events occurring during the three hours of DTMs observed. Due to a lack of comparable empirical data, it should not be assumed that this is representative of such group interactions at DTMs: the individual participants, the history of their social interactions, the state or stage of the project, and many other variables, exist that could produce different results. However, from the perspective of the observer, the meetings consistently felt friendly and comfortable environments to share ideas and work collaboratively for the benefit of the project, rather than to gain individual advantage and harbour adversarial behaviour. The observable positive atmosphere during the meetings may in some part be attributed to participants' response and openness to laugh together as a group from the early phase of the encounter.

Joint Laughter to Foster Collegiality

Throughout the data collection period, the project team reflected a collegial working environment in several ways beyond the opening phase of the meeting. The first and most repetitive social relationship observed was the occurrence of 'in' jokes - 'in' jokes being a reference to a humorous subject matter the group had apparently enjoyed and laughed together at during previous meetings or interactions from those observed. The contents of the jokes included two central themes: the first being the inappropriate name for specific rooms of the completed project (a name that would be considered politically incorrect if used formally and, therefore, potentially a 'secret' held by the

group); and secondly, friendly banter about conversations held with people outside the meeting but into the broader organization. See Extract 2.

Extract 2: Joint laughter linked to collegiality and a previous 'in' joke

P1 The only comment that I have got is that this is going to be a really noisy space with a hard floor and the openness of it.

P2 The prison trays will make no noise at all (laughter) we will get plastic cutlery.

P1 No baked potatoes then (laughter and smiling).

P3 (Chair) John* is very enthusiastic and his prison trays.

P2 He is.

P4 Are they reusable?

P5 Are they like we used at school, with a little slot for you cutlery and stuff (laughter and smiling)?

P2 Yes, they measure out your mash potato. You might get custard on your steak and kidney pudding (laughter and smiling)

*Pseudonym used to maintain anonymity.

The use or occurrence of an 'in' joke appears to bond the group together. The repetitive nature of the joke did not appear to lose its attraction or the level of reaction from the group throughout the three meetings. The level of humour, indicated from the level of loudness and duration of joint laughter, remained consistent during the three meetings. When a new member joined the third meeting and observed an 'in' joke for the first time, it was explained to them openly by the meeting Chair, and the joint laughter continued, this time including the new member. This kind occurrence demonstrates the potential bonding and inclusive influence of group humour and laughter. It also describes the long-term potential of sources of joint laughter to span more than one meeting. This occurrence may, perhaps, extend for the duration of a project (or even beyond that); thereby, keeping the group unified and cohesive, which in turn, may aid collaboration and foster openness to allow the sharing of ideas for integrative decision-making and problem-solving.

DISCUSSION

As previously noted, Greatbatch and Clark (2003) summarise the primary functions of laughter as collegiality, superiority, support from others, relief, and conflict. The data collected during the DTMs were analysed in relation to all five functions. Collegiality was observed to be the most dominant function of joint laughter, with the majority of the critical events linked to this function. The reasons for this are unclear and would require a more extended study, perhaps observing more than one project team. However, it could be suggested that, in line with the findings of Holmes (2000), the benefits of solidarity and good relationships with fellow participants may improve the group's performance, increase employee satisfaction, encourage creativity, and diffuse conflict.

It is interesting to note that there were no examples of joint laughter being linked to superiority, support from others, or relief. The reasons for this are unclear and will again require further investigation over a longer duration.

With regard to the work of Kangasharju and Nikko (2009), who identified joint laughter at the opening phase of a meeting, as a topic-closing device, and as a means of reducing tension in challenging situations, the data in this study support these

observations. The joint laughter that occurred during the opening phase of a meeting determined the general character and atmosphere of the encounter. Including the acceptable nature and discourse of formal or informal group interactions (Ashforth and Humphrey 1995). Although the Chair of the meetings did not always instigate the laughter, they did support it when another participant instigated it; therefore, helping to create and sustain group solidarity and 'fellow-feeling' and encouraging members of the project team to proceed in the same direction.

CONCLUSION AND RECOMMENDATIONS

The design of a construction project is critically important to its overall success and, therefore, needs to be managed effectively. Critical to the development of the design is both the task-related and inter-personal relationships between designers and constructors. Relationships which historically have been fragmented but have been identified as one of the critical elements necessary for successful teamwork.

Joint laughter appears to play an important role by contributing to a friendly and inclusive working environment. This is particularly crucial during DTMs when participants that represent different stakeholders are required to work together to develop the design of a project. The resulting improvement in collegiality and group dynamics may foster increased collaboration and the better integration of ideas.

The research has focused on the positive outcomes of creating a good working environment through solidarity to encourage collaboration. However, as noted earlier, the possibility of adverse consequences of humour and laughter must be recognised, though these were not observed during this study. These include the exercise of 'superiority' and the selective inclusion/exclusion of meeting participants that may lead to adversarial behaviour. Hence, the conscious promotion of joint laughter as a strategy should be undertaken with caution and with a thorough understanding of the potentially 'double-edged sword' effect recognised by Rogerson-Revell (2007).

Limitations and Areas of Future Study

The data used to underpin this study came from a small case study. To obtain more robust conclusions or to postulate recommendations that were generally applicable, a considerable volume of data will be required. Suggested areas for future research include:

- Investigation of the association between joint laughter and conflict resolution - a possibility that this study identified, but remained outside its scope.
- Investigation of the use of 360° panoramic video recording for data collection during team meetings to observe group dynamics and non-verbal behaviour.
- Investigation of the use of 360° panoramic video recording for data collection during team meetings to observe multi-modal examination of laughter that examines verbal, non-verbal behaviour and group dynamics.

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INTEGRATION AND COLLABORATION FOR SUSTAINABILITY

SUSTAINABLE CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT: COMPARISON OF CORPORATE AND PROJECT LEVEL DRIVERS

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The need for sustainable management of construction, demolition and excavation (CD&E) waste has for some years been considered a very important requirement in the construction industry. Construction industries in many countries have responded to the calls for waste management (WM) by instituting measures towards sustainably managing their designs, processes, materials and waste to reduce the negative burden of the industry on the environment. Today, almost all main contractor organizations in the UK have sustainability policies which cover the management of waste. These policies have led to the setting up of sustainable goals and requirements as part of the management of construction projects. Research on the drivers for sustainable WM in the construction industry suggest that, legislation and economic concerns are the key drivers for efforts by construction companies in this regard. Considering the project based nature of the industry, it is argued that drivers at the corporate level may not be the same as drivers at the project level. Through a multiple case study involving 4 construction companies and 8 construction projects in England, the different factors that drive WM in the construction industry at the corporate and project level are investigated. The results provide new evidence which suggest that the drivers for WM differ between the project level and the corporate level. Whereas economic consideration, company image, company sustainability agenda, client demands, government legislation, moral and social imperatives to manage waste, benchmarking and environmental concerns drive WM at the corporate level, at the project level, health and safety, the assurance of repeat jobs, charging schemes for sub-contractors and changing nature of the industry are extra factors that drive WM. This research concludes that, a better approach to sustainable CD&E WM should consider the project based factors together with the corporate or firm level factors in designing strategies towards sustainable WM.

Keywords: corporate level, drivers, sustainability, waste management strategy

INTRODUCTION

The need for sustainable management of construction, demolition and excavation (CD&E) waste has for some years been considered a very important requirement in the construction industry. The problem of construction waste is multiple folds and has social, environmental and economic implications. There is the environmental issue of

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pollution from waste (Esin and Cosgun, 2007), the social issues of misuse of natural raw materials (Lu and Yuan, 2011) and the running out of landfill space (Poon *et al.*, 2003), and the economic issue of increased cost of construction projects from the cost of materials wasted as well as the cost for disposal of waste at the landfill (Hao *et al.*, 2010). The quest for sustainability in construction has been fuelled by the realisation that the industry can improve its effects on the environment and also make economic gains at the same time. In this regard, efforts towards waste management (WM) have been increasing and the adoption of the waste hierarchy has been promoted as the best approach to CD&E WM. Research efforts towards WM have covered different areas including: attitudes of workers (Theo and Loosemore, 2001); practices to reduce waste; critical success factors (Osmani *et al.*, 2008); BIM and WM (Liu *et al.*, 201); and WM legislation (Osmani *et al.*, 2008; Adjei *et al.*, 2015). Lu and Tam (2013) report that the approaches towards construction WM take the form of hard technologies such as prefabrication, use of metal formwork and use of recycled aggregates, and soft managerial or economic approaches such as legislation. All these studies have made contributions to the quest for sustainable CD&E WM by influencing policies and measures adopted by construction companies.

Identifying Drivers for Sustainable Waste Management in the Construction Industry

Over the past two decades, considerable efforts have been devoted to understanding the factors that drive sustainable CD&E WM. Osmani *et al.*, (2008) report that government legislation is one of the most critical success factors for ensuring sustainable CD&E WM. Lu and Yuan (2010) conduct a study on the critical success factors for WM in construction projects and conclude that: WM legislation; WM system; awareness of C&D WM, low-waste building technologies, fewer design changes, research and development in WM, and vocational training in WM are the most critical in ensuring waste is sustainably managed. Osmani *et al.*, (2008) and Yuan (2008) also report that environmental protection is a key driver for managing CD&E waste. Through the use of Bayesian Belief Networks (BBN), Bakshan *et al.*, (2017) report that personal factors such as attitude have more impacts on WM than corporate factors such as training. Wu *et al.*, (2017) investigate the determinants of contractor's WM behaviour in china and conclude that economic viability and government policy both play important roles in improving contractor's behaviour towards WM.

Although these studies have made positive contributions to sustainable CD&E WM, the industry has a long way to go so far as sustainable waste management (SWM) is concerned. This calls for new approaches that have the potential to ensure better results are achieved from the measures adopted by construction firms. The motivation for this research is in line with the need to contribute new evidence towards the sustainable CD&E WM. Although the construction industry operates at two main levels: corporate level; and the project level (Vrijhoef and Koskela, 2005; Zhao *et al.*, 2012), research on sustainable CD&E WM has failed to acknowledge the two tier nature of the industry and the likely impact of this on efforts towards WM.

The Two Tier Nature of the Construction Industry

The construction industry can be said to work at two different levels: the corporate level, where overarching decisions are made; and the project or site level which is generally one of and project based. Unlike the manufacturing industries where policies and approaches developed at the corporate level can easily trickle down to the

manufacturing plant and assembly lines, the fragmented nature and organisation of the industry makes it different (Fernández-Solís, 2008; Nawi *et al.*, 2014). Vrijhoef and Koskela (2005) suggest that construction is dominated by project-based production with project teams constructed from relatively independent participants joining a constantly changing one-off coalitions of firms to deliver make-to-order or design-to-order projects (See also Winch, 2003). The nature of the industry and its projects create two different cultures: the corporate culture and the project culture (Vrijhoef and Koskela, 2005).

This research argues that, the difference in culture and operations between the corporate level and the project level are likely to influence the factors driving WM at the two different levels. It is likely that the measures adopted at the corporate level may not necessarily reach the project level (Keeble *et al.*, 2003; Zhao *et al.*, 2012). Although policy decisions are made at the corporate level, waste generation and management occurs at the project level. This makes the need to investigate the drivers of WM at both levels very important.

RESEARCH METHODOLOGY

For this research, multiple case studies with multiple embedded units of analysis was adopted. For the corporate level data collection, four construction companies who had previously won awards for their sustainability and best practices in WM were purposely selected. At the project level, 2 live projects from companies A C and D, and 3 from Company B (a total of 9 live projects) were purposefully selected. A summary of the case study companies and projects is shown in table 1.

Table 1 Summary of case study companies and projects

Company A		
Part of a British multinational facilities management and construction company		
Project A1		Project A2
School replacement project worth £22 Million, lasting 7.5 months. Educational (public sector client)		Redevelopment of a power station into apartments and shops worth £400 Million, lasting 39 months. (Client developer)
Company B		
Construction and property services company operating in England, Scotland and Wales		
Project B1	Project B2	Project B3
New Build with part refurbishment school worth £12 Million Pounds lasting 8 months (Education Funding Agency)	New Build Leisure centre and retail Park worth £35 Million lasting 23 months (Developer)	New Build University Project worth £8 Million lasting 17 Months (Education Funding Agency for a university)
Company C		
Leading property, residential and construction service group in the UK operating in Middle East, Far East and Caribbean		
Project C1		Project C2
New Build (Technology college on an existing site worth £12.5 Million design and build project lasting 12 months (Education Funding Agency)		New Build Hospital (Rapid Response Unit) worth £36.5 Million lasting 18 months (Health Trust)
Company D		
Property Solutions Management Company in the UK - specialist in retail distribution with major clients being major retail outlets and high-street shops		
Project D1		Project D2
New Build Retail park on a brownfield site with part demolition worth £20 Million lasting 8 months Investor (Contractor is the developer)		Retail Park fuel station and shopping mall with cinema on part green and part brownfield worth £45 Million lasting 27 months (Developer)

Data was collected via semi-structured interviews with 25 personnel from the corporate and project levels, analysis of sustainability, environmental and WM policies documents, site-waste training documents, and site observations. Participants

were sustainability managers, environmental advisors, projects managers, designers, site managers and sub-contractor personnel. QSR Nvivo, version 11 was used as a tool to help in the coding and retrieving of data. To ensure the analysis of data followed a well organised format, all data collected for the research was prepared through transcription and editing of audio recordings, and sorting of documentary evidence.

The coding process followed a cycle of what Saldana (2012) describes as encoding and decoding, where codes were used to represent extracts or passages from the interviews and documents. A total of 150 nodes/codes were generated from the data through micro analysis of (digging beneath) the data (open coding) to discover all meanings inherent in the data. The codes were further developed into categories (tree nodes). Through the process of description, analysis and interpretation, codes representing similar concepts were grouped further to develop themes and sub-themes. The results from the process were grouped under corporate level and project level drivers.

RESULTS AND DISCUSSION

This section of presents the results from the case studies and discusses the implications of the results in relation to achieving sustainable CD&E WM. The results from the corporate level are presented first, followed by the results from the project level. Discussion of the results and the implications for waste management are presented in the last section.

Drivers for Waste Management at the Corporate Level

From the analysis of the interviews with corporate level staff, and the review of company documents on sustainable waste management, the corporate level WM drivers were identified. The criticality of a driver for waste management was identified based on how much emphasis company policy and interviewees placed on a particular driver. The drivers (shown in figure 1) are divided into internal and external drivers. Whiles internal drivers solely dependent on the internal mechanisms within the company, external drivers are arise from factors outside the control of company.

Internal Drivers for Waste Management at the Corporate Level

In total there were 5 internal drivers for WM at the corporate level and these include: company sustainability agenda (vision), economic considerations, moral and social imperative to manage waste, company image, and environmental concerns. As shown in figure 1, economic considerations is one of the most important (and common) drivers for sustainable WM. Cost elements affecting WM were identified to be: cost of materials in the waste, the cost of man hours put into the process, the cost of permits, the cost of transportation, and charges for disposal of waste.

Interviewees suggested that the high cost of waste generation and disposal served as a driver to WM. It was identified that Company B spent about £2.4 million per year on waste generation and disposal and this influenced WM. For company D, about 0.5% of construction turnover is spent on waste and this high cost serves as a driver to put in place strategies to manage waste. Similar issues were identified for Company C. Martin and Scott (2003) previously reported that the Landfill Tax (cost of disposing waste) is an important driver for WM in the UK.

For companies A and B, the quest to achieve sustainability goals drives the overall WM agenda. The need to be sustainable is acknowledged by the Environmental

Policies of both companies A and B. For company A, the Waste Guidance Document and Waste Procedure Document make reference to the need to ensure sustainability is achieved throughout the WM process. Company image was also a common driver in all the companies and related to the need to demonstrate to clients that the company is a responsible contractor. Having a good image was identified to have an effect on a company’s ability to win work and this influenced the pursuit of SWM. Environmental concerns was identified to be the next driver for WM. According to the Sustainability Manager for company A, “It is an internal policy to do well for the environment” and this means ensuring all negative environmental impacts are reduced. Osmani *et al.*, (2008) and Yuan (2008) have all reported environmental concerns as a major driver for WM. Some companies also see the need to manage waste as a moral imperative.

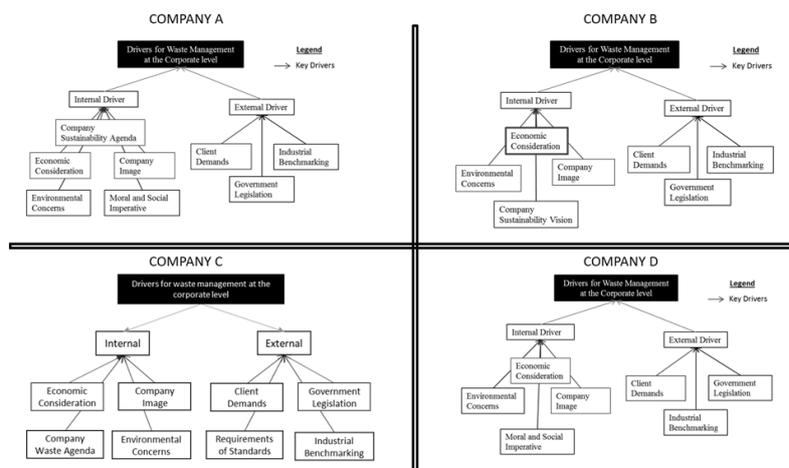


Figure 1 Drivers for sustainable WM at the corporate level

External Drivers for Waste Management at the Corporate Level

The key external driver for Sustainable CD&E WM in all four companies was identified to be client demands followed by government legislation. According to the interviewees, some clients are very interested in environmental performance and this drives WM. Some clients required high BREEAM rating (for example) and this served as a driver for WM. The need to meet client requests for WM influenced WM strategy of company C and B. As explained by the senior environment: “...a lot of clients are starting to have high targets for waste diversion from landfill or, in some cases, zero waste to landfill aspirations, so we need to demonstrate that we’re working towards that too.” Similar comments were made by interviewees from companies C and D. Though clients are generally reported in the literature to have less regard for the environmental burden of their projects, (Yuan and Shen 2011), this research suggests there are increasing numbers of clients who have genuine concerns for environmental and sustainability issues, including waste and these drive corporate level CD&E WM.

Within all four companies, the need to comply with government legislation also serves as a driver for WM. The threat of negative public image resulting from non-compliance with legislation served as an incentive to comply with legislative requirements. Ajayi *et al.*, (2015), Osmani (2012) and Yuan and Lu (2010) all report that government efforts towards WM are influenced by environmental concerns and economic considerations. The influence of legislation notwithstanding, results from this research suggests that government legislation is not the most critical driver for WM. Demands of clients for compliant firms served as a boost to comply with

legislation (See also Adjei *et al.*, 2015). Benchmarking performance against other contractors and the need to meet the requirements of standards such as ISO 140001, the Halving Waste to Landfill initiative of WRAP and the Considerate Constructors Scheme were all identified as drivers for WM. Research by Barthorpe (2010) and Glass and Simmonds (2007) also report that such standards help to raise the environmental awareness of constructions firms.

Drivers for Waste Management at the Project Level

From the analysis of observation reports, interviews with site teams and review of project level documentation, the drivers of sustainable CD&E WM at the project level were identified. A summary of project level drivers is presented in figure 2 below.

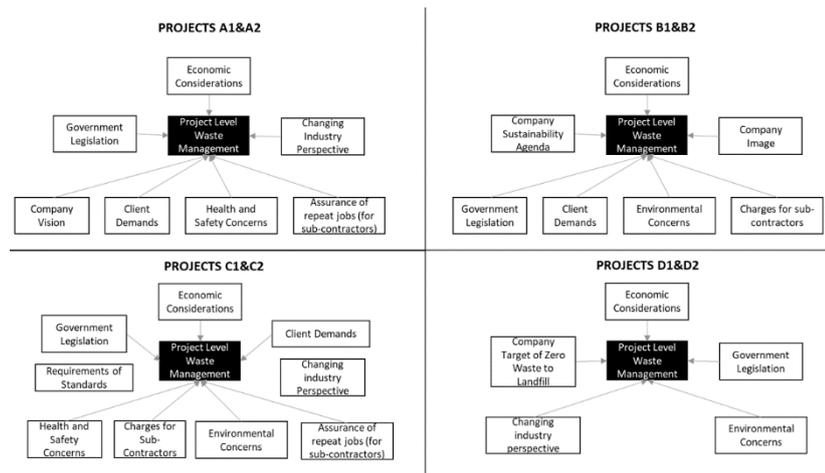


Figure 2 Drivers for Sustainable CD&E WM at the project level

As seen from figure two, although the influences differed, common factors such as economic considerations, client demands, and government legislation were identified to which drive WM. Although these factors are as a direct impact of corporate level action (WM drivers), the extent of influence of corporate level factors differed from one project to the other. Just as the corporate level, project teams were traditionally interested in cost savings and this to a large extent drove their WM efforts. In an interview with the Design Manager on Project B1, he hinted: “cost as a driver is currently an industrial thing where ways of saving money is a key driver for many activities in the industry and WM is definitely one of them. At the end of the day, everything comes back to cost. The cost of transporting waste out of site also drives practices where steel or timber when segregated can be taken away for free but mixing the waste means the need to pay for segregation.” The main cost elements of waste generation on projects were identified to be the cost of materials, the cost for transporting waste and the payment for landfilling of waste. Similar results have been reported in Shen and Tam (2002). Cost was also identified to be the easiest message to ‘sell’ to operatives who were involved in handling materials and work processes.

The next most important driver for WM on all nine projects was client demands where site teams were influenced by the specific demands a client may have for WM (sustainability inclined clients). It was identified that clients such as high street shops generally want high performance in terms of waste and sustainability. The extent of client demands driving WM on projects was to a large extent determined by the type of client. The South East Environmental Manager for Company B who served as an Environmental Manager on Projects B1 and B2 suggested: “the client has got the money and it depends upon what they feel. Some clients will go for the BREEAM

rating, which is highly coded, highly energised to wastage and control thereof, whereas clients that don't have would just be happy to get their building up and not consider that." The Project Manager on Project B2 also passed this comment: "the likes of Network Rail, ask questions like 'well, what are you doing about your waste, how are you managing it, how are you controlling it, what's your WM plan?' Such clients are interested in putting up sustainability reports and as such will require high performance on WM and these requirements drove WM on their projects. For sub-contractors who were involved with the day project, the main incentive for sustainable CD&E WM was the promise of repeat jobs from the main contractor. Sub-contractor personnel interviewed for this research explained that WM and sustainability performance was one of the basis for selecting sub-contractors by main contractors and this influenced their WM efforts. Another driver influencing the WM actions of sub-contractors was identified to be the charging schemes instituted by some project managers for poor WM where sub-contractors were charged for putting waste in the wrong skip.

Another very important factor driving waste at the project level was Health and safety concerns. Site teams suggested that the health hazards posed by waste generation and mismanagement on site served as a driver for WM. Another common driver on almost all projects was identified to be the changing perspective in the industry on the environment which is largely driven by realisation of the negative impacts of the industry on the environment. Legislative requirements such as the need to transfer waste to qualified persons, the need to seek clearance for the management of special waste and the need to use WM plans (which is no more a legal requirement), were identified to drive site level WM strategies. Interview with site teams also suggested that government legislation did not have a directed impact on site teams as this is mediated by company policies.

Comparing Corporate Level and Project Level Drivers for CD&E WM

Comparing figures 1 and 2, it is evident that drivers for WM at the project level do not always mirror the drivers at the corporate level based on the two tier nature of the industry. Where similar drivers are identified between corporate and project levels, the extent to which these drivers influenced WM also differed based on project characteristics and the project team in charge of WM. This difference can be attributed to the two tier nature of the construction industry. Whereas the corporate level determines the general direction of the activities of the company, the project level factors impact on the actual WM practices. Table 2 compares the corporate and project level drivers based on their criticality to WM.

Although previous studies have discussed drivers of WM such as economic incentives, government legislation, environmental concerns, client demands and benchmarking (See Wu *et al.*, 2017; Ajayi *et al.*, 2015; Osmani, 2012, Pit *et al.*, 2009;), which are all largely corporate level factors, the lack of attention to the two-tier nature of the industry remains a gap. Not considering drivers of WM at the two-tier level, means the potential to influence the extent of WM on site has not been fully utilised. Udawatta *et al.*, (2015) suggest that corporate level policies have a big impact on CD&W WM. Although this is true, the project level drivers bring another dimension to CD&E WM. As reported in Bakshan *et al.*, (2017) and Theo and Loosemore (2001), behavioural factors have an influence on WM at the project level. This implies that the drivers at project level could also be taken into consideration at the corporate level to influence corporate level waste policy.

Table 2 Comparison of corporate level and project level drivers for sustainable WM

Case study	Corporate level drivers	Project level drivers
A	Company sustainability agenda, economic considerations, company image, client demands, government legislation, environmental concerns, moral and social imperative, industrial benchmarking	Economic considerations, assurance of repeat jobs for sub-contractors, health and safety concerns, client demands, company vision, government legislation, changing industry perspective
B	Economic considerations, company image, client demands, government legislation, environmental concerns, industrial benchmarking	Economic considerations, charges for sub-contractors, client demands, company image and agenda, environmental concerns, government legislation
C	Economic considerations, company image, Company agenda, client demands, government legislation, environmental concerns, requirements of standards, industrial benchmarking	Economic considerations, assurance of repeat jobs for sub-contractors, health and safety concerns, client demands, charges for sub-contractors, government legislation, changing industry perspective, requirements of standards, environmental concerns
D	Economic considerations, company image, moral and social imperative, client demands, government legislation, environmental concerns, industrial benchmarking	Economic considerations, company target of zero waste to landfill, changing industry perspective, government legislation and environmental concerns

Although company agenda, economic considerations and client demands were the most critical factors at the corporate level, at the project level other factors such as health and safety concerns, charging schemes for sub-contractors and assurance of repeat jobs serve as very critical factors. Tam *et al.*, (2007) suggest there is direct link between sub-contracting arrangements and WM. This link occurs by way of sub-contractors' performance regarding WM. As shown in this research, the extent to which WM performance influences the likelihood of repeat projects drive project level WM. Although sub-contractors' performance occurs at the project level, taking this into consideration at the corporate level is likely to influence WM performance. Results from the project level suggests that project level WM depend to a large extent on the project teams. Theo and Loosemore (2001) and Bakshan *et al.*, (2017) report that attitude of project personnel impact on WM on site. For projects where corporate level staff were involved with site processes, results from this research indicates that corporate level drivers for WM have more impact. This suggests that conscious efforts should be made to enforce corporate level WM policies on site. For example, where H&S professionals were involved on site, H&S became a major driver. The results suggests that unless company waste management policies take project level factors into consideration, the WM goals of companies are not likely to be achieved.

CONCLUSIONS

From the implications of the results discussed above, it can be concluded that the current approach to sustainable WM will benefit from acknowledging the difference in factors driving WM at the corporate and project based levels due to the two tier nature of the construction industry. Considering the two tier nature of the construction industry, this research suggests a rethinking of corporate approaches towards WM taking project level WM drivers into consideration. In addition to the corporate level WM drivers such as company sustainability agenda, economic considerations, company image, client demands, government legislation, environmental concerns, moral and social imperative, industrial benchmarking, and requirements of standards, project level drivers such as: health and safety considerations, charges for sub-contractors, the assurance of repeat jobs for sub-contractors, and changing perspective of project teams are very important considerations for WM. The extent to which corporate strategy influences project level WM practices is to a large extent determined by the measures in place by the company to enforce corporate policy on project teams. Tying down WM strategies to the likelihood of repeat jobs and health and safety performance will have a key impact on sub-contractors and ultimately

influence WM performance as majority of projects are executed through sub-contracting. The design of government legislation on CD&E WM can also benefit from considering these drivers as they have a direct impact on waste generation and management on projects.

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THE IMPACT OF BREXIT ON CROSS-BORDER TRADE BY THE CONSTRUCTION SECTOR IN IRELAND: AN EXPLORATORY STUDY

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Cross-border co-operation can foster learning and contribute positively to business performance and social cohesion. This paper considers construction firms' economic motivation for co-operation around the Ireland - Northern Ireland border. This area, while impacted by the Brexit uncertainty, shares many of the economic and developmental characteristics of border areas throughout Europe. The purpose of the study is to investigate the impact of Brexit on cross border trade by the construction sector in Ireland and investigate the current tensions and barriers to that sector. A qualitative methodology adopted a literature review and semi-structured interview strategy. Data was collected from purposively selected contractors in the North and South of Ireland, who have recent experience of cross border construction. Qualitative analysis identifies themes and issues arising which enabled examination of commonalities and differences between the respondents. Differing regulatory regimes, perceived barriers to cross-border co-operation and uncertainty reduce cross-border trade. The study establishes the lack of Brexit preparedness of industry and the need for more industry specific research regarding the level of existing cross border trade, and the measures that could be adopted to resist fragmentation and integrate Irish cross border construction trade in the context of Brexit.

Keywords: border, Brexit, co-operation, fragmentation, Ireland

INTRODUCTION

On the 23rd June 2016, the United Kingdom (UK) voted by 51.9% to 48.1%, to leave the European Union (EU). In Northern Ireland (NI), 56% of voters opted to remain in the EU. As the only region with a land border between the UK and the EU, the potential risks for Ireland, North and South are severe; impeding cross border trade, labour and supply chain movement (Doherty *et al.*, 2017). At present, tens of thousands of people move freely across the 500km Irish border every day (Basheska *et al.*, 2017). Whilst the final form of Brexit adopted will not be known until detailed trade negotiations are complete, political, legal and commercial arrangements across

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the island of Ireland will be altered, entailing adjustment and potentially making cross border trade more difficult and expensive (de Mars *et al.*, 2016).

Cross border cooperation has been credited with building prosperity and peace (Hayward and Magennis 2014); company cooperation can also facilitate knowledge exchange and increase innovation. However, the Irish border acts as a fault line dividing the economies of the North and South of Ireland. It separates the more dynamic South from the North, which has growth levels lagging behind the Republic of Ireland (ROI) (Hayward and Magennis 2014) and has been characterised as "inward orientated...[with] a small private sector, and an over-reliance on the public sector" (Hübner 2015:3).

Given the uncertainty regarding the outworking of Brexit, there has been little research regarding its impact on the construction sector in general, and none on the construction sector across the North and South of Ireland. The UK Government's construction focused Brexit analysis was published on the 21st December 2017; however, the government analysis contains no primary research. Potentially the most interesting parts of the Government paper, the section covering sector views and stakeholder engagement, were redacted prior to publication.

To clarify the terminology used throughout this study, the term 'Ireland' refers to both the North and South of Ireland. NI refers to Northern Ireland, and ROI refers to the Republic of Ireland, the South. The UK is the United Kingdom of Great Britain and Northern Ireland; whereas Great Britain (GB) refers to England, Wales and Scotland. The authors of the paper do not intend to take a position regarding the rights and wrongs of the Brexit vote, nor of the position and status of the border in Ireland. Instead they aim at dispassionate analysis, undertaken as objectively as possible, given the authors' own backgrounds and experiences.

BACKGROUND

Cross Border Cooperation - from 1922 to Today

Since 1922 when the Republic of Ireland was founded, the citizens of the Republic of Ireland and the UK have been free to travel and work across both jurisdictions, giving Irish and British nationals special status in their closest neighbours' jurisdictions. The Common Travel Area (CTA) was formally agreed and ratified in 1952. Trade tariffs were reduced then dismantled in the 1960s as part of the Anglo Irish free trade agreement (Hayward and Magennis 2014). The close trading relationship was consolidated in 1973 when both ROI and the UK joined the EU; however, the value of cross border trade fell as a result of the conflict in the North in the 1970s and 80s. It is important to note that the CTA predates, and is distinct from, EU membership. The practical result of the CTA is the absence of any physical manifestation along the 500km long border between the North and South of Ireland (Barrett *et al.*, 2015).

Cross border trade accelerated from 1994 onwards (Hayward and Magennis 2014). The 1998 Good Friday Agreement marked a watershed in cross border relations and trade, providing for institutions specifically set up to enhance North - South cooperation and trade, including the North South Ministerial council (Tannam 2006). The EU has provided 1.3bn Euro of 'peace funding' to the North and South of Ireland since 1995, in itself a 'powerful incentive' for the two parts of Ireland to work together, creating 'symbolic' and concrete policies of integration (Keating 2004).

Both sides of the Irish border were affected by the early 2000s construction boom and subsequent bust. The ROI construction industry fell 76% from its 2006 peak output to

€9.1 billion in 2012 (SCSI 2015). The North also suffered, contracting from 2007 to 2014. Cross border trade dipped during the recession, particularly during 2007 - 2010 in "products that were tied to the construction boom" (Hayward and Magennis 2014:160). The construction sector, which has taken years to recover from the worst effects of the recent economic recession, is still susceptible to uncertainty and economic shock (Tansey and Spillane 2016).

European Integration Theory

European Integration theory emerged in the 1960s (Wiener and Diez 2009). Its premise can broadly be summarised that, as Europe became more integrated and assumed more significance in citizens' lives, the rules and boundaries imposed by their national governments would fade in significance, thus creating a condition of 'fuzzy statehood' (Emerson, 2001). Haas defines integration as the process "whereby political actors in several, distinct national settings, are persuaded to shift their loyalties, expectations and political activities toward a new centre, whose institutions possess or demand jurisdiction over the pre-existing national states" (Haas 1958: 16). Keating (2004) claims that operating within the European Union can help ease tensions between state and nationality, enabling borders to be transcended. The stated objectives of the peace funding are "cohesion between communities involved in the conflict in Northern Ireland and the border counties of Ireland; and economic and social stability" (Azevedo and Haase 2017). The resultant cooperation has helped characterise the border area as an evolving patchwork of integrated multiple identities which are continually asserted and negotiated (Keating 2004).

Barriers and Drivers of Cross Border Trade

In the pre Celtic Tiger and pre-1998 Belfast agreement era, Hitchens *et al.* (1996) noted low levels of cross border trade in business services (advertising, graphic design, market research, product design and management consultancy). They noted the main barriers cited to cross border trade in these industries as travel time, travel costs and the frequency of meetings. Tannam (2006) examined the issue of fragmentation caused by the Irish border from a 'bottom up' perspective, where embryonic cross border economic cooperation might multiply from informal, loose contact, to more formal networks of cooperation, generating a domino effect. She found that the single European market had integrated many regulatory and policy positions across the border, enhancing the environment for cooperation. However, she cited "perceptions of conflicts of interests among civil service departments, compartmentalisation, business perceptions of conflicts of interest, insufficient information provision and the need for institutionalisation of cross-border arrangements", as barriers to cross border trade (Tannam 2006:259). These barriers were weakened where economic incentives were sufficiently strong.

In 2006, Roper conducted a study examining the extent of cross border trade and found the extent of local cooperation to be far greater than that of cross border cooperation. One of the reasons cited was that Northern companies were discouraged from trading across the border, in part, due to higher labour costs found in the South. Hayward and Magennis in 2014 found barriers to cross border trade include material impediments, such as differing currencies, taxation and regulatory regimes; and psychological barriers, including an asymmetric knowledge base regarding the home and the target market. Hitchens *et al.*, (1996) suggested that enhanced cross border trade would reduce dependence on local markets, producing a competitive advantage in larger, global markets. Exchange rate instability has been found to drive trade

across the border, the direction dependent on the relative fluctuating strengths of the Pound Sterling and Euro (Roper 2006).

Possible Scenarios and Outcomes from Brexit

It is beyond the scope of this paper to enter into detailed discussion of the possible options which may be adopted for the relationship between the UK and the EU - hence NI and the Republic of Ireland - post Brexit. However, it is worth covering in broad terms the likely implications of Brexit and its impact on Ireland.

If a post Brexit UK opts out of the single market and the customs union, then the Irish border effectively becomes the external border of the EU (Basheska *et al.*, 2017), where EU regulations and tariffs must start to apply (Mars *et al.*, 2016). This could lead to potential restrictions on freedom of movement for business and for the Irish workforce, North and South. The effect on the citizens of Ireland may be mitigated by the CTA (Schiek 2017) or a 'technological' solution, but any bespoke arrangement must be agreed by the UK, ROI and the 26 other members of the EU (Basheska *et al.*, 2017). A 'no deal' Brexit is problematic: under WTO rules, basic construction materials could be levied between 4 - 8% at the border (De Mars *et al.*, 2016).

Barrett *et al.*, (2015) predict that Brexit will impact both North and South Ireland, but the North will be the worst impacted. Brownlow (2016) suggests that negative outcomes could include reduced trade and investment, economic slowdown and uncertainty in labour, materials and money markets. Economic predictions are notoriously unreliable, but Oxford Economics modelled nine different Brexit scenarios in February 2016; and found that the economy of Ireland is disproportionately affected (relative to other EU countries) in every case (Oxford Economics 2016). The same study finds Construction in NI to be one of the two most vulnerable sectors to the impact of Brexit, suffering a predicted 4.9% drop in output, due to its sensitivity to business investment as the foundation of demand. Northern Ireland suffers (with the rest of the UK) from low productivity (Brownlow 2016); hence does not have the resilience that the South might have (Hayward and Magennis 2014), nor the policy flexibility, to weather a potential Brexit economic shock.

Whilst Brexit presents many dangers, it may present an opportunity to the Republic of Ireland, as the last English speaking country in the EU with a well-educated, young population (Schiek 2017) and a taxation regime designed to attract Foreign Direct Investment. De Mars *et al.*, (2016) predict that ROI may emerge as 'winners' from Brexit, which would consolidate its current comparative trade advantages.

Historically, Ireland has been the largest provider of non-native construction labour in GB, but the indigenous Southern Irish construction industry has grown in output and sophistication in recent years, enticing many workers home. In GB, these 'lost' Irish workers have been replaced with those from recent EU accession countries (Fellini *et al.*, 2007). The all Parliamentary working group report "Building on Brexit" found that in 2015, the five most common non-UK countries of birth of construction workers were Poland (55.5k), Romania (27k), India (19.4k), Lithuania (17.9k) and ROI (15.k). With the exception of offsite construction, the construction product is largely stationary, requiring a mobile workforce (Fellini *et al.*, 2007). Restriction of freedom of movement for EU workers into the UK will most likely present a recruitment problem for the construction industry.

It is important to note that despite the referendum outcome, as yet nothing has legally changed. For now, until withdrawal negotiations are completed, the UK remains a part of the EU, and compliance with EU law is required. The political likelihood of

any contest to the outcome of the Referendum is currently low and therefore the authors assume that the UK will be leaving the EU, setting out the research in this context.

RESEARCH APPROACH

This research aims to better understand how the architecture, engineering and construction (AEC) industry in both Northern Ireland and the Republic of Ireland has begun to make sense of the recent decision and expectations following the outcome of the UK vote for Brexit. The methodology applied was determined on the basis of relevance to the focus of this research enquiry, but also on the basis of pragmatic positioning. This was the case as a different methodological stance would not have allowed the research to be completed within the constraints applicable. Creswell (2009) states that research methodology is the systemic approach that a research enquiry adopts to accomplish the research's aim and with that in mind, an explorative interpretivist position has been adopted. In relation to the purpose of the research, it is surmised that the theoretical argument developed for the enquiry has the potential, by using an explorative perspective, to reveal new insights and a better understanding of stakeholder perceptions and awareness of how Brexit will impact on cross-border trade by the construction sector in Ireland and whether there is some alignment of those positions.

The underlying aim of the study is to investigate the impact of Brexit on cross border trade by the construction sector in Ireland and investigate the current tensions and barriers in that sector. The overall research process involves the following steps; (1) a review of the existing literature. 'Grey' literature was included, due to the dearth of peer reviewed journal published data in this area; (2) purposefully selecting sample firms working in the design and construction industry who have historically been associated with cross border AEC activity; (3) developing the semi structured interviews; (4) performing interviews and collecting data from the selected participants; and (5) analysing the collected data.

The semi-structured interview process involved a set of interview questions developed in advance with the same questions asked to each interviewee with a consistently administered process (Campion *et al.*, 1988). Each interview started with questions relating to the participant's background, experience and company. The questions then probed existing trade patterns, barriers and drivers for cross border trade, and the participant's predictions for changes that Brexit might bring. The agreed participants included 9 senior AEC professionals recently involved in cross border AEC activity; from either side of the border as shown in tables 1 and 2. The interviews were transcribed verbatim then analysed using an iterative analysis to determine themes. The use of structural and descriptive coding (Saldana 2016) in NVivo software (version 11) assisted in identification of themes in the interview data (Fereday and Muir-Cochrane 2006).

Table 1: Summary of Northern interviewees' organisations

Northern Ireland Interviews	Type of Organisation	Interviewee Position	Size (Employees)	Turnover (€ equiv /yr)	Current cross border trade (% of turnover)	Current Trade in GB (% of turnover)
Interviewee 1	Industry Representative Body	Assistant Director	N/A	N/A	N/A	N/A
Interviewee 2	Modular / off site construction co	Director and Innovation Manager	250	€75m	10% of turnover	90% of turnover
Interviewee 3	Contractor and property developer	Director	100	€33m	<1% of turnover	1% of turnover
Interviewee 4	Contractor and FM provider	Procurement Manager	1800	€562m	2% of turnover	60% of turnover
Interviewee 5	Contractor Building and Civil	Procurement Manager	500	€281m	2% of turnover	75% of turnover

Table 2: Summary of Southern interviewees' organisations

Republic of Ireland Interviews	Type of Organisation	Interviewee Position	Size (Employees)	Turnover (€ / yr)	Current cross border trade	Current Trade in GB
Interviewee 1	Civils and General contractor	Director	350	€600 Million	7% of Turnover	NA
Interviewee 2	General Contractor	Director	300	€300 Million	NA	2 contracts (England)
Interviewee 3	General Contractor	Director	385	€750 Million	15%	5 contracts (England)
Interviewee 4	Building and Civil Contractor	Director	1208	€1.3 Billion	NA	26% of Turnover

FINDINGS / DISCUSSION

1. Existing North-South and East-West cross border trade of workers and materials

Contractors with live projects in the Irish border region report using a number of direct employees, subcontractors and materials from the opposite jurisdiction for their delivery. However, the main direction of travel is East - West, where key members of staff from organisations all over Ireland travel to GB to deliver contracts there. Organisations working in GB reported using local expertise to navigate regulatory and employment requirements. One of the larger Irish organisations described their long-established presence in GB. The company had established local regional bases to foster loyalty amongst loyal employees and subcontractors and counter the perception of their organisation as 'parachuted in' from Ireland. Physical offices in GB were seen as a key to maintaining flexibility with the ability to "upscale or downscale dependent on how the markets are reflecting." In addition to a physical base, one ROI interviewee's organisation had established a UK registered trading division which controlled UK regulatory compliance.

In NI and ROI, gypsum and steel products are ordered from the GB, Spain, France and China. In terms of movement of material, the importation of goods to NI through Dublin ports was singled out as a key logistical route for EU materials and specialist systems. EU Kitemarking was cited as an important indicator of quality when ordering materials. One southern contractor ordered 60% of materials from outside Ireland, of which 40% came from the UK.

2. Employment of EU workers

Fewer young people are entering into construction, good apprentices are hard to recruit, and the existing skilled workforce of those interviewed is aging. The director of the NI Industry representative body cited an example of a member whose average bricklayer age is 52. A small, but significant, proportion of workers in the

interviewees' companies Northern and South Irish workforces were of EU origin, mainly from recent EU accession countries. In the contracts delivered in GB, reliance on EU workers was heavier and their significance in the workforce greater still. A NI interviewee stated, "We're highly dependent on EU labour to deliver our infrastructure projects, we're highly dependent on our supply chain of subcontractors who employ EU migrant labour". Another NI interviewee described a subcontractor thus "if they didn't have the foreign labour, they wouldn't be able to operate, they've told me that."

EU workers and subcontractors were unanimously reported as being hard working, with one interviewee remarking; "if anything the productivity and work ethic is fantastic." Cultural and language barriers, although referenced, were not considered significant, with pictorial health and safety signage and dual language health and safety briefings commonplace.

3. Factors restraining North-South cross border trade at present

In the interviewees' organisations, it is notable that the extent of current cross border trade in construction is limited. There are currently no restrictions or impediments at any point across the 500km land border between North and South. Contracts are advertised in the Official Journal of the European Union (OJEU) and experience, qualifications and accreditations are mutually recognised. Yet, of the eight construction contractors interviewed, two in the South had no contracts in the North; and three in the North had very limited cross border trade.

Regulation in the opposite jurisdiction cannot preclude an organisation from tendering. However, in the view of one interviewee, regimes in the North and South are "definitely not fully aligned at the moment" with requirements such as the obligation to submit an additional set of accounts with a differing accounting period to that in the home jurisdiction. Although qualifications should be mutually recognised, interviewees have encountered issues with recognition of basic Health and Safety cards (CSR in the north and CSCS in the South). These factors add an administrative burden which disincentivises small and medium firms from tendering across the border. Social clause requirements, measuring the extent that the contract value is ploughed back into the local community, have impeded cross border trade. Although requirements vary, they tend to favour a contractor with a local presence; a physical base in the contract area. As suggested by one interviewee "...if you aren't local and you are not doing that...you are at a disadvantage."

From the NI perspective, the southern marketplace is seen as too competitive to justify a sustained effort in winning work there. Pay rates, compared to those in the North, are high, and profit margins, compared to those in GB, are low; echoing Roper's earlier findings (Roper 2006). The size of the market in Great Britain is clearly a huge magnet for experienced, competent contractors from both sides of the border, with three quarters of all contractors interviewed conducting substantial trade across the Irish Sea.

4. Effect of Brexit to date

To date, construction investment in Ireland and GB has slowed, as investors wait for a clearer picture of the Brexit outcome. In GB there has already been an immediate economic impact on the construction industry, with forecasts for growth being revised downward for 2017 and 2018. Financial experts have predicted that the uncertainty as to the terms of a UK exit will have a negative effect on the construction industry until investor confidence returns.

Sterling has fallen significantly in value against the Euro since the Brexit vote - from £1.29 to the Euro on the 23rd of June 2016, to £1.14 to the Euro, at the time of writing (March 2018.) This has led to dramatic price increases for imported goods, and for raw materials such as timber and steel. One Northern interviewee reported a 60% increase in the price for steel, with a further 20% expected. Timber had increased in price by 25%, leading to a requirement for client 'education' to expect a rise in tender prices. This is a particular issue on multiyear and framework contracts, where no inflation mechanism exists, and the contractor is expected to absorb price rises. Interviewees have started to price currency risk into contracts at tender stage. One Northern contractor has countered this risk through forward buying materials and exploiting their buying power by setting up project specific purchase agreements directly from manufacturers. The expectation is that suppliers "will be loyal to that supply chain agreement and try and hold prices regardless of Brexit." Currency fluctuations have had a positive impact on the profitability of contracts in ROI for Northern Contractors; however, as these tend to form a small percentage of their turnover, they don't offset the problems caused to their organisations by rising prices.

Brexit opportunities were identified by two interviewees. The first, from NI, was involved with providing modular office accommodation in ROI for a pharmaceutical company which wanted to establish a laboratory sign off facility in the EU, prior to Brexit. According to the interviewee, this move was intended to reassure shareholders that the company had 'ticked a box' to ensure compliance with EU regulation, and he identified this approach of risk management, using modular construction as a quick, low cost base, as potential growth area for his company. The second interviewee, from ROI, was filling his order book as financial institutions and international organisations establish bases in the South of Ireland, prior to Brexit, for similar reasons.

5. Potential effects of Brexit: hopes, fears and predictions

All interviewees hoped for a soft Brexit, where the Irish border remains essentially unchanged from its position today. Any sort of hard border creates problems for construction organisations, North and South, and is variously described as "unacceptable" "potentially unworkable" and "disastrous." Customs checks will bring additional delay to construction deliveries and potentially add a bureaucratic burden, as suppliers may have to demonstrate country of origin; and workers and subcontractors might be required to prove their nationality or demonstrate a right to cross the border for work. Customs checks in the Irish Sea would disrupt East - West construction trade, which forms an important part of the business of three quarters of the construction companies studied.

None of the interviewees wanted any divergence in regulation - health and safety, environmental, or procurement - post Brexit. One northern interviewee referred to the UK conversion from British Standards in structural design to Eurocodes and said "I wouldn't like to be in a position where we would have to be adhering to two different standards. I just think that is a recipe for confusion."

CONCLUSION

From a legislative perspective, Brexit is unlikely to cause any immediate change, although in the future, it may give the UK more flexibility in relation to its procurement, environmental and health and safety legislation. The extent of any changes will be dependent on the nature of the new relationship with Europe and/or membership of the single market and customs union, and it remains to be seen how

this will impact on the Irish construction industry. Some opportunity may emerge as companies seek to establish residence in ROI; however, Brexit opportunities are less obvious and less tangible than the potential drawbacks.

The central theme throughout the interviews is the extent of uncertainty regarding the outcome of Brexit and its impact on the border in Ireland; and to North-South and East-West trading relationships. Construction companies are used to uncertainty - "uncertainty is pretty much a fact of life but over the last 10 years, the degree of uncertainty has increased, perhaps more than at any point in our generation." This uncertainty feeds into the climate for business and appetite for risk on both sides of the border. However, there is a limited amount of planning and preparation that can be undertaken to counter Brexit risk, as "It's so unknown - what are you planning for?" The construction industry has always been reactive but with respect to Brexit, this approach seems the only option as "nobody knows what's going on, and we'll probably deal with it when it comes rather than do some sort of planning for it."

This study underlines the need for further research, to examine ways in which the Irish construction Industry can be integrated North and South; and how further fragmentation can be resisted in the context of Brexit. The interviewees, and the researchers, find themselves in a situation with more 'unknown unknowns' than any politician on the "leave" side was willing to admit during the Brexit debate in 2016; and which are only going to become apparent in the weeks and months ahead. We are, it seems, unfortunate enough to live in interesting times.

W.B. Yeats, that greatest of Irishmen, more alive to the subtleties and nuance of the Anglo-Irish relationship than almost anyone, once wrote that "Things fall apart; the center cannot hold; Mere anarchy..." Is this what we are facing? Only time will tell.

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ATTRIBUTING VALUE TO WASTE: THE DIFFICULT ROAD TO EFFICIENT WASTE MANAGEMENT FOR RENOVATION PROJECTS

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The focus on sustainability has pressed the construction sector to process and optimise Construction and Demolition Waste (CDW) activities. The potential of collecting and recycling of waste has received a considerable amount of attention. The life cycle of various products and material is well documented and many models are aiming at optimizing the supply chain and logistic processes. The processes of new built seem to be under control in the Swedish context, but the handling of renovation and demolition waste, traditionally considered as low value work, is still lacking behind. Moreover, the different actors included in this process tend to attribute the responsibility of this situation to each other. In this context, we are interested in how the actors value waste in the different phases of a renovation project. To do so, we build on the concept of value as defined by the sociology of economics, which enables us to appreciate the creation of value as the result of direct interactions in delivery activities and analyze these processes as socially shaped and consequently open to possible changes. We focus on the case study of a renovation project to illustrate the various interpretations and translations of value. We gathered observations on site and interviews with the actors involved: client, architect, contractor, sub-contractors, workers on-site and future users. The preliminary results point at a diversity of understanding and practices of what value is for the different actors, sometimes even contradicting each other, which may jeopardize the expected results for CDW management. The concept of value helps us to analyze the shaping of these practices and consequently may contribute to the improvement of the CDW processes.

Keywords: actors, construction and demolition waste management, value

INTRODUCTION

The European Commission indicated construction and demolition waste as one of the voluminous waste streams; statistically, it accounts for about 25% - 30% of all generated waste streams in the European Union (EuroCommission 2016). This waste consists of concrete, bricks, gypsum, wood, glass, metals, plastics, solvents, asbestos and excavated soil that are considered to have a residual value that can be recycled (EuroCommission 2016). The European commission has indicated that there is a re-use market for aggregates derived from construction waste in roads, drainage and in other construction projects. Moreover, waste management technologies developed and established for sorting and recovery of materials should ease the process

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(EuroCommission 2016). Accordingly, waste could either be avoided to a large extent or reduced, which should produce benefits for construction industries and ensure a green environment.

Despite the established model for waste management i.e., reducing, reusing, recycling, and residual disposal (4Rs) within the construction sector (Peng *et al.*, 1997), most of the construction companies have been slow to embrace these practices. Waste reduction activities have traditionally not been considered as cost-effective, efficient and compatible with core construction activities (Teo and Loosemore 2001). Although Sweden is one of the leading nations in terms of sustainability and environmental consciousness, waste management does not yet reach the expected recycling target (Hall and Nguyen 2012). However, considering the large amount of buildings in need of renovation, waste management is critical to the sector and has the potential to become a new business (Bosch-Sijtsema and Buser 2017, Hall and Nguyen 2012, EuroCommission 2016).

To address the challenges of Construction and Demolition Waste Management, (CDWM) our literature review reveals a large production focusing on measuring waste generation through simulations, live cycle analysis, and mathematical models, or on the sorting of singular material (Bosch-Sijtsema and Buser 2017, Yuan 2013). The majority of the papers in this area focus on new-build and the specificities of renovation or refurbishment are generally not addressed. Renovation waste management follows a different process than new build and is less regulated. The material is often composite, its quality complicated to assess and consequently difficult to reuse or recycle. To increase CDWM performance on site, authors recommend to invest in CDW planning and management tools, organize adequate supervision of waste management activities, deliver clear company policies, provide training and education for all stakeholders, support with financial rewards and incentives, engage the participation of all stakeholders in taking initiatives and responsibility and optimize the supply chain and its connection. Whereas the contractor role is central in this discussion (Alzahrani and Emsley 2013), other stakeholders such as sub-contractors and recycling companies active in reusing, recycling or disposing of renovation waste, take an increasing role in developing new practices related to CDW management in the industry and creating new business value (Adams *et al.*, 2017).

Although, there is a general agreement in both the literature and among practitioners about the potential value of CDW, the notion of value itself seems to be taken for granted. However, previous work indicates that the value the stakeholders assign to waste is not univocal and covers different meanings and interests (Buser and Bosch-Sijtsema, 2017, Bosch-Sijtsema and Buser 2017). So, in order to discuss some of the challenges of renovation waste management and inform on the lack of generalised processes, we build here on the notion of value or more precisely on the act of valuation. Valuation can be defined as: any social practice where the value or values of something is established, assessed, negotiated, provoked, maintained, constructed and or contested (Doganova *et al.*, 2014); it gathers the practices which structure markets through categorizing, ordering and hierarchizing goods enabling consumers and others to make decisions (Kornberger 2017). The paper contributes to the understanding of waste management, by underlying that the valuation of renovation waste covers a number of different and sometimes conflicting practices and outcomes.

Theoretical Frame

A large part of literature in economics assumes that value is either inherent to the property of object or service and accordingly can be measured in terms of profit (Kotler and Armstrong 1997, Lanning 2003), or that it is the result of subjective preferences representing particular value interpretations and interests of specific groups (Grönroos 2000, Miles 2005). Applied to the case of renovation and demolition waste, the value would either be the price calculated in reference to type, quality and weight of the material, or the results of the interest and mitigation of the professional actors of the sectors debating the market.

Another view, building on economic sociology and valuation studies (Callon 1998, 2007, Muniesa *et al.*, 2007), aims at conceptualising value as the association of ongoing valuation practices. Valuation practices are participating to the construction of markets, defined as an arrangement of heterogeneous elements such as rules, and regulations, technical and calculative devices, discourse and material infrastructure (Doganova and Karnøe 2015). These devices appear as critical elements in the valuation process as they stabilize and visualise the product's qualities. But they do not erase uncertainty, rather they highlight the existence of differences in valuation practices (Callon *et al.*, 2007). Orlikowski and Scott (2014) suggest that the shift from actors and categories to practices contributes to a more dynamic and broader understanding of the valuation process. This shift to a practice-based view brings attention to "the specific everyday activities that constitute valuation processes and the outcomes generated as a result" (Orlikowski and Scott 2014, p. 869).

For waste, it means to study the valuation practices that constitute waste as valuable in the first place (Heuts and Mol 2013). This includes the practices of evaluating and ordering material with measurements, norms, standards, indexes, classification, rankings or prices; of mediating between producers, clients, administration and experts, between competing claims, assessments and legitimations, between professional and academic knowledge, between industry guideline and behaviour on site, between theoretical properties of waste material and its properties on site. It contains as well the struggles over competing claims in regards to the legitimacy of different valuation practices, devices and criteria and the categorisations of what is valuable (Kornberger 2017). These practices are seen as constitutive, they do not only mirror existing value but are actively involved in the construction of values (Kornberger 2017). Besides, they are not mere abstraction, but are organised through concrete bases such as material, concrete technologies and visualisation that enable and amplify their actions (Feldman and Orlikowski 2011). This valuation perspective has been used in contexts as diverse as the wine industry (Bessy and Chauvin 2001), law school ranking (Espeland and Sauder 2016) online hotel assessment (Orlikowski and Scott 2014), or cleantech technology (Doganova and Karnøe 2015).

Building on these insights, we explore the constitution of waste value by focusing on the practices and devices involved in the valuation process of a group of stakeholders engaged in the management of renovation waste in a Swedish big city.

METHOD

The present article reports the preliminary findings of an ongoing three years' interdisciplinary research project gathering both practitioners and academics active in CDWM in Sweden. The project focuses on gaining an overall picture of the CDW industry, their practices as well as how they develop new innovations in both material

and processes. The method is multidisciplinary and employs an interpretive approach to discuss the empirical material (Bryman and Bell 2011). The theoretical frame draws on a selective literature review focusing on valuation as well as a literature review on the CDW management in construction. The objective is to develop an appreciation and articulate the dynamics of practices and describe how waste valuations, their boundaries, properties and identities, are performed. We aim at identifying these valuations by focusing on the different actors' accounts and practices (Cecez-Kecmanovic *et al.*, 2015).

To do so, in the joint project platform, we have participated in and observed three general meetings and three workshops organised by the research project discussing the potentials, challenges and barriers of CDWM (see table 1 below). The workshop consisted of a selection of representatives of the CDWM industry and focussed on small group discussions based on a SWOT analysis (Strengths, Weaknesses, Opportunities and Threats) of recycling of construction waste.

Next to the joint project platform, we interviewed a group of representatives of diverse companies and services and administration engaged in construction renovation. The list of interviewees is presented in table 1 and consists of representatives participating in renovation waste management and contributing to the valuation practices of waste. We followed their concrete considerations, choices and actions handling waste management from design to recycling, burning or landfilling. The 27 interviewees are listed below; the majority of the interviews were recorded and transcribed (see table 1).

Table 1: list of the people involved in the data collection

	Interviews	Workshop
Contractors (project managers, site manager, production manager, sustainability coordinator)	10	2
Subcontractor	1	
Demolition contractor	1	
Recycling contractor/firm	6	1
Architect	1	1
Suppliers		2
Municipality (Gothenburg)	4	3
Industry representatives (associations etc)	1	1
Clients/FM	3	1
Researchers		9
Total	27	20

We followed a single renovation case study and visited the site in different phases of the project, performed observations on the site and interviewed the site manager, production manager, FM firm, and sub-contractor. These events were documented with notes and pictures and some discussions were also recorded.

Besides, we have gathered numerous written documents including professional guidelines, norms and certifications, companies' websites, renovation projects and quality control protocols, waste material descriptions, price lists and price calculations, and national and European governmental reports. As this study is

exploratory, we have followed a rather iterative process. The material has been organised and analysed according to the emerging themes related to value and valuation.

VALUATION PRACTICES OF WASTE

The following description presents the valuation practices of a group of stakeholders participating to a renovation project including waste management in one of the largest cities in Sweden.

Valuation Practice at the Property Company

The FM-firm is a mid-sized property company which is running university and office buildings. The main task of the property company is facility management and accordingly they renovate their facilities on an almost continuous base. They flag sustainability as their main competence and use environmental certification to frame the scope of their renovation. Though they let the contractor deal with the organisation of the site and the management of waste during the renovation project, the FM-firm is eager to set clear requirements for handling and recycling of waste during their projects. They wish to have reliable statistics on the treatment of their waste once it has left the building site. As it stands now, the contractor is only obliged to act as much as possible according to sustainable practices. The only information the FM-firm possesses currently, is the quantity of the waste either in kilos or number of dumpsters. Dumpsters are related to the quality in term of material: electric, plastic, metal, tree, gypsum, and "burnable" which gathers everything not fitting with the previous descriptions or is smaller than one-meter. The FM-firm would like to test out how to set up more precise requirements and how to follow up on these with their main contractor to be sure that the waste produced by their sites is treated in the "most sustainable" way. However, the two project managers we have talked to, with no background in construction depend very much on the contractors' expertise regarding the quantity and quality of the building material and waste. Besides, the FM-firm has developed an app for the recycling of equipment and material collected on site. It allows to manage objects such as doors and lamps stored to be reused in future projects. So far, the app has received positive attention but no piece of equipment has yet been reclaimed. The FM-firm's interest in waste is motivated by the sustainable branding of the company. It presents itself as the one "developing sustainable environment" and would like to demonstrate that they do the "right thing".

Valuation Practices at the Contractor's Office

For the large contractor responsible of the project, the design phase of renovation, waste seems to be more a cost than a value. The handling of waste is calculated in terms of work-load and workforces that are needed to dismantle and clean the premises before the proper renovation can start. These calculations follow standards developed in-house, according to the type of buildings and period of construction and follow the legal demand (an audit for hazardous material is necessary). The size of the expected waste is estimated and the cost of transport, handling (sorting on site or not) and taxes are calculated accordingly. In some occasion, when space is scarce on site, the planning also requires precise transport logistic. The contractor works according its own internal CDWM policies and goals. The waste is not attributed to a financial value, but its management serves the purpose of attaining the company's sustainable goals and contributes to improving their reputation and brand as a green and sustainable contractor. It also helps fulfilling the environmental criteria for green

certification. The valuation practices are performed by specifically assigned roles that intermediate between the practices on the construction site, developments in the market and the strategy of the contractor's office.

Valuation practices at the contractor building site

The site manager is in charge of organising the cleaning of the site and handling of waste. The contractor is responsible for the logistics on site as well as the health and safety. In our case a small demolition company has been sub-contracted to carry out the demolition work and deal with the demolition waste material according to the contract agreed with the FM-firm. For demolition, three dumpsters were placed on site (gypsum, metal and burnable); the electric components are collected by the electricians who are recycling the material on their own. The handling of windows containing asbestos is organised separately by the subcontractor. As the work progresses, the first floors are stripped and the rebuilding can start, so the demolition and construction workers are active in parallel. The stripping of the building has revealed unexpected material and construction which have been added during earlier renovation. The suspicion of asbestos in a plastic flooring which needs to be sanded down is for example stopping the work for several days on one floor. The planning on site is updated on a daily base. At the time of our first visit, the work is behind schedule by three or four days, which the site manager is keen on catching up. Dismantling quicker, means less attention given to the sorting of material. However, the small difference of prices between the costs of delivering mixed or sorted waste to the recycling central does not justify a further delay on site. So, the quality of the waste sorting seems to depend on other criteria than the quality and efficiency of the recycling loop. During our second visit, the site is now three months behind schedule due to the discovery of mould in the roof. A large part of its structure needs to be dismantled and a new demolition contractor is brought in. The waste is not sorted anymore, all the material taken out ends up in the same dumpster as there is no time for sorting waste. The project is too late and over budget and waste sorting is deprioritized. The project manager has the possibility to ask for more labour, but this would need to be paid by the client.

Valuation practices at the demolition company

Demolition contractors are hired for the demolition work by the main contractor and the main contractor is legally responsible for the CDWM. The contract is based on the work to be carried according to the age and type of buildings as well as the scope of the renovation. However, the demolition contractors plan their own work, hire their own team and take care of the waste in their own way with their own companies supporting further waste sorting. However, well trained to sorting waste, the employees recognise that a large amount of waste is ending in the "burnable" dumpster. The demolition company is the one selling waste to other recycling companies and therefore attributing a concrete financial value to the material. The quantity and price are not necessarily negotiated for each project, waste can be collected from different building sites before being collectively transported to the recycling central, where there are weighed at their arrival.

Besides, the valuation for demolition companies is reputation and branding in that they are perceived as a reliable partner for demolition in terms of CDWM. On the other hand, they are also driven by contract and cost for their work procured by the main contractor.

Valuation Practices of the Other Sub-Contractors on the Building Site

The valuation practices of the other sub-contractors concerning waste are primarily contract driven and cost driven. Sub-contractors are usually obliged contractually to sort their own waste on site. The main contractor is however responsible for CDWM and feel it is sometimes difficult to motivate sub-contractors to participate in CDW sorting practices. In our case to the exception of the electrician, the other craftsmen are not involved in the management of the demolition work and sorting of waste.

Valuation in Norms, Standards and Professional Guidelines

The Swedish Environmental Protection Agency (SEPA) aims at that 70% of waste produced in Sweden should be recycled and less than 10% should end up in landfill. These figures have been adapted from the European agencies. However, as the production of demolition and renovation waste is not legally monitored in Sweden, reaching these targets is depending on the assessment carried by the contractors on their own production. SEPA has published a handbook on the recovery of waste in civil engineering. The handbook provides guidance values of both hazardous and non-hazardous substances. It should be noted though that these guidance values do not have legislative force for non-hazardous waste. Waste management for the renovation and demolition of buildings is regulated in the Building Code (SFS 2010:900) and guidance is given by the Swedish National Board of Housing, Building and Planning. An inventory of the generation of hazardous waste is required prior to the demolition or renovation of buildings. This inspection plan should include information on: sorting into waste fractions, precautionary actions to prevent environmental and health risks and the final disposal of the waste. They build on the following classification: metal waste, ferrous; metal waste, non-ferrous; metal waste, mixed, glass waste, plastic waste, wood waste, mineral waste; and mixed waste, not specified. Waste tax is currently SEK 500 /t (EUR 54 /t) (2016). Some waste types (e.g. metal wastes) going to recycling are free of charges. To help the contractors gain better control on their waste management, the Swedish Construction Federation has provided guidelines on CDWM and sorting of CDW on site. Besides, addressing the different stakeholders and advising on the possible role and responsibility they could take in waste management, the guidelines enumerate all the waste fractions organised by type of material and propose a classification on the many objects and substances that can be found on site (in rubric such as electricity or type of paint). They focus is on waste minimization and the management of CDW enabling recycling. The renovation and demolition waste are addressed in terms hazardous waste risk management.

Valuation at the City Municipality

The city is interested in optimising waste management on its territory. The discharge of construction waste in nature is a situation the city would like to avoid. The security and respect of work conditions and health and safety rules are also a major concern. The city is focused on maintaining and creating a sustainable environment for the citizen and following the government regulations and laws. They perform these through controlling the application of particular regulations for the demolition inventories and hazardous waste rules. Besides, being legally responsible for the respect of environmental laws, the city has to ensure that no one is trespassing. However, the number of public servants attached to the task is far too little to effectively control the numerous building sites in the city. Therefore, controls are often taken place after citizens complains or denunciations. When confronted with

misbehaving, the strategy of the city is to advice and guide offenders and bring them back to the expected comportment rather than to fine or punish them. One of the reasons to explain this soft policy is the high cost of engaging pursuits as these require the participation and coordination of several public services. The city is nevertheless, keen in interacting with the industry and test different practices to improve the recycling of construction waste.

Valuation practices in the waste management companies

The valuation practices of the waste management company for their customers build on the complementarity of the types of waste to be collected: gypsum, burnable waste, impregnated wood, wood, waste or metal as well as the work needed for the waste to be sorted. The financial value of this different material is attributed according to the size and quantity of waste. Although these prices are public, the final fees can be negotiated for almost every customer, private or business. To the exception of burnable waste, the material delivered to the central is going through a second round of sorting. In term of profit, a large quantity of waste is burnt and substantially contributes to the production of energy for the city. Recycled material is sold further for reuse. In the case of specific construction waste such as gisp or concrete, the possibility of recycling is depending on the quality and purity of the sorted material which therefore needs to be to assessed. These quality values have been determined by specialists and experts to ensure the quality of the new artefact. However, according to some of our interviewees, these values are too strict and prevent a large amount of sorted waste to be reused.

DISCUSSION AND CONCLUSION

Building on the different valuation practices of the stakeholders engaged in renovation waste management enables us to understand how value is attributed to waste. First the value of waste cannot be reduced to apparent objective measures or quantities but are constituted of practices. Second, the analysis underlines the diversity of not only the interpretations between the actors, but also between the different calculation and estimation devices and how these are mobilised to legitimised practices. The stakeholders seem to focus on their own organisational purposes and don't seem to integrate a more holistic view of the recycling processes. Even within the same organisation as in the case of contractor, we find different properties attributed to waste and competing valuation practices. Third, our analysis suggests that the recycling directives and proposed implementations schemes do not align with the renovation practices of the contractor and demolition companies. The possibility of recycling relies on the pure quality of substances and material which is hard to achieve within renovation where waste is mixed and composite. So, to conclude, for improving the waste management for renovation projects, it becomes important to build on some stabilised practices that can be recognised by most of the stakeholders. However, there is still a difficult road ahead to reach an efficient waste management process for renovation projects.

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INVESTMENTS UNDER PRESSURE: A REAL OPTIONS APPROACH TO PREPARE FOR EMERGENCY ASYLUM SHELTER IN A MULTI ACTOR SETTING

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This paper presents a study to define the use of real options to be prepared for challenges that arise when faced with rapidly changing conditions, which take on characteristics of an emergency and require investment decisions. Related to time, real options can be used as a time-saving and efficiency-enhancing support for investments decisions in assets in response to fast changing situations. Related to uncertainty, real options facilitate decision makers to acquire more information about this uncertainty before having to make an investment decision. By building option pricing into a decision making framework to evaluate investment opportunities, one can add additional financial insight to the investment decision making process. Pressure on decision making with regard to investments in assets during rapidly changing situations could be reduced or mitigated when the decision maker has developed a set of options. Furthermore, use of real options supports more integral decision making and consequently allows for more focus on efficiency in decision making related to assets. Finally, time can be saved if such a situation occurs.

Keywords: asset, multi-actor decision making, real options, analysis, uncertainty

INTRODUCTION

In 2015 the Netherlands, like many other countries in Western Europe, was confronted with an unexpected inflow of asylum seekers. This flow challenged the multiple parties involved with the provision of asylum shelter to quickly respond and organize shelter capacity for asylum seekers. The government and COA (Central Agency for the Reception of Asylum Seekers) called on regional and local authorities to respond to the need for more shelter capacity and to fast-track the decision making process to build additional capacity quickly. However, the response of local authorities resulted in unrest and heavy resistance amongst inhabitants in those communities, who felt ‘pressurized’ and ‘bypassed’ in the decision making process to develop the shelter capacity. This case powerfully illustrates the “fire-fighting”-like decision making process of the government and other involved agencies to find, finance and build

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shelter for asylum seekers, when confronted with an unexpected, rapidly changing demand for shelter capacity. The aim of this study is therefore to define a framework which can be used to improve the investment decision making process for time pressured situations.

A real options (RO) approach is used to explore how investments for emergency shelter construction could be addressed when faced with time pressure and rapidly changing conditions. Applying an RO approach to decision making situations in which the context of emergency management plays an important role is relatively untouched terrain in construction management literature. Guadard and Romerio (2015) provide recent attention to decision making in emergency situations. They state that decision makers should acquire an understanding of the dynamics of emergency factors at first, followed by taking the optimal decision based on available information. RO can be used in the first phase of decision making, to study the different available options to resolve an emergency (Guadard and Romerio, 2015) and to facilitate decision making when additional information becomes available. RO has been applied in situations of natural hazards, but not yet in emergency construction management (Guadard and Romerio, 2015). Therefore, the applicability of RO to this context warrants further investigation.

The insights from the pressured arrangement of shelter capacity in the Netherlands from 2014 to 2016, show possibilities for application of RO as a financial framework for investment decision making under time pressure. Firstly, RO as a theoretical approach will be presented, followed by the application of RO in an emergency management context. Based on the description of the Dutch shelter capacity case, a new application of the RO approach is presented, particularly how it contributes to decision making on asset investment in a complex network of multiple actors who are under pressure to decide.

REAL OPTIONS ANALYSIS

In general, investment decisions are made by applying a Net Present Value (NPV) rule and a traditional Discounted Cash Flow (DCF) analysis. These are widely known to fail, because they cannot provide managerial flexibility to adapt and revise decisions in response to unexpected (market) developments (D'Alpaos, 2012). Yet, the RO approach addresses investment uncertainty in these decisions by means of flexibility (Dixit and Pindyck, 1994). The RO literature states that an option provides the right to buy or sell an asset at a previously determined price and time period. This results in financial value since it creates an opportunity to remain flexible to perform the investment for a certain amount of time (Brealy, Myers, and Allen, 2014). This financial value of decision flexibility can therefore be captured in terms of time (Trigeorgis, 2007), expansion or abandonment of existing investments.

RO analysis uses the DCF method integrated with decision trees (the binomial method) as a framework (Taneja, Ligteringen, and Walker, 2012). It then seeks to provide a consistent treatment of risk by defining operating rules (D'Alpaos, 2012). The decision trees can be used to discuss possible outcomes of investment decisions with the multiple parties involved. A critical value of the RO approach, is therefore the option for decision makers to wait and see how conditions develop and adapt investment strategies accordingly, leaving only limited sunk costs if the investment is finally abandoned (Lee and Makhija, 2009, 542). In essence, the merit of an RO approach is the inclusion of past, present and future information in the decision.

The applicability of RO has been widely studied for investment decisions in non-emergency situations. For example, Agliardi, Cattani and Ferrante (2018) demonstrate the use of RO as evaluation method by modelling the source of future uncertainty. Specifically, they applied RO to model energy price uncertainty to validate an integrated design methodology, used for the creation of additional volume on existing buildings. In addition to this, Ajak and Topal (2015) have applied the RO approach in a case study to propose a new methodology to explore the technical application of RO in mine design and decision making at the operational level. They apply a case study to demonstrate how RO can be used in designing multiple pits in multi-zone ore deposits to create a switching option between pits regarding ore grades and fluctuating commodity prices. Bowman and Moskowitz (2001) have applied RO in a case study to sum the value of information from the past to decisions in the present. They examined a case where a pharmaceutical company used RO to justify an investment in an R&D project. This case is used to highlight some of the problems associated with using RO. In essence, they noted that assumptions incorporated in most option valuation models can conflict with the conclusions reached by strategic analysis. As a result, users of a RO approach are advised to understand and adapt the quantitative aspects of RO for a customized application for each situation.

The described case studies focus on particular areas where real option application can benefit an organization. However, there are also studies that focus on the decision process. For example, in a case study on firm differences Pandza, Horsburgh, Gorton and Polajnar (2003) use RO as a means to manage capability development. Van Reedt Dortland, Voordijk and Dewulf (2013) recognize in their case study of two health care facilities, that the way in which RO is applied needs adjustments along with various multiple stakeholders, who form the coalition of an investment alternative. The different forms of RO would require customization for organizations to adopt RO (Bowman and Moskowitz, 2001). Therefore, this paper is focused on particular challenges in investment decision processes under time pressure.

Most case studies using an RO approach find the RO merit in the organizations' ability to focus on a source of future uncertainty, decisiveness in the present and the possibility to provide decision information accumulated from the past. The focus on time developments in a specific case study is used to argue the ability to assess whether real option application is suited for an organization to use for enhancing information from the past and making decisions in the present challenged by specific future uncertainties.

Real options under time pressure

On time pressure, Maule, Hockey and Bdzola (2000) state that the imposition of a deadline creating time pressure, induces a number of affective states in decision making, depending on the importance and the extent to which adaptation allows to ensure goals at an acceptable level. Time pressure of decisions is often connected to the speed of developments in a situation towards negative consequences. Kerstholt (1994) describes decision strategies in terms of the time allocated to decision phases and in behavioural indices related to information requests and actions. As time pressure increases, a general speedup of information processing increases, but the decision strategy remains constant, suggesting a decision maker is no longer able to optimally address the decision problems (Kerstholt, 1994). In essence, the decision making process is challenged by pressure when the decision maker is surprised by an emergency. In fact, being prepared for time pressured decision making could improve

the possible negatives of time pressured decision making, as shown by Fiedrich, Gehbauer and Rickers (2000).

RO has the potential to prepare decision makers for challenges that arise during an emergency situation. The key point in the RO approach is the relation between time and uncertainty (Martins, Marques, and Cruz, 2014). Related to time, RO can save time when an investment must be decided during a crisis. Related to uncertainty, RO can provide flexibility to acquire more information about the uncertainty before having to make an investment decision. By including option pricing into a framework which is designed to consider investment opportunities, one can add financial insights earlier rather than later to the asset investment decision making process (Luehrman, 1998). Only a few studies have linked RO to emergency situations. Abadie, Sainz de Murieta and Galarraga (2017) propose an RO approach to study whether an investment to adapt infrastructure is better to be decided in the present or to wait, considering the climate and socio-economic uncertainty on flood risk in the city of Bilbao. Also, RO is proven applicable to project contingencies by Espinoza (2011), who proposes a way to estimate contingency budgets with the help of RO. Tseng, Zhao and Fu (2009) present a similar approach by approaching the contingency budget from the asset owners' viewpoint. Finally, Van Reedt Dortland, Voordijk and Dewulf (2014) propose a method that combines scenario planning and RO to understand the consequences of future uncertainties in real estate investments and address the flexibility in decision making through weighing the pros and cons of flexibility measures. With regards to emergency management in the direct context of asylum shelter, Moretto and Vergalli (2009) link RO to migration policy, although not from the asset owner's viewpoint. Hence, the way in which the RO approach can guide the government with its shelter construction decisions in a multi-actor setting needs to be better understood.

RESULTS FROM THE ASYLUM EMERGENCY SHELTER CASE

For this study, the investment decisions and actions of COA with regards to the migration inflow between start 2014 and end of 2016 were analysed. COA is the agency responsible for the development and construction of shelter locations for asylum seekers in the Netherlands. As this study focused on the applicability of RO in the context of decision making under time pressure, an in-depth case study was performed through the collection of data from COA, publicly available sources and reports on particular challenges that COA faced during and after the refugee crisis of 2015. This information was used as input for a binomial RO model, for the optimal timing of investment decisions and the valuation of options on shelter capacity.

The decisions concerning shelter capacity are however not solely made by COA, but are the sum of various decisions made by various governmental bodies and agencies with various roles. The Ministry of Security and Justice is politically responsible for asylum shelter, but COA is functionally responsible to provide sufficient shelter capacity (Overheid.nl, 2015). In addition to this, the Immigration and Naturalization Service (IND), the Repatriation and Departure Service (DT&V) and Nidos (the child protection service for refugees), are involved with asylum shelter through the asylum application and shelter processes (Bosch, 2016). Moreover, COA is not empowered to open shelter locations without support from municipalities and their citizens. Every available shelter location is the result of an intensive process in which COA cooperates closely with municipalities. However, since COA is responsible as stated by law, this study used COA as problem owner for decision making concerning

asylum shelter capacity. From this perspective, the approach from COA to the multiple actors involved is also important for a successful decision making process.

For this case study, the 2015 asylum crisis is considered as a contextual factor for which a tailor-made RO approach should be developed. No formal state of emergency was declared by the national government however, the situation posed the following challenges for COA:

1. Predicting asylum flows. Estimations on asylum flows were stated in the Multiple year Production Planning (MPP) which specifies amongst others the historic realization of asylum flows to the Netherlands and the expected amount of asylum applications. The MPP was fed by input from related agencies (Bosch, 2016) and takes global politics and migration trends, identified by international organizations, into account. Due to large fluctuations in asylum flows, accurate estimations are extremely difficult to make. Because of this difficulty, COA also makes estimations of the expected asylum flow to determine the required shelter capacity. By comparing the different estimations and discussions with COA, the Ministry of Security and Justice places a capacity order at COA for the following year (COA, 2016). The requirement to compare the different estimations illustrates the unpredictable nature of the asylum flow that COA and other organizations involved in the asylum shelter are faced with.

2. Planning for stable shelter capacity. Based on estimations of the asylum flow, COA must plan the required level of shelter capacity by a system which consists of different types of shelter locations. Using a so-called portfolio approach, capacity is arranged in different ‘shelter layers’ with different ownership types and for different durations, as shown in Table 1. The core capacity consists of locations in ownership of COA for more than 15 years which have a capacity of at least 600 places per location. Typically COA develops capacity in the higher layers if the asylum flow is expected to exceed the available capacity at the lower levels. For example, if the available capacity in the flexible layers is fully occupied, COA will initiate more capacity lasting for up to a maximum of 1 year in the emergency capacity layer.

Table 1 COA capacity layers

Layer	Description of shelter capacity
1 - Crisis emergency capacity	When other capacity layers are no longer available
2 - Buffer	Developed when core, flexible and emergency layer are occupied
3 - Emergency capacity	1 year < used when core and flexible layers are occupied
4 - Flexibility layer	Flexible layer short term 1-5 years / Flexible layer long term 5- 15 years (determined in housing strategy)
5 - Core capacity	15 years > (determined in housing strategy)

Different types of real estate were used as shelter locations: vacant monasteries, barracks, recreational facilities, but also semi-permanent and new buildings (Dijk, 2016). In 2016, about 60% of the shelter locations were owned by COA and consisted of permanent locations (core capacity and flexible layers). The other 40% was rented from private parties or municipalities and semi-permanent (emergency capacity and buffer) (COA, 2016b). Over 2015, COA and other involved agencies found their capacity assignments from the Ministry of Security and Justice for the different capacity layers simply wrong: the capacity which the Ministry of Security and Justice had requested was insufficient to accommodate the asylum inflow (COA, 2016a). Additional buffer and emergency capacity had to be developed to deal with the unexpected inflow. As a result of this inflow, rental prices for shelter locations increased drastically compared to previous years. At the same time, a significant

number of shelter places were 'lost' in 2016 as contracts for accommodation ended, while the new ordered capacity was in either the realization or planning phase (COA, 2016b). This illustrates the challenges COA faces when planning shelter capacity.

3. Capability to respond quickly to new events. When the sudden inflow of refugees started, COA had to make fast decisions to provide sufficient shelter capacity since the core shelter capacity proved inadequate and a new policy and accompanying legislation had to be put in place to increase the shelter capacity (Dijk, 2016). Consequently, COA was forced to adjust its real estate portfolio to adapt to the rapidly increasing shelter demand (COA, 2016b). These efforts took too much time, caused by shortcomings of potential shelter locations, which needed investment and adjustment before the locations could be used (COA, 2013). COA then made concessions and accepted a lower shelter quality in exchange for the needed increase of capacity (Dijk, 2016).

As the demand for shelter increased rapidly, COA and the Ministry of Security and Justice had to rush to close the widening shelter capacity gap. Normally, it takes at least four months to organize the support of governing bodies such as provinces and municipalities and deal with the necessary planning procedures and building permits. However, under time pressure, formalities were dealt with within a few days or weeks instead of months or years (Teeven, 2014). As a result, citizens in the local communities were sparsely involved or even by-passed by their local governments, resulting in local unrest, frustration and demonstrations. The large inflow of asylum seekers in the second half of 2015 forced COA to find solutions which would be both cost efficient for society, to prevent the further loss of public support, and provide sufficient shelter of asylum seekers. It can only be concluded that the agency struggled to accommodate, deal with and involve so many different stakeholders at the fast pace in which the events were unfolding.

4. Shelter arrangement as a time consuming process. COA had to make decisions while considering the effects of various implications which determined the value of the investment of shelter locations and delays in construction development and formal procedures which had to be followed if COA decided to invest in shelter capacity. For instance, municipalities needed to assign a shelter function to locations in its land-use plan, which made COA highly dependent on the local approvals since the final say on the decision to construct a new shelter location rested with the municipal council (CCV, n.d.). After the decision to increase the shelter capacity, it takes time to construct and prepare the location. The more time between the need for additional capacity and the actual provision of the capacity, the less value a location has. Therefore, municipalities also depend on information provided by COA to start the needed procedures. COA thus had a critical reaction time in starting procedures for shelter arrangements.

This section addressed four major challenges COA faced during the migration crisis in 2015. The consequences of these challenges and COA's unpreparedness were primarily financial, since COA had to pay the costs resulting from troubleshooting and coordinating crisis-like solutions to ensure shelter capacity. The next section discusses how RO could address each of these challenges when investments decisions must be made under time pressure and unexpected events.

Real Options Framework for Time Pressured Decision Making

The described case identifies challenges in decision making concerning investments in shelter capacity when faced with unexpected and volatile global events. Table 2 shows an overview of these challenges.

First of all, asylum flows proved hard to predict. Also related to the unpredictable migration inflow, is that future capacity planning appeared incapable to respond to sudden changes causing planning for a stable shelter capacity to be problematic. This reveals an inability to anticipate future events.

Table 2 Challenges related to decision making

Challenge	Description	How RO could address this challenge
1	Asylum flow proved hard to predict	A timing option offers COA flexibility to gather more information
2	The capacity plan was unstable	Expansion and abandonment options offer an adaptable planning to the existing portfolio
3	COA was unprepared to cope with a refugee crisis: fast response was expensive in terms of rushing for short-time solutions	Portfolio could include permanent on-the-shelf capacity
4	Decision making processes to plan for shelter capacity are slow and delicate processes	Ongoing preparation of options by COA by preparing locations with stakeholders. A binomial model can value options when decisions must be made and time value of money can adjust value when decisions move slow

An RO approach allows for the estimation of asylum flows and planning of capacity by COA to capture the value of waiting, and hence introduce an ability to anticipate future events such as a migration crisis with the introduction of various types of options. With regard to uncertain asylum flows, an RO approach entails the creation of a timing option that captures the value of having the option to wait for more information (Trigeorgis, 2007) (see short line in Figure 1).

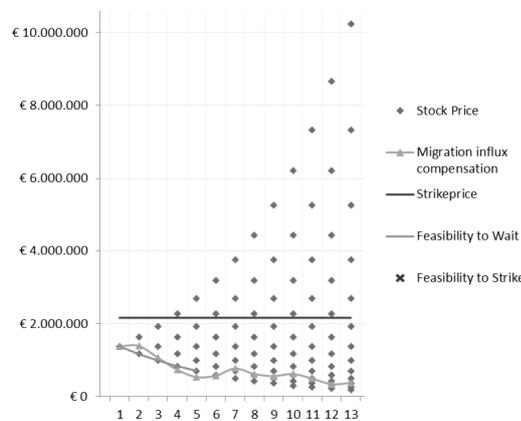


Figure 1 Example of a timing option

This type of option values the right to build a shelter location until the final date to which the option lasts. With regard to the ability to plan for stable shelter capacity, an RO approach entails the creation of a capacity expansion or abandonment option (see table 3). These options mark the value of the right to increase shelter capacity through an additional shelter location if suddenly extra capacity is needed and to abandon the capacity if it appears empty too long and too often (Brealy, Myers, and Allen, 2014).

Secondly, COA was unprepared to respond to a migration crisis as the 2015 case shows. COA showed an inability to accelerate decision making on investment in shelter locations. An RO approach allows for responding to unexpected events and emergencies by means of a permanent development portfolio through which COA can

accelerate the offering of shelter solutions. A development portfolio could provide decision makers with a real-time tracking system of assets and options owned and managed in various stages of completion: a set of assets in each phase of concept, development, construction, and in service. RO thereby provide the possibility for a development portfolio to manage the level of preparedness, considering expected migration demand on the one hand, and having an overview of the shelter development and solutions on-the-shelf, for example as a list of locations at municipalities (see table 3).

Thirdly, COA overcame its unpreparedness by enforcing and speeding up the provision of shelter solutions. This came at an expensive price for COA and partnering agencies, since the solutions were short-lived and caused a lot of public unrest in the localities which were called upon to facilitate the development of new shelter locations. An RO approach can reduce excessive costs by relieving the pressure on the required preparation time to develop new shelter locations. RO can do this by introducing an ongoing practice for COA to prepare locations and decision making with stakeholders.

The preparation of these options can include all the required activities such as permitting and community involvement before servicing the location, which helps to reduce or even eliminate the need to rush development of new shelter capacity. It also allows for time to reach agreement with partnering agencies and collect information about the fitness of the option well before the experience of pressure on these agreements.

Table 3 Examples of expansions and abandonment options

Location	Modality	Shelter Layer	Capacity	Call option value	Put option value
Municipality B	AZC	Flexible short	600	€ 350.752,12	€ 545.446,24
Municipality C	AZC	Emergency	500	€ 169.730,82	€ 1.169.288,97
Municipality D	AZC	Flexible long	864	€ 436.813,13	€ 392.993,56

Finally, COA had to cope with the slow-moving characteristics of investment decision making processes to arrange shelter locations under pressure to quickly solve the capacity shortage. This shows an inability of COA to adapt the decision-making process to the more fast-paced events of a large asylum inflow. An RO approach can adapt the timing and value of decisions in the shelter capacity decision making process (Brealy, Myers, and Allen, 2014). Timing of decisions can be adapted by means of modelling the option values in time-steps that match the formal decision moments of the deciding agency. This is referred to as the binomial option model (Brealy, Myers, and Allen, 2014) (see figure 1). The value of being able to time investment decisions to fast-paced events, can be adapted by including the development time of additional capacity. By use of the NPV of the investment and the time between the investment decision and servicing of the additional shelter, the value of the option on a shelter location can be determined. For example, if the expansion option for a shelter location in Municipality B (table 3) takes a year to build, then the call option value can be computed by servicing cash flows in a year from now.

CONCLUDING REMARKS

An in-depth case study revealed the challenges that COA faced in providing sufficient shelter capacity to asylum seekers during the high asylum inflow in 2015. Through this study is found that an RO approach can introduce changes to the decision making

processes of COA and its partners by which they are better prepared for investment decisions, when faced with fast-paced, unexpected events and dealing with external pressure.

RO allows for the creation of an infinite set of options in a development portfolio. With regard to the investment decision making process, COA could adapt the valuation of the investments in construction projects, to the reality in which the decision moments need to be fed with valuation data. However, the key to success is the connection of the investment decisions to more stable, more transparent and more insightful negotiation processes between COA and its stakeholders. The added value of this study is therefore the explicit relation that is shown between the RO approach and the empirically derived challenges an asset management organization experiences in a real-life case of emergency asylum shelter construction.

The study did not test the actual merit of having such an RO approach in operation. However, it did find plausible connections through which it has potential. A next step to prove the added value would be to develop, apply and validate the RO approach in practice. An application by COA could very well be a useful starting point.

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EXTERNAL STAKEHOLDERS IN URBAN CONSTRUCTION DEVELOPMENT PROJECTS: WHO ARE THEY AND HOW ARE THEY ENGAGED?

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The construction industry is renowned as being fragmented and complex, with a higher risk element in urban development projects, where construction sites are a common feature. Many stakeholders are involved in urban development projects, making effective integration and collaboration difficult. Moreover, the identification and engagement of external stakeholders involved in the project must be given further consideration, as they can influence project implementation, although they have no contractual relationship. Therefore, this paper aims to identify and document who the external stakeholders are in urban development projects, and how they are engaged by on-site project managers. This pilot study is at the beginning of an initial investigation, providing the basis of an ongoing PhD research project. The research method undertaken is qualitatively based, encompassing four case study interviews with four construction professionals on urban development projects located in London, England. The data accumulated is qualitatively assessed using mind mapping software, and cognitively summarised. The Local Authority, Residents and Local Businesses emerged as the three main external stakeholders, from a list of seventeen. From ten different strategies documented, Face-to-Face Meetings and Newsletters were identified as the two main strategies used to engage external stakeholders. The key contribution of this work illustrates to on-site management that the Local Authority, Residents and Local Businesses are the main external stakeholders to consider amongst others. Also, Face-to-Face Meetings and Newsletters are the more beneficial of the various wide-ranging engagement strategies identified, to manage and engage external stakeholders on urban development construction projects.

Keywords: community engagement, stakeholder management, urban development

INTRODUCTION

The global urban population is estimated to reach 67% by 2050 (Yang *et al.*, 2017), and this rapid urbanisation has seen construction projects grow in increased size and complexity (Luo *et al.*, 2017). Despite this growth, the construction industry remains highly fragmented, eschewing collaboration and strategic vision (Alwan *et al.*, 2017). Bhatija *et al.*, (2017) assert that the fragmented nature of the construction field

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involves various stakeholders with different views and opinions. As our urban centres continue to flourish, the demand for stakeholder involvement in the decisions being made during the construction of these developments will also require attention (Isaacs *et al.*, 2010). A large number of stakeholders are involved in major urban development projects (Gilmour *et al.*, 2010), and if a project is to be completed successfully, a high level of integration and coordination amongst these stakeholders is required (Malkat and Byung-GYOO 2012). Furthermore, Nash *et al.*, (2010) state that special consideration must be given to the management and engagement of the numerous external stakeholders that can have either a positive or negative effect on the overall success of a construction project. Olander and Landin (2008) concur that there is a growing tendency for external stakeholders to influence the implementation of development projects. On review, the vast majority of previous research works fail to acknowledge and highlight the integration of both who the external stakeholders are, and how they are effectively engaged, but in particular, on urban construction sites.

Therefore, considering construction projects in urban areas, it is necessary to identify who these external stakeholders are, more importantly, how they are managed and engaged, and what relevance, if any, they have to the project. To address these issues and to fulfil a concise but established topic in the research area, it is paramount to acknowledge and generate results based on actual events that emerge, when constructing in these inherently complex environments. Concentrating on this relevant facet of interest, this pilot study aims to identify and document who the external stakeholders are in urban development construction projects, and how they are managed and engaged by on-site project managers. This is achieved by undertaking a sequential mixed method approach, incorporating a combination of qualitative techniques for analysis, including a literature review and semi-structured interviews, and using mind mapping software, which can be cognitively summarised. In addressing the aim, it is anticipated that this study will assist and aid project managers in identifying and adopting engagement strategies considering external stakeholders on urban development projects.

Urban Development and External Stakeholder Management

The United Kingdom (UK) construction industry is widely fragmented and diverse, due to its project based nature (Elmualim 2010), with a higher element of complexity and uncertainty compared to other manufacturing industries (Adriaanse 2007). Jung *et al.*, (2015) suggest that the element of risk is greater in urban projects, as construction sites in urban areas are constantly emerging (Hendrickson 1998). Stakeholders in urban development projects are individuals or organisations who can affect or be affected by the achievement of a project (Yang 2014), and their involvement can make effective and efficient collaboration difficult (Marshall-Ponting and Aouad 2005). Internal stakeholders are those who are formally members of the project coalition and hence usually support the project (Beringer *et al.*, 2012), while external stakeholders are those who are not formally members but can affect or be affected by the project in a significant way (Aarseth *et al.*, 2014).

Chan and Oppong (2017) argue that the expectations of external stakeholders are comparatively more pressing and critical than their internal counterparts, even though they have no contractual relationship with the project (Elmahroug *et al.*, 2014). Sallinen *et al.*, (2013) further this premise, highlighting that large projects are influenced by their external environment, where the social environment and planning

processes create uncertainty in complex urban projects (Abbott 2005). Failure to accommodate external stakeholder concerns in large construction projects can lead to severe resistance (Li *et al.*, 2013), and Xue *et al.*, (2015) corroborate that there is an urgency for developing more rational construction programs, to minimise the negative impact on their daily lives in urban developments. Yang (2014) supports that stakeholder engagement is unbalanced in urban development projects, where democracy is more often rhetoric than realistic in practice. Thus, a structured process of stakeholder engagement is an integral part of the construction process (Widén *et al.*, 2013), and complex urban projects must be open to change to achieve inclusionary goals (Van Der Veen and Korthals Altes 2012). Furthermore, Yang and Shen (2015) postulate that engaging stakeholders in the construction sector is an important consideration for stakeholder management.

RESEARCH METHOD

This pilot study is at the beginning of an initial investigation within a PhD, which aims to contribute to both academia and industry. Considering the theoretical position this paper and subsequent research is founded upon, a critical realism approach is considered and adopted. As the nature of this study primarily deals with the opinions of human participants, a subjectivist approach is applied to the ontology, which provides a basis for the case study methodology. On completion of an informative literature review, the research method adopted consists of four exploratory case study interviews with four construction professionals based on large urban development projects in London, England. The selection of the four case studies was based on a convenience sampling strategy, and four interviews were undertaken by the researcher during a postgraduate student fieldtrip to London, organised by the construction management department at the researcher's university. The unit of study incorporates both individuals and groups, so the research problem can be approached from a variety of angles (De Vaus 2002). The case study approach is chosen as it is the most suitable for the 'how' and 'why' research questions (Yin 2014), and it is beneficial because it facilitates the investigation of a phenomenon in its real-life context (Rowley 2004). Also, a semi-structured interview format is chosen as this uses an open and closed ended form of questioning, and moreover, questions are asked in no specific order or schedule (Naoum 2007). This method allows questions to lead from one to another, enabling the interviewee to provide as much information as possible.

The four participating interviewees were identified and selected based on their availability at the time of each site visit, and taking ethical issues into consideration, each participant was informed of the nature of the research, its purpose, and what the resultant data will be used for. The identities of those involved will remain anonymous and confidential information (such as company names, addresses, client details etc.) is not disclosed. Case A consists of a new £18 million secondary school scheme catering for over 1,100 students, and the interviewee is a Site Manager with 15 years' industry experience. Case B is the construction of a new £8 million 137 bedroom hotel, and the interviewee is a Project Manager with 12 years' experience. Case C is a new £34 million residential development scheme including 152 apartments, and the interviewee is a Senior Project Manager with over 30 years' experience. Finally, Case D is the £4.2 billion construction of a new sewerage tunnel system spanning 25km, and the interviewee is a Senior Quantity Surveyor with 8 years' experience. The four case studies are a combination of both live and recently completed urban development projects, located throughout London. All four interviews were recorded in handwritten note format, and the interviews with the Site

and Project Managers were carried out during walking tours of each site, whereas the interview with the Senior Quantity Surveyor took place in a meeting room at the site office.

QUALITATIVE ANALYSIS AND RESULTS

The interviews commenced by gaining general background information about each participant and the respective case study, followed by an identification of the main external stakeholders relevant to the project. Emerging issues from these external stakeholders were discussed, followed by engagement strategies used to mitigate the issues identified, and any other comments regarding external stakeholder engagement and management on the project. The external stakeholders identified in each project are illustrated in Table 1. The data gathered from the case study interviews was then qualitatively assessed and cognitively summarised using mind mapping software. A qualitative mapping software application called Banxia Decision Explorer® is used for this research, which builds a visual representation of ideas and can provide a focus for debate, reflection and progression. It clarifies thinking and can be used to map thoughts and ideas gathered from interviews, acting as an effective stimulus to focus on paramount issues (Brightman 2002). Decision Explorer® can undertake many forms of analysis, but for the purposes of this study, Central and Domain Analysis is used. The analysis logically expresses how each factor or 'concept' is linked and interpreted, and each concept was discussed in some form by all the interviewees.

Table 1: External Stakeholder Identification

	Case A	Case B	Case C	Case D
Residents	x		x	x
Local Businesses	x	x	x	x
Road Users	x	x	x	
Pedestrians	x	x	x	
General Public	x			
Local Authority	x	x	x	x
Students (Local School)	x			
Bus Authority		x		
Rail Authority		x		
Highways Agency			x	x
Heritage / Conservation Agency			x	
Environmental Agency			x	x
Health and Safety Executive			x	
Neighbouring Local Authorities				x
Water Agency				x
Utilities Agencies				x
Marine / Port Authorities				x

Central Analysis calculates a score to identify which concepts have the greatest effect or impact on the mapped model, and the higher the score, the higher the effect that concept has on the map. Domain Analysis shows concepts which have many links, and can highlight concepts that the interviewees found interesting or discussed more. Combining the data from all four interviews, the top five concepts in the Central Analysis emerged and, in order of significance, were; 'Local Authority'; 'Residents'; 'Constant communication is necessary to keep project on schedule'; 'Face-to-Face

conversations with external stakeholders are best'; and 'Noise generated from site works'. The top five concepts in the Domain Analysis were; 'Residents'; 'Noise generated from site works'; 'Local Businesses'; 'Face-to-Face conversations with external stakeholders are best'; and 'Engagement with stakeholders is paramount at all times'. Due to space limitations, the remainder of the concept analysis results have been omitted, however, Table 2 illustrates a concise list of all the engagement strategies and general comments regarding external stakeholder engagement that were identified by all the interviewees in each case study. It is worth noting that the findings are from four interviews and are case study specific; thus, not a generalised view. Nevertheless, this pilot study provides a foundation to advance and expand into more detailed research, and supports continuous examination in external stakeholder engagement.

Table 2: External Stakeholder Engagement Strategies and Comments

Strategies	Case A	Case B	Case C	Case D
Issues can be reported to Gateman at site entrance	x			
Emergency hotline available to report any issues	x		x	
Site Manager contact details available on hoarding	x			
Inform Flyers distributed with site updates	x			
Newsletters sent out to all local residents	x		x	
Phone Calls to different agencies			x	
Emails to different agencies			x	
Regular Meetings with agencies			x	
Face-to-Face Discussions		x	x	x
Public Consultations				x
Comments	Case A	Case B	Case C	Case D
Engagement paramount at all times	x			
Critical that stakeholders are kept informed	x	x		
Open days and site visits planned	x			x
Site is CCS registered	x	x	x	
Approachable site manager helps communication	x		x	
Notify stakeholders prior to work being carried out	x			
Constant communication necessary		x	x	
Face-to-face conversation is the best strategy		x		
Liaising with Rail Authority on a regular basis		x		
Liaising with Local Authority on a regular basis		x	x	
Community Relations Manager appointed				x
Weekly Community Meetings (face-to-face)				x
Visitor Centre established				x
Public Consultations are held for residents				x
Early communication very important				x

DISCUSSION

External Stakeholder Identification

Combining the four case study interviews, a total of seventeen external stakeholders are identified. The qualitative analysis identified the 'Local Authority', 'Local Businesses' and 'Residents' as the main external stakeholders. They were frequently

discussed by all interviewees, which corroborates with a wide range of studies including Aaltonen (2010), who commonly identify these three as external stakeholders. Whilst maybe not a surprising revelation, it is interesting to note that the Local Authority emerged as the main external stakeholder ahead of Residents. The Senior Project Manager on the residential development scheme stressed the importance of maintaining regular contact with the Local Authority, as Wallbaum *et al.*, (2010) argue that they can play both a strategic and normative role. Aapaoja and Haapasalo (2014) agree that local (or public) authorities have power, but no personal interest in a project, provided that all regulations are followed. The Site Manager on the secondary school scheme also supported that the Local Authority may not be affected by the project on a day-to-day basis, but is nonetheless the most powerful external stakeholder, who have the capacity to close down the site if necessary. Regarding 'Residents' and 'Local Businesses', all the interviewees identified the usual construction site issues, such as noise, dust and traffic, which can have a negative effect on these stakeholders. Sun *et al.*, (2016) concur that urban construction projects have a negative impact on the surrounding environment which threaten the interests of the residents, while Ferguson (2012) further acknowledges that construction projects in urban areas are a source of serious nuisance to adjacent residents and businesses. The Senior Project Manager added that the local residents and surrounding businesses are a core priority, particularly during the construction phase, and the site team endeavour to cause as little disruption as possible to the people and their surrounding environment.

External Stakeholder Engagement Strategies

Collectively, ten wide ranging engagement strategies were identified and discussed by the four interviewees; 'Reporting issues to Gateman at site entrance'; 'Emergency Hotline available'; 'Site Manager's Contact Details available on the site hoarding'; 'Inform Flyers'; 'Newsletters'; 'Meetings'; 'Phone Calls'; 'Emails'; 'Face-to-Face Discussions'; and 'Public Consultations'. Chinyio and Olomolaiye (2010) concur that stakeholders can be engaged through different avenues, and channels of communication can be exploited as newsletters, flyers, emails and posters. According to Ballan (2011), using a telephone is a channel of communication that will never be replaced in the construction industry, because it is heavily relied upon for peer to peer communication and immediate responses. Yang *et al.*, (2011) in their typology of approaches identify newsletters to engage stakeholders in construction, and Enserink and Koppenjan (2007) opine that public consultations allow stakeholders to express their concerns, issues and ideas as part of a meaningful, participatory process. The Project Manager on the hotel scheme suggested that face-to-face conversations are the best strategy for engaging external stakeholders, while the Senior Quantity Surveyor also remarked that weekly face-to-face community meetings are held on that project. The Tasmanian Government (2005) ratify that face-to-face meetings are the best way to communicate with construction project stakeholders, and Opoku *et al.*, (2014) affirm that one-to-one meetings are a commonly used method of stakeholder engagement. It is interesting to highlight that no one strategy was reflected in all four cases, but face-to-face discussions featured in three cases. However, due to the dynamic nature of the construction process, Molwus *et al.*, (2017) observe that different strategies should be used for managing and engaging stakeholders at different stages of the project, depending on the prevailing circumstances. The Project Manager discussed how he would regular use emails, meetings and face-to-face discussions when engaging with the Local Authority on immediate matters, whereas

newsletters and inform flyers were his preferred action to engage with residents and other concerned stakeholders, to inform them of less urgent matters such as site updates and future activities happening on the project.

General Comments from Interviewees

As the interviews concluded, the remaining comments made by the four case study participants centralised around the importance of stakeholder engagement and communication as a whole. The Site Manager and the Senior Project Manager felt that an approachable and personable site / project manager aids the communication process, supporting Weaver's (2007) view that project managers should be highly skilled negotiators and communicators. Newcombe (2003) concurs that being sensitive and responsive to stakeholder expectations is a skill project managers need to apply when managing construction projects in the 21st Century. However, the Site Manager emphasised that these skills are not taught, but develop through career experience, and most engagement with stakeholders is done in an ad hoc manner based on their own intuition. Similarly to the identified strategies, no one comment is reflected in all four cases, which compounds that site and project managers have no set formula, but use their own initiative when dealing with external stakeholders. Nevertheless, three of the interviewees noted that their sites were registered with the Considerate Constructors Scheme (CCS), which is an organisation that seeks to improve the image of the construction industry, and encourages active engagement with stakeholders and the local community (CCS 2018). The interviewees reiterated that effective communication is paramount, compounding Yang's (2010) findings that the key to good stakeholder management and engagement is effective communication.

CONCLUSION AND RECOMMENDATIONS

Essentially, this pilot study focuses on the identification of external stakeholders and the strategies used to engage them on urban development construction projects. Urban construction projects are fragmented in nature, requiring integration and communication amongst all stakeholders. Therefore, site and project managers in these complex environments are tasked with ensuring that the identification and engagement of external stakeholders is carried out accordingly, through appropriate strategies and methods. Considering the results captured from the four case study interviews and data analysis, the Local Authority, Residents and Local Businesses emerged as the three main external stakeholders, from a list of seventeen. Face-to-Face Meetings and Newsletters were identified as the two main strategies from ten different strategies, used to engage the external stakeholders.

However, the findings established from the interviews and data analysis are case study specific, and only a concise, subjective view of the topic is produced; not a generalised view. The external stakeholders and strategies identified are important in any type of construction project, but are particularly relevant to urban development projects due to their complex and dynamic characteristics. Nevertheless, this pilot study provides a foundation to advance and expand into more detailed research, and supports continuous research in external stakeholder engagement. The findings in this paper can be developed further, and it is anticipated that a broader analytical context will be addressed in a subsequent journal publication, where additional theoretical points of departure can be articulated. It is recommended that further case studies are considered for qualitative analysis, and a sequential selection strategy is incorporated using criterion selection, such as quota and random sampling. This therefore provides the basis for informing and verifying the validity and necessity of the research and

subsequent PhD going forward. Also, additional case studies that are considered for qualitative analysis can be developed quantitatively through the use of questionnaire surveys, introducing another dimension to the area of research. This pilot study illustrates to site and project managers that the Local Authority, Residents and Local Businesses are three important external stakeholders to consider amongst a plethora of others, and Face-to-Face Meetings and Newsletters are some of the wide-ranging engagement strategies identified to manage and engage external stakeholders on urban development construction projects.

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BARRIERS TO SUSTAINABLE CONSTRUCTION PRACTICE IN NIGERIA

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There is a growing body of literature that recognises that adoption of sustainable construction practices (SCP) would result in significant reduction in the greenhouse emissions from the construction industry. Despite its importance, the practice of sustainable construction has not received much attention in developing countries, such as Nigeria. The current research aims to assess the barriers to the adoption of sustainable construction practices (SCP) in Nigeria. A combination of questionnaire survey and interviews were used for data collection. A total of 150 questionnaires were disseminated to major construction industry stakeholders based in Abuja, Nigeria and eight interviews were conducted. The findings of the study revealed that lack of expertise, lack of strategy to promote sustainable construction and lack of demand are considered to be the most critical barrier to the SCP in Nigeria. Also, the dominant culture of short-term benefit over lifecycle costing and the argument for the inclusion of sustainable practice in the contract seems to be peculiar in the Nigeria context and also less reported in previous studies. Taken together, there is a need to improve the knowledge of professional on sustainable construction through training programmes in Nigeria. The study recommends that sustainability module should be formally included in the built environment programmes in higher education in Nigeria to deepen its knowledge among the construction professionals.

Keywords: barriers, construction practices, developing countries, sustainability

INTRODUCTION

Sustainable construction is a rising concept that aims to incorporate the general principles of sustainability current practice of the construction industry. Sustainability means that lifecycle (social, economic and the environment) is the primary criterion guiding the process of creation and management of the built environment (UNEP Report, 2002). This includes but is not limited to new environmentally orientated construction designs, new environmentally friendly operation and maintenance procedures. It is axiomatic that the construction industry has significant impact on the environment. For instance, buildings produce waste that significantly pollute the natural environment during their construction and use (Albino and Beradi 2012).

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While the call for sustainable practice in the built environment sector has received much attention from clients, contractors, small and medium scale companies, researchers, social enterprises, Government and its regulatory bodies in countries such as the UK, USA, New Zealand, Australia among others (Upstill-Goddard *et al.*, 2016; Bond and Parrett, 2012; Shiers *et al.*, 2006). However, very little is known about sustainable construction practice in developing countries, such as Nigeria (Dania *et al.*, 2014). Dania *et al.*, (2014) and Dahiru *et al.*, (2010) observed that sustainable practice is still an emerging concept in the Nigeria construction industry.

In Nigeria, Mbamali and Okotie (2012) and Dahiru, *et al.*, (2010) assert that not until 2006 when discussions for the National Building Code started, the Nigerian construction industry was without uniform regulations, guidelines and standards for the design, construction and operation/maintenance of buildings. Dahiru *et al.*, (2010) noted that while it is true that the situation in the Nigerian Building industry has greatly improved in some aspect there is no adequate consideration for sustainability in the National Building Code (2006) and within the current practice in the construction sector. However, the reasons for the current unsustainable practice are not yet explored in Nigeria. According to Wilson and Rezgui (2013), the construction industry is characterised by a complex socio-cultural, contextual, structural issues as reflected by its endemic resistance to change. While there is considerable need to migrate from the conventional construction system to sustainable construction practice in Nigeria, there is lack of authoritative research to understand the current barriers to sustainable construction practice in the Nigeria through the lens of stakeholders.

In order to endorse and drive the agenda for sustainable construction in Nigeria, the barriers that hinder these practices must first be identified from the stakeholders' perspective. Previous studies on SC in Nigeria focused on understanding capabilities of construction firms on sustainable construction practice (Dania *et al.*, 2014); sustainable health and safety practice in construction (Okoye and Okelie, 2013); prospect of green practice (Dahiru *et al.*, 2014) and prioritisation of sustainable construction attributes (Nwokoro and Onukwube, 2011). None of this study focuses on prioritising the barriers to sustainable construction practice in Nigeria. However, this study maps out the barriers to SC practice and identified the most significant barriers to SC practice in Nigeria through the lens of the key stakeholders. An understanding of the barriers to sustainable construction practice would aid the development of strategies to ease its implementation not only in Nigeria but also in other developing countries as well.

The outcome of this study provides insights on measures to improve SC practice in developing countries in general

LITERATURE REVIEW

The construction industry and its products are major contributors of greenhouse gas (GHG) emissions to the environment. Several authors (Hwang and Tan, 2012; Shi *et al.*, 2013) have shown that the adoption of sustainable practice would reduce the adverse impact of the construction sector on the environment. In addition, research has shown that the use of components, such as precast concrete components (Mao *et al.*, 2013) and green roof systems (Kumar and Kaushik, 2005), results in significant reduction of GHG emissions from construction projects. Similarly, evidence suggests that the demand for eco-friendly products have been on an increase (Sharpley, 2006; Kumar *et al.*, 2011). Based on the foregoing, it is evident that the adoption of sustainable construction practices would be beneficial for construction business in

terms of business performance and client satisfaction, amongst others. However, the adoption of sustainable construction practices still remains as a challenge, especially in developing countries like Nigeria.

To date, the barriers to the adoption of construction practices have led to academic investigations in several countries. These studies found in literature have been carried out in China (Shi *et al.*, 2013); Finland (Häkkinen and Belloni, 2011); Hong Kong (Zhang *et al.*, 2012); Malaysia (Abidin *et al.*, 2013); Singapore (Hwang and Tan, 2012) and United Kingdom (Williams and Dair, 2007), among others. Shi *et al.*, (2013) found that high cost, longer time required, shortage of green suppliers and information and additional consideration for maintenance are the significant barriers to sustainable building in China. A study on barriers to green building project management in Singapore showed that high cost, lack of communication and interest among project team members, low demand/lack of interests by clients, limited research highlighting the benefits of sustainable construction practices and the high cost of implementing green building practices are the five most important barriers (Hwang and Tan, 2012). Both studies agreed that high cost is a major barrier to the adoption of sustainable construction practices. However, there are variances in the significance of the barriers associated with sustainable construction practice in China and Singapore. These differences could be due to the level of government's commitment to sustainable development in these countries. Table 1 provides a summary of significant barriers to sustainable construction practices identified from previous studies found in the literature. This information served as the take-off point for the development of the questionnaire used in the present study.

RESEARCH METHOD

A mixed research design that uses quantitative cross-sectional survey and qualitative opened interviews (Bryman, 2016) was used in identifying and understanding the barriers to sustainable construction practice in the Nigeria construction industry. The use of mixed approach in construction management research has been widely reported in literature (Dainty, 2008). In this study the quantitative survey was used to rate the significant barriers to sustainable construction practice that are peculiar to the Nigerian construction industry. While the open ended interviews, aim to identify other barriers to sustainable practice in Nigeria context and to also triangulate the result of the survey. Creswell, (2007) observes that interviews gives research participants the opportunity present their own view on the phenomenon or problem being investigated rather than that reported in literature alone. The use of interview provides deeper insights into a problem being investigated when compared to questionnaire survey (Creswell, 2007).

A review of the extant literature was carried out to grasp and engage with the current knowledge of barriers to sustainable construction practice (SCP). The barriers to SCP were identified from previous research found in the existing literature (see Table 1). This activity was done to ensure that the current investigation in Nigeria is guided by existing empirical evidence using the deductive approach (Bryman, 2016). This information was used to develop the survey instrument used in examining the barriers to SCP in Nigeria from the stakeholders' perspective. The questionnaire comprises two sections. Section A identified demographic data of respondents while section B considers the stakeholders' view on the barriers to SCP. In section B, respondents were asked to rate the barriers to SCP in Nigeria on a scale of 1 to 10 (with 1 being the weakest and 10 being the strongest).

Table 1: Summary of the significant barriers to sustainable construction practices

Author(s)	Country	Significant barriers
Wilson and Tagaza (2006)	Australia	High initial cost
Williams and Dair (2007)	United Kingdom	High cost, slow return on investment, resistance to changes in the current practices and subcontractors lack the skills and knowledge.
Hakkinen and Belloni (2011)	Finland	Lack of client awareness, lack of reliable information on the cost savings associated with the use of sustainable construction and lack of methods that support the adoption of sustainable construction.
Hwang and Tan (2012)	Singapore	High cost of sustainable construction projects, ineffective communication and interest among project team members, and cost of implementing sustainable construction practices.
Zhang <i>et al.</i> , (2012)	Hong Kong	Lack of client demand, shortage of government's incentive and high cost.
Abidin <i>et al.</i> , (2013)	Malaysia	Lack of government commitment, high cost and client demand.
Shi <i>et al.</i> , (2013)	China	Extra cost associated with sustainable construction, schedule overrun linked to sustainable construction and shortage of green suppliers.
Szydluk (2014)	US	Poor perception due to bad experience, lack of experience and resistance of changes in the current culture.
AlSanad (2015)	Kuwait	Lack of awareness
Ametepey <i>et al.</i> , (2015)	Ghana	Resistance to change, lack of government's commitment and perceived high cost.

Face validity as suggested by Bryman (2016) was used to ensure that the survey instrument sufficiently measure the barriers to SCP in Nigeria. Accordingly, two construction management experts in the academia and two senior construction manager based in Nigeria validated the research instrument. The initial survey instrument was modified based on the recommendations and suggestions from these experts. Additionally, the survey instrument was piloted with two clients, two contractors and two consultants, this was done to identify and minimise any form of ambiguity with the survey instrument.

The data employed in the study were gathered from construction stakeholders based in Abuja, the Federal Capital of Nigeria. Preliminary investigation at the start of the study revealed that major construction projects that involve the major stakeholders in the Nigerian construction industry are initiated and on-going in the Abuja metropolis, for example the Centenary City project (Oxford Business Group, 2018). It also housed the head offices of the construction companies in Nigeria. This suggests that current information on SCP could be gleaned from construction professionals based in Abuja Metropolis; this informed the choice of Abuja as the study area.

The sample for the study was purposive drawn from client organisation (Federal Housing Authority of Nigeria); contracting organisation (registered contractors with the Nigeria Institute of Building); consulting organisation (Nigeria Institute of Architects). This was done to ensure only those who are qualified professionals participate in the study. This approach ensures the view of the designers, the contractors, the professional bodies and statutory agencies on the barriers to

sustainable construction practice is sought. These organisations were selected to participate in this study because the professionals in their employ play active roles in phases of construction projects. The invited participant in the study has over 8 years' experience within the Nigeria construction industry and they are fully chartered with their professional bodies. This means their response could be relied on.

A total of 150 questionnaires were disseminated to major stakeholders in the construction industry based in Abuja, Nigeria. The questionnaire was sent via email and physically given to the respondents in their offices. Out of the 150 questionnaires administered, 80 questionnaires were received. Relative importance index (RII) was used to rank the dominant factors under the objectives of the study. Johnson and LeBreton, (2005) observed that RII enable a study to identify how a given variable contribute to the prediction of a criteria in relation to other predictor variables for the purpose of ranking. In this study RII was used to rank the most significant barriers to the SCP in Nigeria in relation to other variables as perceived by the research participants. Additionally, eight research participants were interviewed. This includes one client (CL 01); four main contractors (MC, 01, 02, 03, and 04); three consultants (CO, 01, 02 and 03). More contractors were interviewed because they are more involved in the construction phase of a project. All the interviewees have over 8 years' experience in construction and they are chartered member of their professional bodies. The interview was analysed using content analysis and themes (Bryman, 2016).

RESULTS

The RII and the rank of the barriers to SCP in Nigeria are presented in Table 2. The five most important barriers to SCP are: lack of expertise and professional knowledge; lack of strategy to promote sustainable construction; Lack of demand; Lack of legislation, enforcement and monitoring; and Lack of government incentives and support with corresponding values of 0.94, 0.92, 0.92, 0.90 and 0.87, respectively. However, extensive pre-contract planning is considered to be the least important barrier to SCP in Nigeria.

Emerging Themes from Interviews on the Barriers to SCP in Nigeria

The core themes that emerged from the content analysis of the eight semi-structured interviewed on the barriers to SCP in Nigeria include: (1) Lack of consideration for sustainability in the design phase (2) Low level of knowledge and ignorance of sustainability among construction practitioners (3) Dominance of short term benefit culture over life cycle benefit (4) Absence of clear government policy and standard on sustainable construction practice (5) Lack of demand for sustainable product and process.

DISCUSSION OF RESULTS

The evidence on the significant barriers to SCP gleaned from the survey result presented in Table 2 is now discussed and triangulated with the themes that emerged from the interviews.

Lack of expertise and low level of sustainability among practitioner

The survey result indicates that the lack of expertise and professional knowledge was ranked as the most significant barrier to SCP in Nigeria. This view was further echoed by the research participants that participated in the semi-structured interviews. Some of the respondent interviewed stated that: The current knowledge on sustainable

construction among practitioners in Nigeria is low and there is less emphasis on it in trainings in schools especially in the past [CO1, Consultant Project Manager]. "The level of awareness and education on sustainability among practitioners here is still very low" [CL 01, Construction Director].

Table 2: Barriers to the adoption of Sustainable Construction Practice in Nigeria

Barriers to SCP	Relative importance index	Rank
Lack of expertise and professional knowledge	0.94	1
Lack of strategy to promote sustainable construction	0.92	2
Lack of demand	0.92	2
Lack of legislation, enforcement and monitoring	0.90	4
Lack of government incentives and support	0.87	5
Lack of public awareness of the benefits of sustainability	0.85	6
Resistance to change from the current practices	0.85	6
Lack of training opportunities	0.82	8
Lack of design and construction teams for sustainable construction	0.80	9
Perceived increase in cost and time	0.79	10
Lack of measurement tool to showcase benefits of SCP	0.78	11
Lack of cooperation	0.77	12
Risk associated with investment	0.76	13
Increased documentation	0.76	13
Higher investment cost	0.75	15
Lack of financing	0.74	16
Extensive pre-contract planning	0.72	17

It is not surprising that most of respondent see lack of expertise and knowledge as a major barrier to sustainable construction practice in Nigeria. This perception could be due the non-existence of clear framework for sustainable construction practice for practitioners and even in the training of built environment professionals (such as construction managers, architects and engineers, among others) in the institution of higher learning in Nigeria.

This finding align with Dania *et al.*, 2014 and Dahiru, *et al.*, 2010 where they found that the concept of sustainable construction practice is still in its infancy among practitioners in Nigeria. While sustainability is seen a core module or incorporated into most module in developed countries such as the UK in construction related programmes, this is yet to be a common practice in construction related courses in higher education in Nigeria.

Lack of policy, standard and strategy to promote sustainability

Table 2 reveals the lack of strategy to promote sustainable construction ranked second, closely related to this is lack of standard, legislation and enforcement which ranked 4th. This finding is supported by the interview result where some of the respondents stated that: "Although some knowledge of sustainable construction is now being disseminated in part to those who has been to school in recent time but because of lack of policy to drive it this is not implemented in practice people do want they like" [CO2, Project Coordinator]. "There is lack of government policy to support sustainable construction, for instance there is no regulation on the nature or quantity of waste that should be sent to landfill or reused as done in other parts of the world"[MC

02, Project Director]. There is no law or framework to guide and enforce sustainable construction practice [CO3, Consulting Architect]. According to Dahiru *et al.*, 2010 there is dearth of regulation, standard and policy to drive the implementation of sustainable construction practice in Nigeria. Similarly, Mbamali and Okotie (2012) observed that there is still no clear policy to drive sustainable construction practice in Nigeria. However, in developed countries such as the UK and USA where there are standards such as BREEAM and LEED among others to drive sustainability practice (Sherratt and Farrell, 2015). The interview result further suggests that in addition to developing appropriate legislations and standards, mechanisms for monitoring compliance must be put in place.

Lack of demand for sustainable product and lack of inclusion in contract clauses

Table 2 shows that there is lack of demand for sustainable construction practice also ranked second. The lack of demand is both from public client and private client Professionals have primarily focused on the cost, time and quality as the metrics for evaluating the of construction projects (Chan and Chan, 2004). However, in recent times, there has been a shift towards the inclusion of sustainability as a performance indicator for construction projects (Shen *et al.*, 2007). This view was further echoed in the interview; one of the main contractors stated that: "Most time SCP practice is not clearly stated in the contract and this makes it difficult for us to deliver"[MC 04, Project Manager]. It could be argued that the lack of reference to sustainable construction practice in the contract shows a lack of demand for it by the client. The lack of demand for sustainable construction by clients in Nigeria could be explained from two perspectives. First, it could be due to clients ignorance of the benefits associated with the practice of sustainable construction. Studies such as Hwang and Tan, 2012 found that the lack of awareness and limited evidence on the benefit of sustainable construction practice are among the barriers to it adoption. Second, the client may not be demanding for it because for it because of it cost implication. One of the Designers stated that: "Do you know that some of these clients would not like to pay for it, for example my client seek for advice on the choice between wood or asbestos for ceiling. After giving him the cost for both, the client went for asbestos instead of wood that is more sustainable" [C0 3, Consulting Architect].

Lack of consideration for sustainability in design and short term benefit culture

The interview result shows that sustainability issues seem not be adequately considered during the design phase of the project in Nigeria and clients focuses more on short-term benefit than the lifecycle benefit in choosing materials and method for constructing a facility. Some of the respondents stated that: "Sustainability is not considered during design most time it seen as an afterthought or as ad on during construction"[MC 03, Project Manager]. "There is this culture that is with us, seeking for immediate short term benefit without looking at the lifecycle costing in choosing material and process"[MC04, Project engineer]. This shows the need to develop appropriate regulation for the inclusion of sustainable consideration into design for constructed facilities. However, with the current culture of going for lowest cost over value and sustainability client may still continue in their old way in the absence of enforceable regulation. It is worth mentioning that the conflict between cost and value as captured is not peculiar to the Nigeria construction industry alone; rather it is an industry wide problem. The recent Hackitt report following recent Grenfell fire incidence and other construction industry report such as Latham reiterate this assertion (Hackitt Report, 2018)

CONCLUSIONS

The purpose of this study is to identify the barriers to SCP within the Nigerian construction industry with a view to suggest strategies to mitigate them. The study found that lack of expertise and professional knowledge, lack of legislation, stand and strategy to promote sustainable construction, lack of client demand, lack of consideration for sustainability in design and the culture of short term benefit over life cycle costing are the core barriers to SCP in the Nigerian construction industry. While some of these barriers have been reported elsewhere the form in which it manifest in the context of Nigeria construction industry as seen from the interviews response is unique. However, some of the barriers identified from the semi-structured interview such as the non-consideration of sustainability in designs, the dominance culture of short term benefit over lifecycle costing and the argument for inclusion of sustainable practice in contract seems to be peculiar in the Nigeria context and have been less reported in previous studies. The study conclude that the need to include sustainability consideration right from the design and its inclusion in the contract cannot be underestimated especially in Nigeria and in other part of the world where contract dictates the tune on how construction projects are delivered.

This study has shown that the level knowledge of SCP among core construction stakeholders in Nigeria is still very low compared to other part of the world. Again, this suggests there is a need for training and retraining of built environment professional on issues related to sustainable construction practices. This could entail introducing sustainability modules into the built environment and construction management programmes in the Nigeria Universities and holding of CPD events on sustainable construction practice by professionals bodies in the built environment in Nigeria. Client demand can be generated through publicity of the benefits of sustainability on the environment and business performance. Additionally, incentives (financial and non-financial) are vital for improving the practice of sustainable construction. For example, government could reduce the import tax on sustainable technologies. The findings of the current study contribute to the existing knowledge on the barriers to SCP from the context of the Nigerian construction industry.

Although the current study is limited to the view of construction stakeholders and practitioners in Abuja metropolis, the study provides valuable insights on the barriers to SCP in a developing country such as Nigeria and contributes to future implementation of sustainable construction practice in Nigeria and possibly in other developing countries.

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BEHAVIOURAL ASSESSMENTS IN CONSTRUCTION PROCUREMENT: A BANDWAGON OF INSTITUTIONAL WASTE?

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The drive to create integrated and collaborative project teams has seen the behavioural assessment of suppliers become increasingly common in construction procurement exercises. Within the stated objectives of this are the desire to procure supply partners with the right ‘collaborative working capabilities’ and ‘cultural alignment’. Belief in the benefits of behavioural assessments in procurement has become so prevalent as to be referenced in the Infrastructure Client Group’s ‘Alliancing Code of Practice’ published by HM Treasury in 2015. However, the spread of this resource intensive practice has occurred without published evidence that it increases the effectiveness of procurement objectives. The purpose of this study is to examine the efficacy and value of behavioural assessment practices commonly used in UK infrastructure procurement exercises. The analysis draws on theories of organizational psychology and sociology as well as the industry experience of the co-authors. Importantly, the study addresses practices attempting to secure integration but which evidence suggests that they generate actual and potential waste. It is concluded that for several reasons the practices commonly used in behavioural assessment in construction procurement have little validity. The study’s findings shed light on institutional pressures in the development and introduction of management policies and construction procurement practices, and call for greater collaboration between behavioural scientists and construction management disciplines. Such collaboration can be used to critically examine change proposals that may go on to generate ‘institutional waste’.

Keywords: behavioural assessment, procurement, performance prediction, waste

INTRODUCTION

The inclusion of a process of behavioural assessment in UK construction programme procurement has grown in the past decade. Puckett (2007) reports on the team simulation exercises used in the procurement of the delivery partner contract for the Olympic Delivery Authority (ODA). Doyle and Jones (2009) describe a behavioural assessment approach used in the procurement of a partner for the decommissioning of the Sellafield nuclear power station. Jensen (2015) describes how Network Rail used behavioural assessment in the procurement of its Wessex Capacity programme.

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Mitchell (2016) refers to the use of behavioural assessment in the context of large scale alliance procurement by the Environment Agency, Highways England and High Speed 2 (HS2). Among the authors' experience is providing support for procuring authority and supplier preparations for behavioural assessment processes in procurement for Thames Water's AMP6 capital works programme, Heathrow's Q6 investment programme, Crossrail2 design and the Palace of Westminster project services.

The intent of using behavioural assessment as part of the process of selecting suppliers has been variously described as to "isolate the precise attitudes and personality traits they're [clients are] after" (Puckett, 2007, 44b), to "estimate how well bidding contractors will collaborate" (Mitchell, 2016, 36), to "evaluate how potential partners would perform in the future" (Doyle and Jones, 2009, 44b) and, "to gauge whether a contractor's behaviour and working style will be a good fit with the project team" (Mitchell, 2016, 36a). Belief in the benefits of behavioural assessments in procurement has become so prevalent as to be referenced in the Infrastructure Client Group's 'Alliancing Code of Practice' published by HM Treasury in 2015. The process is seen as able to "expose flaws that the bidding team can conceal in standard written and oral presentations" (Puckett, 2007, 43c). It is also seen to be able to address shortcomings in traditional evaluation methods, involving written and oral submissions, perhaps countering a view that "promises are not a predictor of delivery" (Doyle and Jones, 2009, 46b).

The behavioural assessment process can, however, be resource intensive (Hancock, 2015). For example, there were two assessment centres (ACs) used for the Sellafield project, each bringing together teams of 15 to 20 people (Doyle and Jones, 2009, 46c). The behavioural assessment process for Highways England's Collaborative Delivery Framework (CDF) involved assessing 36 bidders over a four-month period (Turton, 2015). In January 2016, a notice was published in the Supplement to the Official Journal of the European Communities (OJEU) relating to the award of a contract by Parliament UK for 'STC1115 - Behavioural Assessment Services for use in major programme procurements'. The contract value was stated as £477,216 for the duration of 2 years. Puckett (2007, 44b) notes a company that will, "set up and run "soft issues assessments" at a cost of anything from £50,000-250,000" As well as the cost of consultants engaged to design and manage a behavioural assessment process for procuring authorities, other tangible and intangible resource costs accruing will include the staff time of procuring authorities, supplier staff time taking part in assessments and the cost of consultant support for suppliers preparing for the assessment process. The costs incurred by suppliers may be reflected as added premiums in tender prices or contribute to reduced supplier margins (Sarhan *et al.*, 2017).

Within the construction industry discourse, the origins, and perhaps by inference, the face validity of behavioural assessment in construction supplier selection has been attributed to its development in the military (for example, see Puckett, 2007, 43c). The organizational psychology literature commonly acknowledges the origin of ACs as from German, British and Australian military officer selection efforts in the 1930s and 1940s and the Office of Strategic Services (Lance, 2008). However, whereas we can find no literature pertaining to the validity of measures used for selecting supplier organizations using behavioural assessment, the organizational psychology literature concerning selection methods for individuals and the validity of AC measures is

extensive and has developed over thirty or more years (see for example, Lance, 2008; Jackson *et al.*, 2016).

Drawing upon this organizational psychology literature, this study questions the efficacy and value of behavioural assessment practices used in construction procurement. It acknowledges that although no single approach to behavioural assessment in procurement exists, there appear to be practices and assumptions commonly used and made for which there is no evidence for utility in relation to the purposes for which they are intended. Common practices for which there is no evidence of utility include the use of multi-situational, multi-dimension approaches to assessment in ACs and interviews, and the extrapolation of the results of assessments of individuals to infer behaviour at an organizational level. This study therefore provides a critical discussion, and proposes that behavioural assessment processes commonly used in UK construction programme procurement are counterproductive, as they consume resources and may generate wasteful behaviours without adding practical value. This study further proposes that, in the face of a lack of evidence for their utility, the use of behavioural assessment in construction procurement has spread because of institutional forces that have parallels with a ‘bandwagon effect’ found among consumers (Kuwashima, 2015), social legitimacy (Meyer and Rowan, 1977), and a normative form of institutional isomorphism to which the professional environments of public sector organizations can be susceptible (DiMaggio and Powell, 1983; Frumkin and Galaskiewicz, 2004; Kallio and Kuoppakangas, 2013). The spread of this ineffective process therefore seems to constitute an element of ‘institutional waste’ in construction procurement processes (Sarhan *et al.*, 2018).

Behavioural Assessment in Construction Procurement - a Critical Review

Behavioural assessment processes in procurement are often used in conjunction with technical, commercial and management approaches submissions. They generally include some, or all of the following: simulation and other team exercises at an assessment centre (AC) style workshop, interviews with project team and ‘corporate’ leaders, site visits, evaluation of written team member biographies and project case studies (Mitchell, 2016, 37b). Table 1 is adapted from Turton (2015) to illustrate behavioural assessment practices commonly found in UK construction procurement exercises. Additionally, among the authors’ experience is witness to the use of psychometric tests and organization cultural inventory questionnaires.

This section raises the following concerns relating to the efficacy and value of behavioural assessment processes commonly used in construction procurement: (1) the use of assessments based on job-relevant competencies (e.g. “teamwork”, and “communication ability”) instead of simply examining how well candidates perform in specific job-related situations; (2) the validity of tests used to evaluate the performance of individuals in multi-situation, multi-competency approach AC settings; (3) the assumptions of the prediction of organizational performance in a future context based on the evaluation of the performance and assessed characteristics of a small sample of individuals in a competitive procurement process; and (4) ethical issues relating to the well-being of candidates taking part in ACs.

The study found no evidence-based research literature pertaining to the prediction of organizational behaviour based on the assessment methods commonly used in construction procurement. Conversely, the evidence-based research concerning the measurement of the characteristics and the prediction of performance of individuals is extensive. Jackson *et al.*’s (2016) work on the measurement of behavioural

dimensions in ACs informs our findings and discussion. Their work draws upon hundreds of studies on ACs and the measurement of ‘competencies’ - behavioural dimensions that construction procurement behavioural assessment exercises commonly purport to attempt to measure (Doyle and Jones, 2009, 47a).

Table 1: Typical UK behavioural assessment practices [Source: Turton, 2015, 14]

Behavioural Assessment Activity	Data Evaluated/Nature of Evaluation
Behaviour Biographies	Biographies of bidders’ core team including professional qualifications and collaboration experience.
Case Studies	Examples of how the bidders’ organisation has demonstrated the required behaviours with other organisations (clients, other suppliers).
Workshops	Residential workshops with core bidders’ teams to observe their ability to collaborate and understanding of the required behaviours.
Leadership Team Interviews	Panel interviews with key individuals who have full accountability for overall delivery within the bidding organisation.
Site and Premise Visits	Validation of behaviours and collaborative working in practice at an operational site.

Assessments Based on Job-Related Competencies

It is important to critically review the idea of ‘competencies’; the behavioural dimensions against which candidates’ behaviour is assessed in both selection procedures found across industry and reportedly used in construction procurement behavioural assessment. Reports of construction procurement behavioural assessment exercises refer to exercises based on ‘simulations’ (for example, see Puckett, 2007; Mitchell, 2016) and the assessment of candidate performance in those simulations in relation to a set of competencies. This is consistent with the authors’ experience: supplier candidates are given tasks to perform and are then ‘scored’ according to how well their behaviours indicate the presence of the prescribed competencies. Tasks or simulations can attempt to recreate some aspect of the project likely to occur, such as a “first 100-day stakeholder engagement plan” (Doyle and Jones, 2009, 49b). An example of an AC scorecard is illustrated in Doyle and Jones (2009).

One of the first references to competencies in the academic literature on organizations was made in an article published in 1973 in the *American Psychologist* by David McClelland, a Harvard professor of psychology. McClelland argued that research indicated that intelligence was a poor predictor of performance at work. To evaluate job candidates, and to successfully predict their future performance, he suggested that assessing job-related “competencies” such as communication skills, patience, the tendency to set goals of moderate difficulty, ego development, as well as more traditional reading, writing, and calculating abilities, rather than intelligence, or personality, is the best way to predict the future performance of job candidates. In 1981, Richard Boyatzis, a consultant with the McBer Corporation, founded by McClelland, was commissioned by the American Management Association to examine whether a generic model of managerial competencies could be identified. Boyatzis reported the results of his work in his 1982 book *The Competent Manager: A Model of Effective Performance*. This book was highly influential in popularizing and fuelling the growth of competencies in organizations. This growth was further encouraged by the availability of the assessment centre (AC), a system for assessing the future performance of individuals developed by the military.

It is noted in this study that despite the widespread adoption of competencies and competency frameworks by human resource management practitioners, to date there is

not a single study in academic, peer-reviewed journal articles, in which evidence is presented for the structure of human competences using the standard statistical technique of factor analysis to analyse data on the measured behaviour of people. This is in stark contrast to the hundreds of studies in which factor analytic techniques have been used successfully in this way to identify the structure of cognitive ability, and of personality. This study notes that this may seem radical and challenging.

The Validity of Tests in a Multi-Situation, Multi-Competency Approach

The overall AC process of evaluating competencies across several exercises, and then using some method of integration to arrive at an overall evaluation of the candidate, is generally known as the ‘multi-situation, multi-competency approach’. The idea has military origins in Germany in the early 20th century and was drawn upon by the British Government’s when setting up the War Office Selection Boards (WOSBs) in 1942 and the Civil Service Selection Board introduced in 1945. The private sector’s use of ‘multi-situation multi-competency assessment methods’ was initiated by the American Telephone and Telegraph Company (AT&T) in 1956 in what they called ‘assessment centres’ (ACs). In the 1960’s, 1970’s and 1980’s, there was considerable growth in the use of ACs to measure behavioural dimensions in public and private sectors organizations. The current construction industry practice of using site visits to gather competency related data are simply an extension of the situations or exercises from which competency data is gathered in ACs.

‘The concept of ‘validity’ in AC processes is of strong relevance in being able to demonstrate that a fair process of evaluation has been followed (Petrides *et al.*, 2010). ‘Validity’ concerns the degree to which available evidence supports inferences or judgments made from scores on selection measures (Gatewood *et al.*, 2015). An AC is essentially a technique for measuring behavioural performance. As with all other measurement techniques, the validity of this measurement is a primary concern. There are several ways of examining validity (Gatewood *et al.*, 2015); the two aspects of the validity of ACs which have attracted by far the most research are: (1) construct related validity - do ACs measure what they are designed to measure; and (2) criterion-related validity - to what extent do they predict what they are designed to predict (which is normally the future job performance of candidates).

Construct Validity

‘Construct validity’, as the question of whether ACs measure what they are purportedly designed to measure has been the subject of considerable research and debate (Sakoda, 1952; Sackett and Dreher, 1982; Jackson *et al.*, 2016). This debate was sparked by the observation that there appears to be a greater correlation between the ratings given to candidates and the exercises they are taking part in than the correlation between the ratings they are given and the competencies that they are intended to be rated against. This phenomenon appears to contradict the notion that ACs are primarily measuring candidate competencies; instead it suggests that they are primarily measuring the candidates’ performance on specific exercises. It is known as ‘the exercise effect’ and is an important observation in relation to the validity of ratings and, consequently, the presence of a fair evaluation process (Petrides *et al.*, 2010).

Until recently it has not been possible to resolve this debate because the rating given to a candidate on any one exercise, when evaluated on any one competency, is influenced by multiple variables (e.g. who is doing the rating, the competency in question, the exercise in question, the overall performance of the candidate

irrespective of specific exercises and specific competences etc.). However, in the last few years advances in generalizability (or ‘G’) theory statistical techniques have made it possible to establish what ACs measure. Two major studies (Putka and Hoffman, 2013; Jackson *et al.*, 2016) have been conducted using these techniques, both focusing on ‘state of the art’ ACs. The findings generated by these studies are remarkably similar and striking. They indicate that ACs measure two things: (a) the performance of candidates on specific exercises, and (b) the general performance of candidates across all exercises and competences. However, crucially, they do not measure a candidate’s competencies. There appears to be no evidence that suggests competencies are measured in ACs; even in ‘state of the art’ ACs.

Criterion-Related Validity

‘Criterion-related validity’ refers to the extent to which ACs predict what they are designed to predict - which is normally the future job performance of candidates. The approach commonly used to establish the criterion-related validity of ACs is meta-analysis (Hoffman *et al.*, 2015). This technique involves obtaining the results of multiple academic studies of the correlation between: (a) overall assessment ratings (OARs) given to candidates in ACs, and (b) subsequent job performance of these candidates. This information is then combined statistically to obtain an overall indication of how well OARs predict job performance.

Large scale meta-analytic studies estimate the criterion-related validity of ACs to be between .23 (Hermelin, 2007) and .37 (Gaugler, 1987). This indicates that the results obtained from ACs may account for somewhere between 5% and 14% of the variance in job performance between different people, meaning that the results from ACs do not strongly predict differences in job performance. A related issue is the extent to which OARs add to the prediction of job performance over and above other assessment techniques such as interviews, cognitive ability tests, and personality questionnaires. A recent meta-analytic study by Hoffman *et al.*, (2015) found that cognitive ability testing and personality questionnaires jointly accounted for 20% of the variance in a candidate’s future job performance, and five AC exercises each explained only an additional 2-3% of the variance in job performance. There is some evidence therefore that ACs offer a small amount of incremental validity over other widely used (and very considerably cheaper) selection techniques. However, it should be noted that the Putka and Hoffman (2013) and Jackson *et al.*, (2016) studies outlined above suggest that any predictiveness in AC’s is derived from the measurement of the overall performance of assessee’s, and their performance on exercises, and not from the measurement of individual competencies.

Inferring Prediction of Organizational Performance from a Sample of Individuals

The general intent of the behavioural assessment processes commonly used in construction procurement seems to be to predict the future performance of tendering organizations. Doyle and Jones (2009, 44b) describe “an assessment centre approach involving team simulations to evaluate how potential partners would perform in the future”. However, of behavioural assessment processes commonly used, only one, the evaluation of case studies, is at the organizational level of analysis. Others, such as biographies, interviews, and behavioural assessment in ACs, focus on individuals rather than the organization for which they work. Commonly used behavioural assessment processes used in construction procurement adopt techniques originally developed to predict the future performance of individuals, and do so in order to

predict the future performance of organizations. Whether or not such an approach can, in principal, be successful is unclear. There is, to our knowledge, no scientific evidence that the future performance of organizations, or parts of organizations, can be predicted by evaluating samples of behaviour, in samples of people, from those organizations. Sampling adequacy, both in relation to sample size and sample representativeness, is an issue of very significant concern in current behavioural assessment exercises in construction procurement. The issue of sample and process inadequacy is compounded further by the possibility, or even likelihood, that supplier candidates assessed may not actually take up a role in the project being procured or may only take up a temporary role. These concerns are in the context of expectations that behavioural assessment is being used to determine whether clients and suppliers can work together for the duration of a contract (Puckett, 2007, 43c) that may last for several years.

Ethical Issues Relating to the Well-Being of AC Candidates

Puckett (2007, 44b) notes the ‘toughness’ of the ‘team simulation’ process and how one veteran of the technique describes it as a way of “testing people almost to destruction, seeing how far you can upset people before they crash out”. Approaching the design and administration of behavioural assessment in this way may not only detract from the assessment of the competencies that are purported to be the subject of evaluation but may breach ethical codes; AC managers and the client organization perhaps exercising power through dictatorial behaviour and AC candidates believing it important to comply (Liefoghe and MacKenzie Davey, 2001) within a competitive process, risking undue stress or humiliation.

The British Psychological Society’s Division of Occupational Psychology has published a standard for the Design and Delivery of Assessment Centres; within that are references to fairness of process, objectivity and ethical standards. This study has found no references to that or any other AC design and management standards in literature pertaining to the use of ACs in the construction programme procurement. Having discussed the main concerns in relation to the efficacy and validity of behavioural assessment in procurement, we offer possible explanations, underpinned by well-established social science theories, to the wide-spread of this seemingly inefficient and ineffective procurement process

The Bandwagon Effects and Institutional Waste

Work by Sarhan *et al.*, (2018) introduced the concept of ‘institutional waste’ within the construction procurement context, which emphasises the significance of how imperfect regulations, norms, cultural and cognitive assumptions may influence our approaches to construction procurement, leading to irreconcilable and self-perpetuating cycles of waste. Waste here can be in the form of monetary, time, effort or value loss, and can occur prior to or post contractual stages. Their study argues that many counterproductive construction procurement arrangements are formed and prevail in the industry, due to social legitimacy and mere ceremony (Meyer and Rowan, 1977) or flawed risk-averse safeguarding considerations compounded by vested interests of external consultants and third parties (Sarhan *et al.*, 2017). These wasteful procurement governance arrangements dominate the management of the project delivery often to the detriment of the project itself; but because there is a belief that interests are safeguarded, construction buyers and decision makers feel they have taken the best course of action (Sarhan *et al.*, 2017).

The references in construction industry publications to military origins and the ODA (Puckett, 2007) may represent social legitimacy in action as an explanation for the industry's widespread adoption of practices with no known evidence base for efficacy, yet which become desired and established norms. The Infrastructure Client Group's 'Alliancing Code of Practice' published by HM Treasury in 2015 articulates beliefs in the benefits of behavioural assessments in procurement. This may again both reinforce social legitimacy and suggests that behavioural assessment is included in the construction procurement process to act as a safe-guard against perceived opportunism (Sarhan *et al.*, 2017). Yet again, known evidence for efficacy is absent.

The spread of behavioural assessment in procurement has occurred over ten years within an industry where independent client authorities have a choice about procurement practices to adopt yet have seemingly chosen to do similar things without evidence that these practices achieve their intended aims. This study posits this phenomenon has similarities with the 'bandwagon effect' found among consumers (Kuwashima, 2015). Veblen (1899) suggested that consumers are concerned about others' perception about them rather than private utility gained from products themselves. Leibenstein (1952) found empirical evidence for links between this and consumption patterns and termed it a 'bandwagon effect'. In the context of this study we propose that the behavioural assessment process has strong parallels with the 'product' being consumed - the consumers being procuring authorities or their representatives. Burt (1987) proposed the idea that 'social contagion' is prevalent among actors having 'structural equivalence' in a network - i.e. the same relationship with others within that network; a phenomenon not uncommon in professional networks in the construction industry. Explaining the growth in municipal enterprises in Finland, in spite of a lack of rational reasoning for their form, Kallio and Kuoppakangas (2013) attributed growth to a bandwagon effect in which institutional isomorphism played an essential role. Frumkin and Galaskiewicz (2004) examined the susceptibility of public sector organizations to institutional pressures, including normative isomorphism, that result from belonging to an association of peer organizations and stemming from "the collective struggle of members of an occupation to define the conditions and methods of their work" (DiMaggio and Powell, 1983).

This study proposes the close relationship of the forces of social legitimacy, bandwagons and institutional isomorphism, rather than evidence and rational reasoning, as the reason for growth of a behavioural assessment process in construction procurement. Further, the study proposes that the lack of evidence for the efficacy of the process has generated institutional waste. Social actors (e.g. individuals and supply-chain organisations) typically conform to institutional pressure, to gain self-interested rewards (e.g. access to resources/work, survival, legitimacy, expedience to avoid questioning). Their strategic responses can range from passive to active resistance (i.e. acquiescence; compromise; avoid; defy; and manipulate) (Oliver, 1991). Within the construction industry, the audible voices of dissent in relation to the use and value of behavioural assessment in procurement appear to be few, although Hancock (2015) reports the scepticism of one industry supplier. Giving "a very strong message to the supply chain regarding collaboration" (Turton, 2015, 24) may be an important aspect of creating expectations of a working relationship. Supply team employees may feel they have "personally benefitted" from attending behavioural assessment workshops (Turton, 2015, 20). However, it is suggested that using prevailing behavioural assessment methods in construction

procurement for those ends, without addressing the concerns raised in this study, sustains a false process that can be detrimental to project performance and worsen relationships rather than improve them.

CONCLUSION AND RECOMMENDATIONS

This study critically articulated how the organisational psychology literature gives rise to serious concerns related to the validity of behavioural assessment processes used in construction procurement. Empirical evidence contradicts the assumption that the competencies of individuals are reliably measured in behavioural assessment. It also suggests that the performance of individuals can be more effectively and more cheaply predicted by alternative selection methods (e.g. structured interviews and cognitive ability tests). Furthermore, the idea that the performance of samples of behaviour from samples of individuals from (supplier) organisations can be used to effectively predict the performance of the organizations they work for is not evidence-based.

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MANAGING NEW ZEALAND URBAN STREETSCAPE DESIGN: UNDERSTANDING PEOPLE'S PREFERENCES

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Urban design is conducted at scales and across timeframes that are much broader/longer than those of conventional, site specific projects. Indeed, as noted by Christopher Alexander, the aim of urban design is to orchestrate the outcomes of discrete projects such that they each contribute to a more coherent whole. In most cases the coherent whole is centred on public streets, the spaces that people use every day as they conduct their lives. The research responds to gaps in knowledge about which building and street design characteristics people find most attractive. Other researchers have noted that most contemporary design guidance is developed largely on the basis of normative theories rather than on empiric evidence. The paper discusses the findings of a study designed to understand people's visual preferences for buildings and streetscapes in two New Zealand cities. When people were invited to evaluate individual building facades and to consider entire streetscapes, the study confirmed their strong preferences for ordered variety. These findings were reinforced through the preferences they also expressed for building height relationships that vary within a narrow band of difference and for close plan alignment between the facades of adjacent buildings. The findings provide empiric evidence that can inform the work of designers and of those who regulate urban change proposals. The challenges local governments must confront if they wish to manage changes toward better aesthetic outcomes include a legislative framework is not conducive to proactive development control, particularly where they refer to outcomes that are not easily quantifiable, such as aesthetics. Planning authorities in New Zealand have tended to shy away from the vexed matter of aesthetics, preferring instead to leave this in the hands of experts. In addition, local governments are inadequately resourced to be able to be able to proactively plan urban areas toward specific aesthetic outcomes. To get there, aesthetics must be elevated to a status equal with other performance matters in regulatory planning processes.

Keywords: environmental aesthetics, streetscape, urban design review

INTRODUCTION

Think of a city and what comes to mind? Its streets. If a city's streets look interesting, the city looks interesting; if they look dull, the city looks dull.

With this very simple observation, Jane Jacobs (1961) provides the rationale for ongoing interest in urban streetscapes. Although not always recognised as such, managing development and use of streets and other public spaces ranks amongst the most important of activities undertaken by local government. It seems ratepayers and other stakeholders have vested interests in the way these assets are managed, as they

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are known to affect people's economic, physical, emotional and social wellbeing (Mehta 2013). Streets contribute significantly to a city's sense of place and are increasingly referred to in promotions aiming to attract tourists, businesses and high-quality workers. All cities seek to encourage positive growth by promoting their comparative advantages and in many cases, this can include the quality of their public realm. An example of this is Wellington, New Zealand, where the district plan looks to "encourage positive growth that promotes the City's comparative advantages". The quality of the public realm, which depends to a large extent on the characteristics of the buildings and structures that define it, is noted to be one of Wellington's advantages. Safe and attractive streets encourage people to linger or to walk and cycle along them, not only helping to raise levels of physical activity but encouraging shopping and other impromptu economic exchanges. As attractive places encourage people to linger for longer periods of time there is also the chance they will run into someone they know or strike up new social acquaintances. There is evidence confirming that people have stronger connections with the physical settings they find attractive and such connections help to lift emotional well-being (Cold 2001, Dovey 2001). People generally feel better about the places they know and love. For these reasons and many more, it is clear that local authorities should work to help ensure that a city's streets are well liked.

This paper is concerned with incremental changes that take place through the development of private land facing onto urban streets. In particular, how can these changes be managed to help ensure that the visual appearance of urban streetscapes meet with people's preferences? Managing building appearance remains a contentious matter for many architects, site owners, planners, and even the public (Holden 2012). As privately initiated development is increasingly speculative in nature, with seemingly limitless choice of materials and construction methods and with little control over the qualifications of those undertaking the design and development in our urban centres, many people are of the opinion that the quality of the built outcomes is diminishing. One such critic was Peter Buchanan, who in 1988 took the architectural profession to task over the quality of buildings he saw emerging in British cities. Buchanan reminded his colleagues of the responsibility they had for ensuring the future quality of the spaces their buildings faced out onto. Facades, he noted, do not simply enclose interior spaces or become a filter to the weather and other external conditions, but they also address and articulate outdoor space. He argued that buildings should be considered together, with new designs responsive to those that are already there, such that they create well-mannered outdoor rooms (Buchanan 1988). Punter and Carmona (1997: 200) offered compelling arguments for contemporary societies to control the aesthetic design of buildings, reaffirming that "the quality of architecture and the external appearance of development are important to perceptions of environmental quality and sense of place, and that the controversial issue of architecture has to be faced by policy."

Context for Managing Streetscapes

Streets are the primary public spaces in any city, in many cases occupying more than 50% of the urban land area (Moudon 1987). They are literally and metaphorically the most fitting symbol of the public realm (Mehta 2013: 9). However, the important role streets play in the social life of cities has not always been acknowledged, in circumstances that are particularly relevant over the past hundred or so years. Streets in cities, or parts of cities, that have been developed after the advent of motorised transport are by and large designed to facilitate movement of people and goods. In

this context, the pedestrian environment almost always gives way to the dominance of vehicles. A compounding factor is that the layout of contemporary cities often do not include the squares and plazas that could provide alternative venues for people's social activities. However as noted earlier, there is a renewed interest amongst urban planners, politicians, economists and the general public in the potential of cities and this is leading many to recognise the importance of making streets attractive to people so that they choose to linger along them.

People make choices about how and where they wish to spend time based on visual perceptions. Recent studies by Mehta (2013) and Lesan (2015) found the visual attractiveness of streets to influence people's lingering social activities. Mehta looked specifically at the influence of the visual qualities of the buildings lining both sides of a street on people's feelings of sensory pleasure. His study found a direct positive correlation between attractive, visually interesting streets and the social activities he observed taking place. Despite concerns about the subjective nature of aesthetic perception, people were found to agree that some street blocks are more visually attractive and that these qualities affected their choices to use these areas for social and lingering activities. Mehta's respondents also chose not to make use of unattractive streets, findings that correspond with earlier research by Gehl (1974).

Through the work of Kevin Lynch (1960) and other environmental behaviourists, we have come to understand the important role streets play in helping people comprehend the environments they find themselves in. To help them navigate, people form mental images incorporating the spatial and visual character of pathways, nodes and edges. The street is a fundamental spatial type extending across all three. Streets are important, not only for their imageability potential but also for the health and wellbeing of individuals and the community as a whole. As noted by Allan Jacobs (1993: 314); "if we do right by our streets we can in large measure do right by the city as a whole - and therefore and most importantly, by its inhabitants."

In light of the important role contemporary urban streets play in the health and wellbeing of towns and cities, there is growing interest in the quality of these spaces and how they may be managed to meet the needs of different stakeholders. Local governments have come to recognise the need for management to extend from the way public spaces are designed and developed to the way they are managed on a day to day basis (de Magalhães and Carmona 2006). Early efforts to manage public streets were largely focussed on retailing activities and seldom had aspirations higher than to ensure streets were swept and maintained to an appropriate standard. As the field has developed, its potential strengths have been encouraged by engaging all stakeholders with interests in how streets are developed and managed. The broad remit of public space management revolves around three core processes; regulation of activities, maintenance routines, and obtaining new investment and resources. A fourth, and overarching process is coordination, which seeks to ensure that the efforts of a wide array of people and organisations that manage public space are pulling in the same direction (de Magalhães and Carmona 2009). This paper is particularly concerned with management of the design and development of the privately-owned sites along streets.

Development activities in New Zealand cities are managed by local authorities through the Resource Management Act (RMA). Emerging in 1991, the RMA has its roots in a period of economic liberalisation, where planning had fallen out of favour with the government of the day (Dixon 2003). The RMA provides a permissive

context for development and is open to any outcome provided the potentially negative effects can be suitably managed. This presents a significant challenge to any efforts that aim to closely manage design outcomes.

One of the biggest challenges for planners when managing and regulating changes to the built environment is to navigate between the needs and expectations of all interested parties, including the public (Dovey 2017). To assist them, planners in the largest New Zealand cities are increasingly referring to design guidelines alongside the more objective zoning criteria they have traditionally referred to. The design guidelines are generally prepared by planners, with input from the community arranged through public consultation, to achieve desired form and activity characteristics (Holden 2012). Where they are prepared on the basis of empirical research findings, design guides are seen as a suitable way of influencing project outcomes in the absence of the public being directly involved in each project. However, Holden (2012) has argued that design guidance is generally prepared with ad-hoc reference to theory and that the bases for individual guidelines is implicit rather than explicitly communicated. His concern is that such guidelines are vulnerable to inconsistent interpretation and to legal challenges and in response proposes a model for preparing design guides on the basis of empirical research. The research discussed in this paper responds to that call.

RESEARCH METHODOLOGY

A research methodology was developed that would enable identification of the building design characteristics that people find most attractive. This methodology would enable collection of responses to design characteristics of individual building facades as well as of entire streetscapes. One of the questions driving the research relates to how people evaluate design characteristics observed across a number of closely spaced individual buildings. The findings of the overall project are intended to inform design review, recognising the important role this process plays in the way cities manage change. Two studies were undertaken in sequence, the first of which invited people to evaluate urban streetscapes on the basis of photographic representations. In the second study, people provided their responses as they walked along the streets being studied. The streetscapes were selected on the basis of the particular characteristics of individual buildings along their length and the relationships they formed with each other. The aim was to present a range of conditions encountered in design review processes.

In the first study, more than 200 people responded through a paper based survey to photographic representations of six urban blocks. The elevations were prepared from digital images corrected for perspective and stitched together using Adobe Photoshop software. The elevations were printed on A0 size paper and presented to survey respondents. This helped ensure that respondents could see sufficient detail in the facades. In the second part, respondents were invited to visit two streets in Auckland and one in Wellington. At least 40 people participated in each of the three cases and were asked to evaluate the design characteristics of individual buildings, the relationships between adjacent buildings and the overall streetscape composition along both sides as they walked along each street. Both surveys employed Likert scale response fields to generate data that could be analysed quantitatively. Correlations between different responses and demographic characteristics of respondents were analysed with the help of SPSS software. To help tease out the key

issues that influence the ways people perceive the environment, two focus groups comprising people who had participated in the Wellington survey were held.

Understanding People's Preferences

In respect of individual buildings, people were found to prefer facades that are monolithic in nature, where the structural floor levels behind the façade are not expressed in it. Such monolithic facades are generally considered to be more traditional, seen conceptually as a wall extending over the full height of the building. While the majority of traditional, monolithic facades incorporate surfaces that can be painted, the most preferred surface finish was found to be brick. A critical distinction between traditional and non-traditional materials is that the former are significantly thicker than the latter and therefore the resultant facades also appear deeper, a quality most apparent at door and window openings. These materials appear monolithic even though they may or may not be providing load bearing structural support.

The façade design features that people liked most were discrete (individually articulated) window openings. Discrete windows provide buildings and their facades with a sense of scale and human proportion. Windows establish a scale relationship in the façade of a building, enabling viewers to better understand the size of other elements in it and within the building. Discrete windows in a façade can assist people to gauge the overall size of a building. It can also be noted that the human mind looks for patterns in the environment and derives pleasure from discovering rhythms that extend across more than one building (Smith 2003: 35-47).

Preferences for monolithic building facades and discrete windows corresponds well with people's dislike of facades that appear horizontally banded through the use of continuous strip windows and/or by expressing the horizontal loadbearing structure. People expressed strong preferences for buildings that were well maintained and found those that were not well looked-after to be unpleasant. Indeed, it seems that the levels of maintenance and cleanliness of the exterior surfaces of a building are more important preference factors than the design composition and materials of the façade itself. While maintenance is not specifically a design characteristic, the extent to which it can be perceived is influenced by design. The surface qualities of cladding materials, their durability and the way different components of a construction are detailed can all affect the aging process and some designs will perform better than others. At present, maintenance is not regulated by local authorities and yet it appears to have measureable effect on people's perceptions. Specialist expertise would be required if maintenance or anticipated aging are to be evaluated during planning approvals processes.

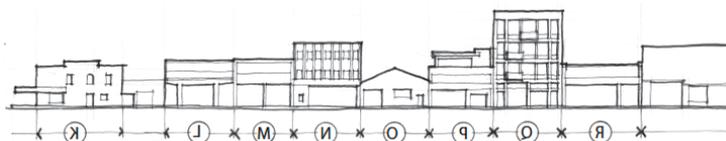


Figure 1: Partial elevation of the streetscape with the highest preference rating. A key factor for this rating is the height relationships between buildings.

Buildings that enable visual links to interior spaces, particularly at ground level, were also well liked; further analysis revealed that the extent to which buildings were liked was influenced by the activities people understood to take place in them. An example of a well-liked activity at ground level is a bar or café. Positive perceptions of such activities are enhanced when people can see into the interiors. While in many cases

the two factors of well-liked activities and a visually permeable façade treatment worked well together to enhance people's perceptions, they were not mutually dependent. Women exhibited strong preferences for retail activities, but it was not necessary to see into the building and the activities inside for the host building to be liked. Signage and building typology appeared to be suitable signifiers of the retail activities that caused the building to be liked.

At the scale of the street, the height relationships between buildings on adjacent sites were found to be the most important success factor. Streetscapes where heights varied within narrow bands of difference - between two and three storeys - were the best liked in the study and correspondingly, large variations - anything more than four storeys - between buildings were disliked by most. Building height consistency appeals to people's natural underlying preferences for ordered variety. Indeed, where building heights were absolutely consistent across the whole of the street, preferences were somewhat lower. With these findings, it would seem that blanket height limits across an urban area, which is not uncommon, may be problematic. Height limits may be set in conjunction with anticipated future growth as well as expert opinions about scale relationships with the adjoining street environment. Height limits are likely to be higher than buildings in the current environment, which may lead to disliked building to building relationships and streetscapes when acted upon. An approach that would enhance people's experience of the resultant streetscapes would be to map existing building heights along the street or in an area to enable heights to be prescribed on a site by site basis.

Plan continuity of building façades along the street edge is another well-liked streetscape characteristic. However, it appears that spatial definition and containment, in the sense advocated for by (Sitté 1979) and (Jacobs 1993), is not the strongest factor underlying people's responses. Their preferences for continuous facades along the length of the street appear to be driven by a dislike of blank and uninteresting flank walls on internal site boundaries. Side walls become visible where the facades of adjoining buildings do not align in plan or height. People's preferences are also linked to the notion of positive space, where the space between the building facades and the footpath is developed positively for use by pedestrians. People liked seeing coordinated visual interest across individual facades in a street. This feature corresponds to broadly-held aesthetic preferences for ordered variety. Green landscaping and positive open spaces in a street are very well-liked streetscape characteristics. These help to mitigate the negative visual effects that might arise from other poor relationships between buildings. An example of this is in relation to large differences in building height. Where these are mediated by open space, even an intersecting road, the otherwise negative visual effects are reduced and may even become positive.

A summary of the findings from this project is presented in Table 1. These findings are discussed in terms of physical characteristics and relationships, which welcome translation into specific design guidelines. For example, a guideline could be written requiring "the height of a new building to be the average of the heights of the two buildings to one side of the site and the two buildings on the other side of the site, when looking at the site from the street frontage". Such a design guideline would be supported with an explanation that through a survey of public preferences, it seems people prefer streetscapes that vary within a relatively narrow band of difference, no more than two storeys. Additional guidelines could be written and supported by other findings of the research.

Table 1: Summary of the preferences people were found to have for building and streetscape

Buildings	Streetscapes
People preferred traditional cladding materials, particularly those that can be repainted	Relationships between buildings where there was coordinated visual interest across the individual facades were best liked
People preferred buildings with discrete window openings	People preferred streetscapes where building heights vary within a narrow band
People preferred building facades that appear clean and well maintained	People preferred streets where building façades are aligned consistently
People preferred street level designs that enable visual engagement with the activities inside	Open spaces were found to mitigate potentially negative relationships between adjoining buildings
People disliked horizontally banded building facades	
The findings were inconclusive about whether "contextual fit" is considered when people evaluate individual buildings	

Regulating Change for Aesthetic Outcomes

While the findings address the knowledge gap identified by Holden (2012) and can ensure that urban design guidance is informed by a ground up understanding of aesthetics, several challenges remain to be overcome if urban streetscapes are to be managed effectively toward meeting people's preferences.

The first to be noted here is the challenge represented in the underlying agenda of the RMA, which assumes market-led development activity, free to innovate as long as the outcomes are manageable. The RMA and the planning context it creates lacks aspiration beyond the pillar of *sustainable management*. This is evident in the expectations that decision makers focus their decisions on whether any negative effects that a project would lead to can be tolerated or somehow mitigated (Dixon 2003, Baker, Sipe *et al.*, 2006). In this context, urban design and aesthetics fall far behind other, measurable effects such as changes to wind speed, water usage and shading onto adjoining properties. Consequently, design issues are marginalised in the vast majority of planning decisions because, where building form and location are controlled by clear standards, local authorities do not believe it is their role to comment on aesthetic matters (Hunt 2008). In New Zealand's planning context, aesthetics is considered "like a kind of froth, difficult to analyse and easy to blow away" (Lynch 1976: 68). Even with evidence-based guidelines, which could be informed by these research findings, the RMA is not conducive to proactive development control focussed on aesthetic outcomes.

A second challenge is that development and ongoing management of the built environment is administered through two uncoordinated pieces of legislation. In practice, the Building Act trumps the RMA when it comes to public safety, as it should. New Zealand is a seismically active country and many of the buildings contributing to attractive streetscapes are those built to the lower structural design standards of earlier building codes. Streetscape amenity continues to be reduced in many cities through removal or alteration of existing buildings in order to satisfy Building Act requirements. There appears to be greater clout in matters of public safety allowing demolition to be successfully argued without adequate resistance under planning legislation to require alternative courses of action. In some cases, this has led to severely negative effects, even after considering the contribution made by the replacement, but local planners have been powerless to intervene. Despite this, where owners are committed to retaining the economic and social values of older buildings, there are also many good examples of sensitive structural strengthening and adaptive reuse. In some cases, adaptive reuse and the cost of structural strengthening has been fostered through making additions to these buildings aided by innovative

practices of designers and builders. While maintenance sufficient to ensure ongoing viability of building systems is required by the Building Act, only those that affect life safety appear to be controlled because of resource limitations.

Local governments have few resources they can call on to help them manage for improved streetscapes and public space appearance. While aesthetics is recognised in the RMA as a contributor to amenity, it is over to local councils to advocate for aesthetics through their district planning instruments. During a Labour led government in the 2000s, the Ministry for the Environment (MfE) had an active agenda aimed at encouraging better urban design; the highly regarded but non-statutory Urban Design Protocol is perhaps the best known of the resources made available to urban planning and design practitioners. Following a change in government in 2008, the past decade has seen attention to urban planning and design diminished in MfE and other departments.

To address these challenges, it is helpful to look at the experience in other countries. Norway and Sweden are two countries with which New Zealand is at times compared. All building activity in Norway is administered under the Planning and Building Act 1965. From the time it was introduced, the Act had included a so called 'beauty paragraph', requiring authorities to exercise reasonable judgement about the aesthetics of new buildings. Even so, this expectation proved difficult to pursue in practice in regulatory processes. Then, in 1997 after having made a commitment to advocate for stronger place identity in towns and cities, the government issued a circular requiring that aesthetic considerations would be pursued in all private and public developments and at every level of the planning process. Aesthetics now has the same status under Norwegian law as the functional, structural and durability outcomes of a building project. The focus on aesthetics, backed up by clear legislation, creates an environment where local government planners can negotiate with developers from a position of strength (Pløger 1999). A similar building regulatory system, established under the Planning and Building Act of 1987, links across all planning and building activities in Sweden (Nystrom 1999). Through the Act and in the National Agenda for Architecture and Design, Sweden's government foregrounds aesthetic outcomes in all building work.

Local and county administrators in both countries appear to be resourced at levels that enable leadership and preparation of plans outlining agreed public/private aspirations for municipal areas and individual sites. The key planning instruments here are municipal plans and building development plans. Building development plans may be prepared for individual development sites, in consultation with the owner and the public, and are the main instruments used by regulators to communicate aesthetic ambitions for a local area (Pløger 1999). A review of the Norwegian and Swedish contexts for managing changes affecting streetscape appearance reveals that

Central government actively supports aesthetically pleasing outcomes in legislation and with national policy guidance.

Local authorities are resourced to enable positive planning of areas and individual sites, informed by consultation

Aesthetic outcomes are given the same status as other, measurable performance matters in planning and building regulations

Decisions are not made on the basis that a proposed development is acceptable i.e. not too ugly, but on the basis that all new and altered buildings must add to the visual qualities of the area.

The development control systems in these two countries appear to have overcome several of the circumstances that appear to limit achievement of well-liked streetscapes in New Zealand through regulatory planning processes. The findings of the study of people's visual preferences for design characteristics of buildings and streetscapes could, in conjunction with changes to the regulatory planning system, enable streets to be managed to enhance people's experiences of them.

CONCLUSIONS

Streets are the essential form of public space and deserve close attention from those charged with managing their quality. While considerable attention and resources flow toward managing design of and activities taking place within the public spaces of streets, somewhat less attention has been paid to actively managing changes to the buildings that define streets. Changes to the built environment are market led and in New Zealand the regulatory planning system has been created to assess effects. Consequently, the spatial configuration of public streets simply happens instead of changing to an agreed design goal. In a conducive regulatory context, design guidelines can be used as tools to help local authorities pursue well liked streets. Holden (2012) has noted that most design guidelines are developed through top down processes, informed by normative theories of good design. He argued that to be effective, design guidelines should also be grounded in the local, referring to people's expressed design preferences.

The paper reports on the outcomes of a project designed to understand which design characteristics people find most appealing and which they find to be least pleasant, at the two scales of individual building and of overall streetscape. It is noted that people prefer traditional design expressions, comprising monolithic street facades and discrete window openings. This confirms theories that people prefer scenes that provide moderate levels of visual interest within overall patterns that can be ordered. This preference pattern also extends to those expressed for overall streetscapes, where people preferred height relationships between buildings that create variations of between one and three levels over those that were absolutely consistent and over those that had large differences of height. The findings of this research can be used to inform ground up design guidelines, reflecting people's known preferences.

The paper has also discussed challenges to implementing proactive management of urban streetscapes through development control processes. It would appear that similar challenges have been faced in other countries, with Norway and Sweden cited here. Their regulatory planning systems and practices could provide guidance to central and local government leaders in New Zealand if there is a will to manage public street spaces toward people's expressed preferences.

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MURMURATION AS METAPHOR FOR SUSTAINABLE INNOVATION PROCESSES

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The construction industry stands before an extensive and essential transition towards sustainability; however, the configuration of the innovation processes that lead to such transition is unclear. In this paper, the concept of murmuration, i.e. the collective behaviour of starlings, is introduced as a metaphor for sustainable innovation processes in construction. The murmuration metaphor captures the flowing, ever-changing non-structure that characterises innovation processes within sustainable construction. This conceptual hypothesis is based on an empirical observation, and the potentials of the metaphor are explored at two interdisciplinary workshops with actors from the Danish construction industry. The empirical validation shows that the murmuration metaphor can generate a useful framework for understanding and discussing sustainable innovation processes in construction. Furthermore, murmuration can be a fruitful addition to the understanding of the societal transition towards sustainability as an elaboration of the niche-to-regime processes emphasised in the Multi-Level Perspective.

Keywords: innovation, metaphor, murmuration, sustainable transition

INTRODUCTION

The transition towards a sustainable construction industry has received a growing interest during the past years (O'Neill and Gibbs 2014; Nykamp 2017; Martiskainen and Kivimaa 2017), and globally, innovations to support and accelerate such a transition are highly in demand (UN Environment and International Energy Agency 2017). Still, the configuration of the innovation processes that lead to the sustainable transition is unclear and much literature calls for further research that can lead to a more profound understanding of innovation processes in sustainable construction.

An important strand of literature is based on the Multi-Level Perspective (MLP) as an analytical framework for studying sustainable transitions (for an overview, see e.g. Lachman 2013). The MLP argues that sociotechnical transitions come about through interacting processes within and between the incumbent regime, radical niche-innovations and the sociotechnical landscape (Rip and Kemp 1998; Geels 2002). Through the years, the MLP has received extensive criticism regarding, for example,

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its undervaluing of agency (Smith *et al.*, 2005) and the simplified conceptualisation of the levels and their roles in the transition process (Berkhout *et al.*, 2004). We particularly notice the critique by Smith (2007) that the approach gives insufficient consideration to the processes by which niches and regimes interact and are interdependent.

In the wake of this criticism, fruitful debates have emerged, leading to clarifications and elaborations on e.g. politics and power (Grin 2010) and agency (Fuenfschilling and Truffer 2016). Still, the MLP framework does not offer an operational understanding of the innovation processes that support the sustainable transition. With this paper, we wish to gain a better understanding of the dynamics and mechanisms of sustainable innovation processes that emerge from niche experimentation and lead to changes in the socio-technical regime, thus inducing the transition towards a more sustainable construction industry. In other words and with reference to the illustrative representation of the MLP (see figure 1 for a simplified version), we wish to study and discuss 'what happens in the arrows?'

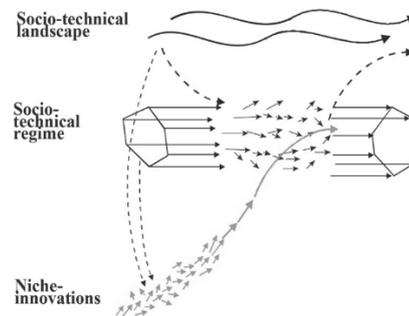


Figure 1: The Multi-Level Perspective. Adapted from Schot and Geels (2008, p.546)

The paper is structured as follows. First, the general characteristics of innovation processes within sustainable construction are introduced. Then, based on an empirical observation, a metaphor is introduced as an illustrative device for comprehending the profoundness of innovation processes within sustainable construction. The findings from an empirical validation are presented, followed by a discussion of implications for practice and theory. Finally, the conclusion sums up and offers recommendations for further research.

Innovation in Sustainable Construction

As a starting point, we present a brief overview of the current understanding of innovation processes in sustainable construction, and highlight the research avenues suggested by the literature.

Innovation processes in general are complex and characterised as chaotic and unpredictable (Cheng and Van de Ven 1996). The construction industry constitutes a loosely coupled context (Dubois and Gadde 2002) for innovation activities that are characterised as “messy, complex and dynamic” (Harty 2008, p.1038). Innovation in construction involves alterations, parallel and overlapping activity flows, setbacks etc. (Winch 1998; Slaughter 1998). Implementation often takes place in projects, and so innovation processes are collaborative engagements and a product of networks of actors (Harty 2008; Bygballe and Ingemansson 2014).

Focusing on sustainable innovations, extended usage is necessary to provide long-term benefits and create value for users, organisations, and society (Den Ouden 2012). The sustainability agenda includes a very broad range of issues to address and thus

sustainable innovations have to be reflexive, adaptive, aware of its consequences and therefore open-ended (Berker 2010). The extensiveness of the agenda, the requirements for flexible and open-ended solutions, and the loosely coupled context including involvement of multiple actors are factors that all contribute to the fact that sustainable innovation in construction is a highly uncertain and extremely complex process.

This outline of innovation processes in sustainable construction is widely known and acknowledged in academia as well as in practice. However, the characteristics are not very precise nor particular operational - yes, the process is highly complex and uncertain, but how to navigate in such context? Is there a way to gain a more cohesive understanding of the processes, so that practices and strategies can be designed to support more sustainable construction? This request for a more profound understanding of the processes that actually take place in practice - 'what happens in the arrows' - is mirrored in the literature on innovation and sustainable transitions in construction. For example, authors call for recognition of the complexity of the processes (Gibbs and O'Neill 2015), suggest more attention to the relations between the actors involved in innovation (Dubois and Gadde 2002; Bygballe and Ingemansson 2014), and requests wider debates on the nature of innovation (Harty 2008).

We are highly motivated by this unclear, however sought-after, understanding of the profoundness of innovation processes in sustainable construction, and have based our research on the aim of generating a platform for new insights into this field.

An Empirical Observation

In our work with studying and clarifying the substance of innovation processes in sustainable construction, we have been inspired by an empirical observation made at a green building conference in Copenhagen. Here, a recognised Norwegian architect was asked to describe the process, she had been a part of, of designing and constructing a highly sustainable state-of-the-art building. The best way to describe this process of actors entering and leaving the project, continuously adding knowledge and value to the project, she said, was as a flock of birds, and she showed an image of a murmuration.



Figure 2: Tine Hegli, Snøhetta, presenting on Building Green 2015

This image and its narrative made a great impact on us. First, because it originates from a practical experience of working with innovation processes in an actual sustainable construction project. And second, because the content of the image, the flock of birds, represent a flowing, ever-changing movement that we sense has something to offer to our search for a better and more comprehensive understanding of what actually happens when innovation takes place in sustainable construction.

MURMURATION AS METAPHOR

We propose that murmuration, i.e. the collective movement of starlings, is a useful metaphor for innovation processes in sustainable construction. Before discussing how murmuration can contribute to the understanding of innovation processes, we introduce the concept of metaphors; what is a metaphor and what can it do?

Metaphors

A metaphor is an illustrative device (Alvesson 2002) that offers a new awareness (Brown 1976) and “extends horizons of insight and creates new possibilities” (Morgan 1986, p.341). A metaphor is able to illuminate aspects of a system and shadow others, thus creating meaning and understanding of complex situations. A metaphor is not to be taken literally, as it then will appear absurd (Brown 1976), instead there should be an appropriate mix of similarity and difference between the metaphor and what it represents (Alvesson 2002).

A particular type of metaphors is called Generative Metaphors (Schön 1993). Such metaphors generate seeing rather than describing a situation. Schön exemplifies a generative metaphor with the story of the development of artificial paintbrushes, where researchers struggled to transfer the qualities of natural paintbrushes until one researcher pointed out that a paintbrush is a kind of pump. Using the metaphor, i.e. seeing the paintbrush as a pump, helped the researchers to better understand both their unit of analysis (the paintbrush) and the challenges they were facing (how to create a new paintbrush with the same functionality as the old one). We are interested in this type of metaphor to improve our seeing and understanding of innovation processes, and thus to contribute to solving the challenge of supporting the transition towards a more sustainable construction industry.

Schön (1993) discusses two interesting aspects of the generative metaphor that are useful to include in our case. First, he points out that adding normative dualism such as nature/artifice or health/decease to a metaphor helps to see a complex, uncertain and indeterminate situation differently, and to encourage in what direction to move. Second, he describes the life cycle of the making of a generative metaphor in four steps: (1) A notice or a feeling that A and B (e.g. the paintbrush and the pump) are similar, but without clarity on similarity with respect to what. (2) Description of relations of elements and the start of an analogy between A and B. (3) Construction of a general model where a modified version of A can generate understanding of a modified version B. (4) Once a generative metaphor is constructed (i.e. in this context, A can be seen as B) then similarities and differences between A and B can be explored and reflected upon. A final notion here is that, in line with Brown (1976), generative metaphors are not literal, which is what actually makes them useful; it is precisely because paintbrushes are not literally pumps that it can be beneficial to see them as pumps.

We are currently approaching step two in our development of murmuration as a generative metaphor for innovation processes in sustainable construction. Like the Norwegian architect, we too intuitively feel that the flying flock of starlings and the innovation processes are somewhat similar and wish to unfold the metaphor to see what insights it generates. The murmuration metaphor captures the flowing, ever-changing non-structure that characterises many of the innovation processes within sustainable construction that we previously have been studying. Further, it matches the characteristics of innovation processes in sustainable construction described in the

literature. Our next step, and what we will focus on in this paper, is to describe the relations of elements and generate an analogy between murmuration and innovation processes in sustainable construction. We start by exploring what murmuration actually is.

Murmuration

Murmuration is the collective behaviour of starlings (King and Sumpter 2012), where thousands of birds, shortly before sunset, perform impressive aerial manoeuvres before choosing a place to roost for the night (Ballerini *et al.*, 2008a). The main goal of a murmuration is to maintain cohesion of the group when pressured for survival; the larger group you are in, the better the chance someone else will get eaten if a predator attacks - a behaviour also known as the selfish herd (King and Sumpter 2012). Even though the group is exposed to a high degree of uncertainty regarding the behaviour of each bird as well as disturbances from the environment, they are able to maintain cohesion and coherence due to simple, local interactions among the individual birds (Young *et al.*, 2013). Each bird keep a minimum distance from each other comparable to their wingspan as to avoid collisions. Furthermore, studies have shown that each bird interacts with a fixed number of neighbours (on average six to seven), rather than with all neighbours within a fixed distance (Ballerini *et al.*, 2008b). The number of interacting neighbours is independent of the number of birds within a flock or the flock density (Bialek *et al.*, 2012). It is shown, that interaction with this fixed number of six or seven neighbours optimises the balance between group cohesiveness and individual effort (Young *et al.*, 2013).

Couzin *et al.*, (2005) have studied movement decisions and leadership in travelling groups of animals. They found that in many cases, only few individuals in a group have pertinent information, such as knowledge about the location of food or the migration route, and only a very small proportion of informed individuals is required to achieve great accuracy. Informed individuals do not have to be able to recognise each other, and leadership can emerge as a function of information differences among the group members, and is therefore transferable. No inherent differences between individuals, e.g. dominance due to larger body size, need to be invoked to explain leadership.

To sum up, murmuration occurs as a way for the group of starlings to sustain, offering both protection from predators and guidance towards food. Each bird interacts with its six to seven neighbours, thus balancing between increasing the group cohesiveness and reducing its own individual effort. The leaders of the group are not necessarily the biggest or the strongest birds, only a few leaders are needed, and the leadership can shift position as other birds become better informed.

Innovation Processes as Murmuration

Seeing innovation processes within sustainable construction as murmuration offers an understanding of the dynamics that take place and that all together influence and change the regime to become more sustainable. We see that innovation can emerge from all sources. There is not one leader and it is not necessarily the strongest or largest company, and not necessarily a company within the construction industry, that can develop a radical innovation with potential for changing the regime. For such an innovation to rise from the niche level, enter the regime and make a transformative impact, it must be supported by other actors. A lonesome bird will most likely be eaten, but together in a murmuration, the birds can survive. This dependency on other supporting birds or actors also means that an innovation can travel from one actor to

its neighbours. Furthermore, several innovations can occur in the murmuration at the same time, and as they travel from actor to actor or project to project, the innovations can meet and interact. Such innovation interactions can be divergent or complimentary and thus hold the potential of generating new, improved information and with that influence the motion of the entire flock.

The leader of the formation is the one with the newest and best information, and by following the leading bird, others gain both better protection and potentially new information, and thus the opportunity of becoming the new leader. This group mechanism or collective behaviour is essential in a murmuration, and it makes sense that the same balance between group cohesiveness and individual effort is the key to secure a sustainable transition of the construction industry. However, as the construction industry is characterised by a highly divided value chain and significant internal competition, this collective behaviour is seldom performed in practice. Perhaps this is one of the answers to the omnipresent critique of the productivity and innovation rate of the construction industry - and perhaps an avenue that requires much more focus from both researchers, governments and practitioners.

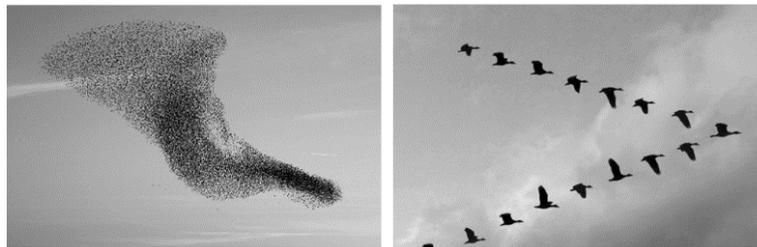


Figure 3: Murmuration and migration

In contrast to murmuration, we find migration (see figure 3). This normative dualism, as Schön (1993) called it, adds further aspects to the murmuration metaphor. The migration formation is highly structured, well proven and very effective for reaching the intended destination. This could resemble a traditional, linear stage-gate managed project. It is an optimised process, but only when the target is known and the destination has been visited so many times before that it comes to lie inherently in the actors involved. When the target is unknown, when all we know is that we need to do something radical to secure our survival, we need a different formation that allows for creativity and changeability. The murmuration formation might not seem optimised, but it offers an ever-changing non-structure that enables the reflexive, adaptive and flexible innovations needed to support the transition towards a more sustainable construction industry.

Empirical Validation

To explore the potential of murmuration as a metaphor for innovation processes, and to validate its applicability and relevance in practice, we have conducted two workshops with practitioners from the Danish construction industry. Each workshop were performed in cooperation with a professional network facilitation organisation. One workshops was held with a network focusing on innovation in construction, and the other with a network on sustainable construction. At each workshop, 10-12 practitioners participated, representing client organisations, architects, engineers, consultants, and IT/BIM specialists. The participants held positions at different levels in their organisations, spanning from project managers over department leaders to CEOs. Overall, a broad and diverse selection of practitioners who at large represent the stakeholders usually involved in innovation projects in sustainable construction.

The workshops were divided in two main sections. First, a presentation by one of the present authors, including an outline of the current knowledge on innovation processes in sustainable construction, and an introduction to the concept of murmuration and how it can be a metaphor for innovation processes. Second, a loosely facilitated discussion between the participants and the presenter. By ‘loosely facilitated’, we mean that only a few questions were asked initially to allow the discussion to flow as freely as possible, as the aim of the workshops was to validate the applicability of the metaphor in practice, and see in which directions the metaphor could take the practitioners. The questions asked were “How can we support innovation processes in sustainable building” and “Should we identify ‘rules’ for a murmuration process and support innovation based on these, or should we structure the process, make order and secure a focused progress (migration)”. The discussions of the two workshops were recorded, transcribed and interpreted by the authors.

The discussions at both workshops primarily circulated around three topics. One topic was diversity, where the practitioners argued that the numerous actors involved in the construction industry is actually a gift as diversity inspires for creativity. Furthermore, ‘knowing the flock’ can be an advantage in innovation projects compared to constantly being part of new constellations. A second topic was leadership with emphasis on the point that everyone can be a leader or a driver of the development, and that a leader must allow himself to follow his instincts. A third topic discussed was the contrasts between murmuration and migration. In migration, the practitioners argued, there is only one leader, which entails a fatal risk of derailment - what if that one leader has forgotten or misunderstood the road to the final destination? Another argument was that murmuration is a way of creating space for creativity; however, many people feel more confident with linear thinking. Finally, it was argued that perhaps the right way to organise the transition towards a sustainable construction industry involves both formations: murmuration as the way of finding the destination, and migration as the way of reaching it.

FINDINGS FOR PRACTICE AND THEORY

The workshops showed that the murmuration metaphor offers an illustrative language for understanding and discussing innovation processes. The practitioners intuitively grasped the metaphor and used linguistic references to Murmuration to elaborate on the challenges and possibilities within innovation and sustainable construction, for example when talking about 'leader instincts' or 'the flock'. Based on the discussions, we found that the murmuration metaphor generates new thoughts and understandings regarding: (1) Why is sustainable innovation difficult to perform in practice? (2) How can innovation processes be organised or managed? (3) How can the sustainable transition of the construction industry be supported?

The first question, why sustainable innovation is difficult to perform in practice, relates to the practitioners' discussions on linear thinking and leadership. Innovation as murmuration requires iterative and diverting processes, involvement of multiple actors, fruitful clashes of knowledge, and shifting leaderships. However, many people and organisations are accustomed to and comfortable with linear thinking, and prefer innovation projects where roles and tasks are clearly defined, and where the progress is systematically planned and led. Furthermore, the phase-divided construction process, where design is followed by planning, followed by construction and maintenance, is a poor fit for iterations, change of leadership etc. Thus, both the

personal, the organisational and the industry's tradition for linear thinking is complicating the performance of murmuration-like innovation processes.

The murmuration metaphor also generated insights into how innovation processes can be organised or managed. However difficult and untraditional it might seem, there are positive examples of how murmuration processes can take place in practice.

Returning to the Norwegian architect who introduced the image of the birds, she represented a successful, innovative, sustainable construction project where a murmuration-like process had enriched the project. The key aspect in that case was the formation of an alliance, a group of interdisciplinary companies including architects, engineers, contractors, suppliers, researchers etc., where extraordinary interactions across traditional disciplines and phase boundaries were accumulated in order to design and construct an innovative, sustainable building. Such alliances, where murmuration is not only possible but also encouraged, utilise the diversity of the construction industry and the opportunity of 'knowing the flock', as highlighted at the workshops.

Finally, the murmuration metaphor shed new light on how the sustainable transition of the construction industry can be supported. Connecting to the MLP, the Murmuration metaphor generates an illustrative description of the collective movement of innovation niches that potentially can influence and change the existing industry.

Seeing the niche processes as murmuration generates an understanding of the dynamic and arbitrary aspects of such processes, emphasising that even though the movements seem chaotic and time-consuming, there is an underlying logic in that myriad of niche activities that in the end, and with the right support, potentially can accelerate the transition process. The murmuration understanding challenges and supplements the traditional migration approach found in many policies that tend to focus on implementing disciplined systems such as, for example, sustainable certification schemes. This linear, migration-like approach is unquestionable useful and valuable; however, there might be a noticeable gain by implementing strategies that encourage both migration and murmuration processes. As the workshop practitioners said, murmuration can be a tool for finding the destination, and migration is for reaching it.

CONCLUSION

The purpose of this paper was to gain a better understanding of the sustainable innovation processes that lead to a transition of the construction industry. Inspired by an empirical observation, we have unfolded the potential of applying murmuration, i.e. the collective movement of starlings, as a generative metaphor for understanding innovation processes in sustainable construction. Introducing the metaphor to construction practitioners at two interdisciplinary workshops showed that seeing innovation processes as murmuration generates new understandings and fruitful discussions on why innovation in sustainable construction is difficult and how it can be done in practice. Furthermore, the Murmuration metaphor contributes to the MLP framework by illustrating the dynamic interactions that take place in and between niches in the movement towards sustainable transitions.

We realise that the murmuration metaphor is a new and rather creative addition to the fields of innovation and transition research. However, murmuration is not only an idealistic approach; it can be performed in practice. Having said that, we want to make it clear that the metaphor should not be used literally, and we further acknowledge that it does not - yet - provide a precise formula on how to organise and manage innovation activities. Further research on the configuration of innovation

processes is needed in order to clarify the theoretical aspects of how innovations take place and particular how niche innovations interact and collectively influence the transition of a regime. In addition, we call for further studies of successful innovation projects within sustainable construction to understand how innovation processes can be organised and managed in practice, and thus add further operational aspects to the murmuration metaphor. The murmuration metaphor is only at its infancy, and much more unfolding, elaboration and coupling to empirical cases is needed to create a solid contribution to existing knowledge. Still, we sense a significant potential for murmuration to open up discussions and to generate a holistic and fruitful language for both practitioners and researchers to support and accelerate the sustainable transition of the construction industry.

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PERCEPTIONS OF SUSTAINABILITY IN DOMESTIC HOUSING: HOW DO THOSE WHO MUST DELIVER IT UNDERSTAND IT?

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A response to the needs of the sustainability ‘agenda’ has been the development of different assessment methods that are intended to direct and inspire designers towards sustainable practices. Each of these assessment methods are underpinned by a particular understanding or interpretation of the best way to meet a perceived set of sustainability needs. This situation raises questions surrounding how notions of sustainability and sustainable development are assimilated and interpreted by Industry Professionals. These questions revolve around how a designer perceives sustainability and how this influences their personal design approach. However, one issue that persists is the lack of a shared sense or understanding of what sustainability is and why it is important to our industry and society. In order to explore the breadth of perception within the domestic housing sector, a series of 24 semi-structured interviews with architects and structural engineers have been thematically analysed. Early outcomes suggest that while there is a thread of working towards sustainability, three aspects need further exploration. First is a confirmation that the level of understanding around sustainability practices and procedures among designers is diverse. Second is a potential lack of engagement with the standards they are being asked to adhere to. Thirdly, is that designers consider the impact of cost when pursuing sustainability in their design - particularly to enhanced levels, to be extensive and often prohibitively so. The outcomes of this study will be beneficial in three ways - they can contribute to the understanding of sustainability practices within the domestic housing sector; knowledge dissemination via guidance and design guides could help limit the variability of approaches of design teams; and, finally, the understanding developed will allow a more informed approach to policy development.

Keywords: housing, sustainability, standards, architectural practice

INTRODUCTION AND CONTEXT

Sustainability, or at least the *notion* of ‘sustainability’ or ‘sustainable development’, is now seemingly at the very heart of the Construction Industry, while sustainability credentials have become the near-ubiquitous means of marketing any given building product. With a widely acknowledged housing shortage in the UK, too, the residential element of the construction industry faces a considerable task to meet this demand while also meeting increasingly stringent sustainability requirements that must be met through the Building Standards.

Sustainability - as a concept - has become increasingly prominent in recent years and is now fairly ubiquitous across all sectors - not just the construction industry. This

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originally emerged from environmental concerns and goes hand in hand with discoveries and advances in scientific knowledge concerning the interactions or impact that humans have on planet Earth. In the 1960s this could be characterised by a greater understanding of pesticide use and the associated unintended consequences; in the 1970s and 80s with (fossil) fuel shortages, ozone depleting chemicals and the emergence of continent-wide famine. Since the 1990s it has largely been driven by a greater understanding of climate change and how extensive the human contribution to this might be (Edwards 2014)

As applied to the construction industry, it is *environmental* sustainability that is often implied when referring to sustainability. In practice, this is essentially a variety of factors that reduce CO₂ emissions - widely accepted as the primary driver for climate change. With residential buildings still accounting for around 14% of carbon emissions in the UK (Department for Business, Energy and Industrial Strategy 2018) and around three quarters of this from the heating of space and light, mostly from natural gas (The Scottish Government 2018) before including electricity generation, which itself accounts for around 25% of UK emissions, this is hardly surprising.

While not necessarily synonymous with each other, 'sustainability' and 'sustainable development' are sometimes used interchangeable and often erroneously so. Indeed, Sustainable Development, is a term that is actually much broader in its scope and is one that is ingrained in the relevant primary legislation across the UK, including the Climate Change (Scotland) Act (2009) and Climate Change Act (2003) which drive the implementation of the associated aspects of the Building Regulations. Rather than employing the term 'development' in the way it would typically be understood for the construction industry i.e. 'housing development' or the 'development' of land, 'development' in this context is instead concerned with a society-wide notion of sustainability and includes a variety of interrelated factors that are '...crucial for the well-being of individuals and societies.' (United Nations 2016). For the United Nations this has traditionally been defined as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' and is the definition that has been widely employed since the Brundtland Report in 1987 (United Nations 1987). This is now embodied in 17 distinct goals laid out by the UN that cover a range of goals that seek to 'harmonize three core elements: economic growth, social inclusion and environmental protection' (United Nations 2016).

For the construction industry, the rise of the sustainability agenda has led to a multiplicity of 'Tools' and 'Assessment Methods' to promote more sustainable building practices. Most notable in the UK are: BREEAM, used exclusively for non-domestic developments, CEEQUAL, The Code for Sustainable Homes (now retired and being rebranded as the Home Quality Mark following recent changes to Government Policy) and EcoHomes (now also retired and latterly only applicable in Scotland). Since the early 2010s there have been efforts to increase the requirements of the Building Regulations (termed the Building Standards in Scotland); beyond their original Health and Safety orientation to include increased mandatory levels for conservation of energy and materials or design factors covering aspects such as glazing and insulation, amongst other 'sustainability' requirements.

However, in spite of substantial advances in knowledge in these areas and continuing efforts to implement measures at the supra-national level to tackle sustainability issues, sustainability is far from being achieved and many questions remain. Not least

of these is the need for greater understanding of how designers perceive the problems they are being asked to help solve and how they see their own particular role in that, as it is the designer who must (de facto) meet the various sustainability requirements that are now laid down in Standards and Regulations.

Questions arise around how designers view the issue of sustainability - both a concept and as a deliverable - and how much a designer's perceptions of sustainability influences their approach to meeting or surpassing the requirements of the Building Standards. Questions also revolve around how far these perceptions influence their personal design approach; the ongoing impact this has on their sustainability literacy (Higham and Thomson 2015; Stribbe 2009) and to what extent these impact their final design. Together, these may begin to reveal how effective the current 'system' is in attempting to deliver its stated aims and desired outcomes.

Looking at the views of designers is not to diminish the role that other professionals play in the construction process. It is, however, the designer that is responsible for a design that complies with minimum standards and the designer, more than any other person, that is likely to be involved from the concept stages through to the construction phase. In so far as 'sustainability' is concerned, then, the designer resides in a fairly unique position with unique knowledge.

Aims and Objectives

The aim of this paper is to capture and begin to understand the perceptions of sustainability that exist amongst construction industry designers in order to develop insights into the relationship between sustainability policy and practice. Specifically, the research presented will attempt to understand how perceptions of sustainability differ and how designers perceive their role in delivering sustainability.

RESEARCH DESIGN

The overall approach for this investigation to bring about an understanding of the 'themes of the lived daily world from the subjects' own perspective' (Brinkmann and Kvale 2015:27). This understanding has been obtained via the views of individuals currently working in the construction industry, (see data section below). This took the form of semi-structured interviews - that is - interviews that are intended to in essence, the interviews seek to 'research other persons' worlds' (Fellows and Liu 2008:156) and enable the researcher to find meaning from the information they glean from the interviewees.

Data

Specifically, at the time of writing, twenty-three individuals have been interviewed so far for this research. Each person was interviewed on their own and, while the intention was for the interview to last around 45 minutes, the length of each interview did vary in time substantially - from around 30 minutes to in excess of 1 hour and 30 minutes. In each interview the order, phrasing and framing of each 'prompting' or starter question was as similar as possible and practicable.

The recruiting of interviewees was via a variety of sources including existing contacts known to the researcher, and, in many cases the contact networks and recommendations of the participants themselves. All potential participants were emailed to ascertain their willingness to contribute and this was followed up with a further explanatory email to provide broad details about the project and what to expect for the format of the interview.

The majority of interviewees - 19 - were chartered architects. One interviewee was a very experienced Architectural Technologist, two were approaching chartership and one was a chartered structural engineer. Professionally, the breakdown of experience is: two 'early career' (less than five years experience); 13 'early mid-career' (five to 20 years experience); seven 'late mid-career' (more than 20 years experience) and one 'late-career' (within five years of retirement).

This research has been carried out in Scotland and has only gathered information from practitioners currently working in Scotland with experience of residential projects. This has partly been done to reduce a factor of complexity in the findings, since Scotland operates under different Building Standards compared to the rest of the UK. While the Scottish Standards are arguably more ambitious than the current Building Regulations applied elsewhere in the UK, the findings are thought to be equally important across the Industry - not least because several interviewees had worked under both systems and were asked to draw upon the entirety of their knowledge and experiences in their responses. Similarly, every interviewee had experience in both the Commercial and Domestic sector and, while asked to reflect primarily upon the domestic projects, they were free to draw upon the breadth of their professional experience.

Thematic Analysis

Analysis of the data obtained from these interviews is through a thematic analysis of the interview data using NVivo. Thematic analysis is described by Braun and Clarke (2006) as "a method for identifying, analysing and reporting patterns (themes) within data". In part, this is achieved by 'coding' the transcripts of the interviews. Coding is a means of gathering and collating the different pieces of related information that exist across sources and the use of NVivo allows them to be analysed more accurately and systematically to identify themes and develop theory. In the data presented here, for example, one of the themes that has been identified across interviewees is that of cost - but no questions in any of the interviews specifically asked about project costs, or indeed, the costs associated with implementing sustainability. Yet, almost every person interviewed offered cost as one of the major obstacles to sustainability in their professional experience.

Further to this, and to go beyond an objective, descriptive mode of analysis and "attempt to theorize the significance of the patterns and their broader meanings and implications" Braun and Clarke (2006) and begin "to identify or examine the underlying ideas, assumptions, and conceptualizations" (ibid), it is necessary to adopt aspects of 'latent' thematic analysis and thus adopt a subjective, interpretative approach to the data in order to develop themes.

As far as possible, these interviews are intended to operate much like an everyday conversation, but this 'conversation' is, of course, led and developed by the researcher to gravitate towards the areas of specific interest to the research by choosing which areas to pursue and respond to in reaction to what is said to them (Barbour 2008). The researcher must continually be at pains to not unduly influence the responses of the interviewee in developing the conversation, as this could inadvertently lead to the development of the 'Hawthorne' or 'observer' effect whereby the respondent, in different ways, may alter or conform their answers under this influence (for an example of how this can be mitigated see Oswald *et al.*, 2014). This was felt to be particularly relevant when discussing the matter of sustainability, as it was felt that

there might be an inclination on the part of the participant to provide what they thought to be model' or 'good' answers.

This paper presents early findings in this process and the complete analysis is being developed as part of a larger PhD project.

FINDINGS

This paper draws on early-stage analysis of the interview data and a number of themes are already apparent.

1. The level of understanding around sustainability practices and procedures among designers is diverse.

In the interviews, participants were asked a range of questions intended to draw out their own definitions of sustainability, how and when issues of sustainability are introduced to a project and also questions designed to capture the practitioners understanding of sustainability and sustainable development more broadly - beyond the individual project and even beyond the realms of the Construction Industry.

The noted diversity manifested itself in a number of ways, although there was a clear and general propensity to gravitate towards a discussion of materials and energy rather than broader issues. This is exemplified by one participant expressing their understanding of sustainability as the "...use of material or certain levels of, energy to be achieved."

Of course, this is quite understandable since a considerable portion of minimum compliance is reliant on the reduction of CO2 emissions. However, it does raise questions about whether some designers are operating with a somewhat blinkered approach to their work. This may be wilful and deliberate on the part of the designer, but it may also be an indicator of shortcomings either in education or ongoing development of designers.

Even when asking directly about broader themes such as 'society', 'the economy' and 'the environment' comments were largely directed down to the individual building or development level - with a particular tendency to equate 'economic' elements of sustainability with the cost implications of their particular building(s).

Some architects are very clear in their own mind what sustainability means to them and in some respects, this is not in line with what they are required to implement by the Building Standards. A number of interviewees mentioned the concept of 'fabric first' - particularly with reference to their distrust or dislike of the expectancy to use technological or mechanical solutions in their buildings [by the Standards].

I'm resistant to the idea of sustainability being something that you just plug on bits of kit to make it work... form, function, materiality as being a kind of holistic part of the design process - that's what I would think of as being sustainability... in a wider sense as well as, you know, culturally sustainability what it means to be living in rural Scotland today and how people can kind of make that a sustainable lifestyle.

For others, however, there is a marked lack of clarity around what they understand sustainability to mean or what it is to be defined as. This should not be taken out of context - 'sustainability' is undeniably an inherently intangible term to define. More generally, however, was the sense that a broader awareness of the wider issues of sustainability was not present for some - aside from the fairly narrow range of factors that the Building Standards ascribe as 'sustainability'. This line of discussion led one participant to express their understanding of the societal element of sustainability as:

How it affects peoples as well - in their lives and stuff like that.

This, too, could potentially indicate a shortfall in training and/or education of some architects as well as potential deficiencies in how CPD is delivered, since, as a number of participants pointed out, sustainability CPD can often be little more than a marketing exercise for a product that claims to be more sustainable than another.

...the trouble is most CPD that the industry provides aims essentially marketing under a different guise, so in general everyone, whatever their product is, is what's going to save the world

The role of the client should not be forgotten in this with regard to sustainability practices either. The architect can attempt to lead a client in a particular direction, but it is ultimately the design brief that that architect must fulfil. Some participants did, however, stress that they may not be willing to continue working with a client who was asking them to compromise on aspects that they would see as being essential to their own approach - particularly with respect to their sustainability credentials as they would see them.

2. There is a notable lack of engagement with the relevant building standards and particularly the enhanced levels of achievement.

Several questions were posed to the participants relating to the Scottish Building Standards. Of particular interest for this research was Section 7: Sustainability although clearly Section 6: Energy is relevant here too.

Since minimum compliance with Section 7 ('Bronze' Level) is fulfilled by meeting the requirements of Sections 1-6, for some participants there has scarcely been a reason to familiarise themselves with the enhanced levels of achievement (Silver, Gold and Platinum) because there have been so few occasions where their clients have been willing to consider the extra (financial) burdens of doing so. Some participants noted their general ambivalence to some of the requirements due to their perceived unsuitability or seemingly contradictory nature with telling comments such as:

I'm not sure if it's necessarily attempting to measure the right things anyway.

and

...I've never really quite understood what it's meant to be doing because it seems to be a section that's there that you can comply with if you feel like

It should be noted, however, that there was a general appreciation from a number of participants of the "backstop" benefits that may be gained with the Standards generally:

We quite often find ourselves in a situation where with clients who don't have any sustainability agenda, that the building regulations provide a really, really useful backstop where we're able to say you just have to do this...

For others, there was somewhat different attitude expressed about some elements of the Standards:

I'll be honest with you - in practice I think section Seven is a waste of time.... I don't know of anybody that actually has adopted the gold standard. I've never seen it in any marketing literature for any housing development

This does not, however, provide a complete picture. Several participants suggested other reasons for their admitted reticence to engage with the Building Standards and it is certainly does not seem to be because designers are taking no notice of them, One

participant expressed their frustration in terms of how they had to go about complying with some aspects and the negative effect they feel it has on their design process:

You spend all your time trying to comply with them rather than try to do it well

Another reason is that some designers broadly consider their design process as embodying superior sustainability aspirations to those that are required by the Standards and thus - in their estimation at least - exceed the minimum requirements in a different way. In addition to this, a number of participants were clear in their opinion that seeking such achievement would provide very little added value for them or their client, who so often just wanted to meet the minimum compliance levels. One participant, reflecting on this noted, to his amusement:

I think I did exceed the minimum standard one time on sustainability but it was purely by accident!

Further to this, several participants indicated a frustration with the Building Standards and the approach they find themselves taking to material use which is, to them, seemingly contradictory:

Are we using less plasterboard in a house than we did 15 years ago? The answer is probably not because, what has happened is that because of issues with noise and what not, we're now using more plasterboard in houses... So, if sustainability was to drive down the use of materials... We should be using less, but are we?

3. Designers consider the impact of cost when pursuing sustainability in their design - particularly to enhanced levels, to be extensive and often prohibitively so

Whilst it will seem somewhat obvious or even hardly worth noting that cost is a prohibitive feature for the Construction Industry, it is nonetheless significant, and of particular interest, when considering the pursuit of increased and enhanced levels of sustainability and this has emerged in this research in a number of ways so far.

One thing this may indicate is that the embedding of sustainability aspirations still has some way to go. As such, it has become something of a 'movable feast' inasmuch that it can be all too easily dislodged and essentially 'parked' for the sake of a project continuing rather than a project being altered in some other way.

As one participant reflected:

Sadly it's also true that having set out with a high aspiration for a project - when that translates to pounds, shillings and pence, people's agendas often change and they're then able, or somehow able, to find the ways around things that were previously sacrosanct as it were.

While another reflected that when the 'wish list' is longer or larger than the budget:

...it is about making distinct decisions.

Of course, much could be written about the economic and regulatory frameworks that exist to create this situation and, while this will not be possible here, it is clear that changes to these frameworks or a change to how sustainability is incentivised may yield increasing benefits for the pursuit of sustainability.

A further nuanced aspect of the impact of cost may simply be that for some, and particularly the clients that control the project brief, sustainability is not much more than something to 'be seen' to be doing, with one participant noting that:

we quite often find that we have clients who maybe talk about that ambition early on as part of their brief and when the cost plan comes in they want to revert to the cheaper materials that maybe don't have the same sustainable credentials

And for another:

I very often find that a big factor, that overrides all sorts of other things is cost. You start off with “oh yeah, yeah, we’d love to do this” and then “oh wait, that costs more than doing the bare minimum... ah right, no - forget about that then

For another participant when the issue of cost came up, there was a further example of this need to ‘be seen’ aspiring to sustainability but this also highlighted the dangerous extent this type of approach can lead to. This is when the mistaken belief persists that sustainability is being pursued - even when it has systematically have been abandoned as a project has progressed:

...particularly sometimes clients start off with the, the ambition that they’re going to do something really good, you know, might talk about getting BREEAM certification and whatever. And as it goes on, that gets watered down and watered down [due to cost constraints] until you get something that they’re still claiming is wonderfully sustainable that actually “well, yeah, we used a bit of timber on it.

As this research progresses, further features relating to the impact of cost will emerge but, ultimately, as one participant revealed when reflecting on sustainability aspirations specifically, is the need to compromise on something - and currently it is these sustainability aspirations that have to give way:

The punchline for everybody, though, or punchline for 90% of the people, is that they cannot really afford to indulge their dream or aspiration and it always comes back to money, does it not? So, when it comes back to money, people’s philosophies ideas, aspirations always get compromised

CONCLUSIONS

The results obtained from this research thus far reveal several interesting features and offer insights as to how specific sections of the construction industry are currently operating to meet the demands of the sustainability ‘agenda’ in the UK and many more are expected to unfold as this research progresses.

This is shown in three areas that have been expanded up on in this paper. Firstly, is that there is significant diversity of knowledge, understanding of sustainability principles amongst designers. Second is that the Building Standards, having been re-imagined in recent years to further the delivering of a more sustainable built environment, do not yet seem to be engaging a substantial number of designers - and particularly not to seek the higher levels of achievement included in the standards. Thirdly, is the significant impact that cost has on a designer’s ability to pursue higher levels of sustainable design and construction, and how this impact affects either their client’s sustainability aspirations or their own.

There are a number of ways that the findings from this research may be further developed to provide vital contributions to both sustainability discourse and its practical application in the Construction Industry.

In relatively simple terms, practicing designers, can gain an insight into how their fellow professionals perceive of themselves and their work and therefore be in a position to understand and appreciate each other better. Additionally, insights from this research can also feed directly into CPD delivery for designers - to make it more applicable and more robustly ‘educational’ rather than the marketing opportunity that has been experienced by many.

For the education and training of designers there is an opportunity to input directly and constructively into these processes. A small number of ‘early career’ designers

were interviewed in this project and there was a clear lack of both knowledge and familiarity with sustainability issue that cannot simply be attributed to their limited amount of practical work experience. Indeed, it might be expected that practitioners who have only relatively recently completed their formal training might be much better informed on these issues. That was not seen in this research and indicates both a clear need for, and opportunity to contribute to the educational frameworks that direct the education of future designers.

This research can also offer much to the development of Policy, Legislation and Regulation for sustainability and the built environment. In discussing designers' thoughts and perceptions around the applicable Building Standards, much was learned about how they interacted with the regulatory aspects of their work. Greater understanding of these issues can assist in developing increasingly realistic, robust and achievable regulation - and in ways that might empower and incentivise designers to begin addressing the current, seemingly inescapable, compromise between cost and aspirational levels of sustainability in their design.

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EARLY CONTRACTOR INVOLVEMENT IN GOVERNMENT CONSTRUCTION PROJECTS IN GHANA

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The importance of Early Contractor Involvement (ECI) and the input in project development has been acknowledged, however little has been done in practice to actually involve contractors early in government projects in Ghana. This study explores the prospects of early contractor involvement in public construction projects in Ghana. It investigates current construction procurement practices, evaluates potential benefits and challenges of ECI and examines the prospects of adopting the practice in public construction procurement. The research adopted quantitative research methodology using survey that solicited the opinions of 100 professionals from contracting organisations, consulting firms and the relevant government ministry. Results from the study shows that some challenges encountered under the traditional procurement route are linked to poor project development. It also reveals that the government of Ghana might be reluctant to try ECI on its projects however, if adopted; the practice could be successfully implemented and perpetuated. The research shows that ECI could be greatly beneficial to public sector projects if the government embraces the concept and explore the numerous benefits that could be achieved; the practice has good prospects in the delivery of public sector construction projects in Ghana.

Keywords: Early Contractor Involvement (ECI), pre-construction phase, Ghana

INTRODUCTION

The traditional procurement method whereby the contractor is selected based on price and is brought in only after designs are completed has been infamously problematic. This called for the shift to more collaborative forms of procurement. ECI arose in the early 2000s in the UK due to the realization of the need for contractor input during projects' early stages (Turner and Riding, 2015; Mosey, 2009). Turner and Riding (2015) noted that the early introduction of other parties could increase the prospects of benefits realization in construction projects. Benefits of early contractor involvement include quality improvements, cost and time saving, better understanding of risks, reduced conflicts and litigation and improved collaboration (Song *et al.*, 2009). According to Westring (1997) construction procurement forms a large chunk of government expenditure through its Ministries and Agencies. Based on this premise, efficient public construction procurement ensures the appropriate use of state funds to achieve economic growth (Anvuur *et al.*, 2006). Construction procurement in Ghana

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is plagued with adversarial relationships and delays right from the pre-contract stage through the post-contract stage and cost overruns and legal disputes post-contract (Westring, 1997; World Bank, 2003). Though the Public Procurement Act of Ghana (Act 663) suggests a number of other procurement routes, National Competitive Tendering is the most widely used in public construction procurement. This allows contractors to be brought on board only after designs have been completed and construction is set to commence presenting a challenging atmosphere for the integration of construction and design (Song *et al.*, 2009). The early involvement of contractors and their input at project inception and development stages is therefore limited (Mosey, 2009).

Public Construction Procurement in Ghana

Procurement of goods, works and services stood at \$600m as reported by the World Bank (2003) and this is an estimated 10% of Ghana's GDP. Government's procurement includes the acquisition of goods, works and services for public consumption and benefit (Hughes, 2005). The Public Procurement Act 2003 (Act 663) of Ghana emerged from the realised shortcomings of the public procurement system in Ghana (Bamfo-Agyei *et al.*, 2015). The Public Procurement Act of Ghana is applicable to all publicly funded procurement whether fully or in part (PPA-Section 14, 2003). The procurement Act 663 (2003) aims at promoting competition, efficiency, transparency and accountability in contract awards so as to ultimately achieve value for taxpayers' money (Bamfo-Agyei *et al.*, 2015).

The usual tendering process for public works as stipulated by Act 663 (2003) begins with an invitation to tender, submission of tenders, opening of tenders, evaluation of tenders and acceptance of successful tender and contract award. For public construction works the traditional procurement route, where designs are completed before main contractors are invited to bid competitively, is most widely used and accepted. Prior to the enactment of Act 663, the procurement of public works were plagued with issues of monitoring, no clear link between procurement function and public management, delays in procurement cycle and corruption, some of which are still problems today (Transparency International, 2009; Lengwiler and Wolfstetter, 2006). Westring (1997) emphasized the development of adversarial relationships between contractors and clients on government projects due to time lags. Apart from pre-contract delays, project execution delays as well as cost overruns are characteristic of public construction projects in Ghana (World Bank, 2003; Westring, 1997). The dynamic nature of the construction industry through its fast changing demand and supply has necessitated innovation to meet public needs and to obtain value for money (Anvuur *et al.*, 2006). Such dynamism within the construction industry has brought about a host of challenges, which may work against efforts of innovation and value for money.

The Nature of Early Contractor Involvement

Early Contractor Involvement (ECI) simply concerns the main contractor actively engaging in the design process, construction programming as well as risk management (Mosey, 2009). Scheepbouwer and Humphries (2011) define ECI as the process of bringing on board a contractor to contribute to design before construction work begins. It is also described as the informal engagement of the main contractor/service provider at the design stage and also the formal process of obtaining efficiency and value for money from the contractor's early engagement (Turner and Riding, 2015). The process involved in early contractor involvement describes the approach where a

partnering agreement is entered into with the main contractor early in the project lifecycle to assist and advice on project planning (Rahman and Alhassan, 2012; Nichols, 2007). A target price system is then used in determining the contractor's compensation as stipulated by the contract. However Seah (2012) adds that, ECI involves competent contractors submitting documents on their financial stance, human and other resources strength, completed jobs track records during a pre-qualification exercise. The early involvement of the main contractor at the pre-construction phase could either have the same contractor being engaged early on planning and also carrying out works on site or different main contractors for pre and post planning phases. A pre-construction phase agreement ought to be in place to legitimize main contractors' contributions earlier on in the project and also to assign risks and responsibilities as well as contractor compensation (Mosey, 2009). The Joint Contracts Tribunal (JCT) in the UK has in place standard forms of pre-construction services agreements for general contractors and specialists. However, they must be used in conjunction with one of the JCT standard forms of contracts, which serves as the main construction contract (JCT, 2011).

Extent of Early Contractor Involvement in Ghana

In Ghanaian public construction procurement, the standard form of building contract is that of the Public Procurement Board's tender documents for the procurement of works for medium contracts (lump sum) and more recently in use are the standard contract forms that are part of tender documents for international competitive tendering. There also exists a form of contract for consultant services for complex time-based assignments and large lump sum assignments. According to Act 663 (2003) the main contractor (consultant) could be selected based on quality and cost only subject to the client's preference.

Public construction procurement in Ghana has contracts awarded to main contractor's right before construction starts on site as it's the general practice in other developing countries. There is no formal knowledge of Early Contractor Involvement being practiced on public projects in Ghana as the government as a client depends on its consultants to provide services that the main contractor would otherwise provide at the project development stage. Mosey (2009) argued that the single stage procurement process involving price based selection of main contractors complicates and perpetuates an already fragmented construction sector. The fragmentation of the construction industry as a barrier to growth among other issues has been stressed severally (Emmerson, 1962; Banwell, 1964; Latham, 1994). The notion of integrating design and construction has also been overemphasized as main contractors' input in design has been found to achieve more functional designs.

Benefits and challenges of Early Contractor Involvement

ECI could be a source of the much-needed increase in productivity levels in construction and also advocated the approach as a means of encouraging partnering in tendering (Seah, 2012). Lines of responsibility are better defined and understood under the ECI contractual arrangement. The contributions of the main contractor as well as subcontractors will ensure buildability of designs while making the project more affordable to pursue (Mosey, 2009). The most important benefit of ECI is that it seeks to reap much improved results than that offered by traditional procurement routes (Seah, 2012). Other benefits of ECI in a project are presented in Table 1.

Early Contractor Involvement has its downside and challenges to its successful implementation. The benefits of the approach however, far outweigh its challenges.

Such constraints could be minimized or eased if it can be proven that better value for money as well as honesty on the part of the main contractor can be achieved with his early involvement or with two-stage procurement. Some of the challenges of ECI are presented Table 2.

Table 1 -Benefits of Early Contractor Involvement

	Benefits of ECI	Source
1	Project risks are better understood and dealt with through joint problem solving which enables the easier prediction of project outcomes	Seah, 2012
2	Subcontractors are also able to prepare responsive bids due to the availability of information on design, risk, etc.	Mosey, 2009
3	There is less adversarial relationship amongst the project team reducing the occurrence of conflict during or after projects	Rahmani <i>et al.</i> , 2013
4	The joint risk management approach between the client and the main contractor when adopted allows for effective value engineering and prevents delays on site	Mosey, 2009
5	The development of a partnering relationship under ECI could reduce risk due to transparency involved	Van Elburg, 2008
6	ECI improves productivity, encourages innovation and successful project execution	Turner and Riding, 2015
7	The construction programme is also better-developed and followed, with milestones set within realistic time periods	Mosey, 2009
8	The main contractor is able to infuse latest construction technology and knowledge into projects due to his early involvement in the project	Seah, 2012

Table 2 -Challenges of Early Contractor Involvement

	Challenges of ECI	Source
1	The construction industry being slow or resistant to change and constitutional constraints negatively impacts progressive concepts such as ECI in construction procurement	Mosey, 2009
2	Ineffective information sharing in the project team stifles the progress of the practice	Turner and Riding, 2015
3	Absence of trust in contractors' expertise coupled with competitive tendering and a rigid contract are likely to strain contractual relationships and reduce project performance	Laan <i>et al.</i> , 2011
4	Cost estimates produced at the early stages of a project with ECI may not be accurate enough to incentivise clients to adopt the practice in future projects	Nichols, 2007
5	Simple, small sized or low risk projects may not warrant ECI as it may include unnecessary cost and contractors may be unwilling to sign an additional contract	Mosey, 2009

METHODOLOGY

The study adopts quantitative research methodology for primary data collection using a survey; the use of quantitative method provides a wider view of respondents' offering an increased reliability and validity of research results (Opoku *et al.*, 2016) Quantitative research methodology provides responses that describe the experiences, opinions, and other characteristics of respondents with the view of making statistical interpretations of the phenomenon under investigation (Fowler, 2013). Questionnaire survey as a data collection technique provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population. The study is focused on the Greater Accra Region of Ghana, which is the commercial capital of the country and as such has a concentration of most large construction firms

in the country. The D1K1 class of main contractors are chosen for this study as they handle contracts valued above \$500,000, and are therefore most likely to execute large public construction projects. Professionals with experience in the areas of Engineering, Architecture, Quantity surveying, Project management and Contracting were randomly selected from the consultant, main contractor and client (government) organisations that took part in the study.

RESULTS AND DISCUSSIONS

A total of 100 questionnaires were distributed to professionals from the Ministry of Water Resources, Works and Housing, construction consultants and main contractors involved in Ghana government projects. A response rate of 83% was achieved with 24% representing consulting firms, 45% contracting organisations and 31% respondents belonging to the Ministry of Water Resources, Works and Housing.

The concept of Early Contractor Involvement (ECI)

In exploring respondents understanding of the concept of Early Contractor Involvement (ECI), respondents were asked to rank their thoughts on statements identified through literature review concerning the ECI practice on the Likert scale of; 1- Strongly disagree, 2- Disagree, 3- Neutral, 4- Agree and 5-Strongly Agree. The results is summarised in Table 3. Analysis of these results indicates that the Mean rating for pre-construction phase agreements being used as contracts (3.40) is closer to 'neutral' (3). The remaining statements could all be said to be closer to 'agree'. The Modes of all but one of the statements depict agreement (4), with integration of design and construction through ECI as a means of eliminating issues having a modal rating of 5 (strongly agree).

Table 3 - General Statistics on the concept of ECI

		Main contractors services formally engaged early	Formal signing of contracts for ECI	Pre-construction phase agreements used as contract	Lack of ECI being linked to government project issues	Integration of design and construction through ECI to eliminate issues	Possibility of ECI being successfully adopted in government projects
N	Valid	83	83	83	83	83	83
	Missing	0	0	0	0	0	0
	Mean	3.72	3.59	3.40	4.07	3.96	4.13
	Median	4.00	4.00	3.00	4.00	4.00	4.00
	Mode	4	4	4	4	5	4

Analysis of the statistics shows that statements with particularly high percentages of responses in favour of 'agree' were main contractors' services being formally engaged early and formal signing of ECI contracts, which had 53% of respondents and 47% of respondents respectively, agreeing with the statement. For ECI having pre-construction phase agreements as the form of contract, though 35% of respondents agreed, 28% were neutral and 22% also disagreed. This could mean a different form of contract is signed for such an arrangement in Ghanaian public construction. Respondents were also asked if there was a link between a lack of ECI and government project issues, 45% of them agreed with a further 35% strongly agreeing. In terms of integration of design and construction through ECI eliminating project issues, 36% strongly agreed while 29% agreed and 31% were neutral. Though majority of respondents agreed this was possible, a significant number were not fully convinced. Lastly, when respondents were asked if ECI could be successfully implemented in government projects, 48% of respondents agreed with 36% strongly

agreeing. This raises a beacon of hope for the adoption of ECI practices in the Ghanaian public sector construction.

When respondents were asked to express their opinion on government’s willingness as a construction client, to adopt ECI in its projects, the analysis of the results indicate that 47% of the respondents observed that public construction procurement entities will be reluctant to adopt ECI. It further shows that a significantly 33% are of the view that government will be unwilling to adopt the practice while only 20% admitted that government will be very willing to adopt ECI. This is contrary to the research expectations, which hoped to see a significant number of respondents affirming the government’s willingness to embrace the ECI concept. Responses are illustrated in the Figure 1.

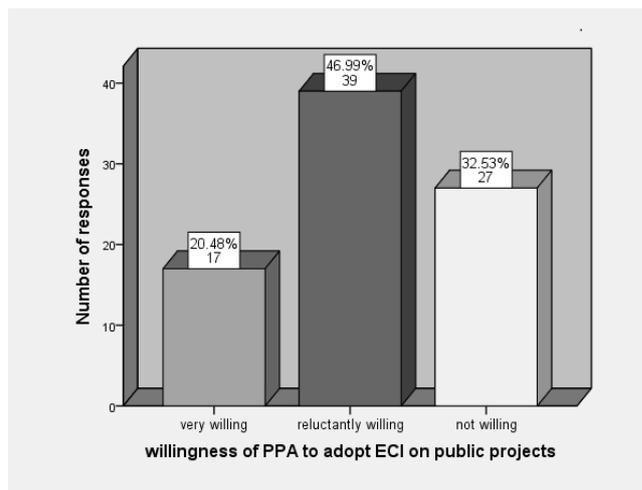


Figure 1: Willingness of Government procurement entity to adopt ECI

Benefits of Early Contractor Involvement

This section of the study required respondents to rate their level of agreement with a number of benefits of ECI. Respondents were to select their preference from the Likert scale with the following rankings: 1- little importance, 2-some importance, 3- quite important, 4-important, and 5- very important. The tables and figure below illustrate the rate of response to each question.

Table 4 shows Mean values for all benefits to be close to 4 (important) on the Likert scale.

Table 4: General Statistics on Benefits of ECI

	Development of feasible plan	Better risk cost assessment	More information to prepare responsive bids	Effective value engineering due to joint risk management	Better developed construction programme	Development of team spirit and transparency
N Valid	83	83	83	83	83	83
Missing	0	0	0	0	0	0
Mean	3.86	3.93	3.99	3.93	4.10	4.00
Median	4.00	4.00	4.00	4.00	4.00	4.00
Mode	4	4	4	4	5	4
Std. Deviation	.912	.973	.994	.894	.970	.937

The Mode for five benefits is 4 (important) while that on ECI enabling a better-developed construction programme has a Mode of 5 (very important). The results

therefore show that, better developed construction programmes as a result of ECI is a very important benefit. Respondents also believe benefits of ECI such as the development of a feasible cost plan, better risk assessment, more information to prepare responsive bids, effective value engineering as a result of joint risk management and the development of team spirit and transparency, to be important.

There is a significantly high percentage of respondents finding all the listed benefits either 'important' or 'very important' as shown in Figure 2. These benefits are directly linked to the issues encountered on projects without ECI. Respondents' affirmation of these benefits therefore substantiates findings from literature review that, ECI could reduce or eliminate some construction challenges.

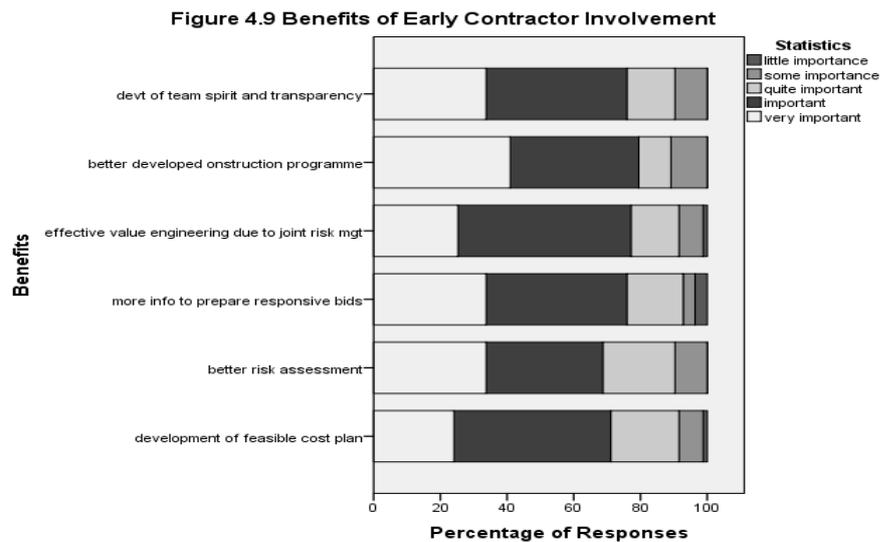


Figure 2: Benefits of ECI

Challenges of ECI

Finally respondents were asked to rank their level of agreement on a number of challenges of ECI identified through literature review on the Likert scale where 1- Strongly disagree, 2- Disagree, 3- Neutral, 4- Agree and 5-Strongly Agree. Table 5 shows that 25% of respondents disagree that ECI is a new procurement approach. In spite of majority of respondents agreeing or strongly agreeing that it is, construction literature reports its existence for several years. Respondents therefore generally agree that ECI could have the downside of smaller projects not needing ECI, procurement laws limiting ECI prospects and lengthy and expensive processes surrounding pre-construction phase agreement.

Table 5: Frequency table on the challenges of ECI

	ECI is a new procurement approach	Lack of incentive to adopt ECI	Smaller less complex projects may not need ECI	Procurement laws limiting prospects of ECI	Length of time and cost of construction phase agreements deterring use of ECI	Reluctance to the signing of pre-additional contracts such as the pre-construction phase agreement
Strongly disagree	1%	3%	2%	6%	1%	0%
Disagree	25%	19%	12%	8%	5%	16%
Neutral	11%	24%	18%	28%	29%	31%
Agree	39%	29%	40%	45%	42%	31%
Strongly agree	24%	25%	28%	13%	23%	22%

The results however, did not fully lean towards the reluctance of the government and contractor to sign an additional contract and ECI being a new procurement approach as major challenges of ECI.

Generally, the analysis shows that, the traditional method of procurement, which is most commonly used for government projects in Ghana offer poor project development and strongly linked to the issues encountered on such projects. It was also found that ECI usually involves the signing of a formal contract to ensure contractor compensation for project development activities. Respondents also strongly believe that ECI could enable the development of a better construction programme.

CONCLUSIONS

The prevalence use of the traditional price-based procurement route to obtain the services of a main contractor is associated with numerous challenges most of which are regarded as being strongly linked to poor project development. The results of the study show that there is lack of early contractor involvement in most Ghana government project. However, respondents were generally sceptical about the government's willingness to adopt the ECI approach due to procurement laws or the relative newness ECI to the Ghanaian construction industry. The study revealed that public construction procurement entities are reluctant to adopt ECI in government projects. However there is hope that the practice of ECI could become common in the near future as the construction industry continues to grow and evolve. The construction industry is known as being resistant to change, ineffective in information sharing amongst the project team and a general lack of trust in the main contractor's expertise.

These challenges are believed to be affecting successful implementation of ECI in Ghana, especially in government projects. However ECI in government projects offer numerous benefits including the assurance of buildability of designs, better risk management, better developed construction programme and cost plan as well as effective value engineering and greater team spirit. The study highlighted the importance of these benefits in ensuring the successful implementation of ECI. Mapping these benefits to the challenges of current government procurement practices in Ghana, it is evident that early contractor involvement, if not completely, could make a significant difference in public construction procurement by minimizing the incessant issues plaguing the construction industry in Ghana. The paper therefore recommends that, public sector construction procurement entities in Ghana should be sensitised and exposed to the concept and benefits of early contractor involvement. Public procurement entities in Ghana could introduce early contractor involvement, governed by a pre-construction phase agreement, in their procurement of works by testing it on some pilot projects, which meets the criteria of it being large and quite complex. As ECI has been successfully implemented in government projects in some developed countries such as UK, Ghana's construction industry could draw from these experiences to successfully adopt ECI practice in public sector procurement of construction projects.

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CRITICAL SUCCESS FACTORS: THE DEVELOPMENT OF A CONCEPTUAL FRAMEWORK FOR DEMOLITION PROJECTS

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Critical success factors (CSFs) are an established tool to distil key issues. While extensive research has been undertaken to develop CSFs for construction projects, no known CSFs study has been undertaken specifically for demolition projects. While some studies have looked at identifying CSFs for diverting end-of-life waste from landfill, their attention has been limited to the design phase and its impact on the performance of the demolition contractor. This study focused on the engagement and delivery process of demolition. 30 academic papers relating to the end-of-life phase of buildings were carefully studied to extract potential CSFs for demolition projects. As a result, 49 factors were identified and categorised under 5 main categories: Project procurement; project stakeholders, project management actions, project related factors; and external factors. The identified factors were ranked based on their number of mentions in literature, of which the following were highlighted as most important: 1) Effective communication among project stakeholders; 2) Client to give sufficient time for demolition contractor to deconstruct rather than demolish; 3) Designers to consider the end-of-life in their designs; 4) Clean on-site separation of materials; 5) Government to provide financial incentives for demolition contractors for adopting less wasteful demolition methods; 6) Government incentives through standards to create a market for reused/recycled materials. From the CSFs study, a conceptual framework is presented which helps to clarify the complex nature of demolition projects and pinpoints the factors that affect the success of demolition projects.

Keywords: CSF, demolition, stakeholder management, end-of-life

INTRODUCTION

Critical Success Factors (CSFs) are an established tool to distil key issues and are considered to be one of the essential ways to understand the core challenges to a particular industry at a particular time (Bullen and Rockart, 1981). Many attempts by researchers have been made to identify CSFs for construction projects (Chan *et al.*, 2004; Liu *et al.*, 2012; Yong and Mustaffa, 2013; Alias *et al.*, 2014) to reduce waste, improve efficiency, develop new strategies and processes, manage stakeholders, and to promote frameworks and guidelines for project success. In contrast, very few studies have been conducted for demolition projects and the end-of-life phase except for those which focused on minimising waste through design driven CSFs (Akinade *et al.*, 2016). The demolition industry has been noted in many studies as lagging behind

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in terms of research compared to the construction industry (Quarmby *et al.*, 2011; Thomsen *et al.*, 2011). The study of project success and critical success factors for buildings end-of-life is therefore timely for many reasons. Firstly, the demolition contractor is required to take a lot of managerial decisions during the delivery process of projects (Diven and Shaurette, 2010), and to date, there is no evidence that a study has explored the CSFs at projects end-of-life (Akinade *et al.*, 2016). Additionally, one of the major drawbacks in the current demolition industry is the lack of consideration in terms of the relationship between demolition contractors and other construction stakeholders (Kunieda, 2016). Also, Takim *et al.*, (2004) noted that one of the hindrances of successfully managing a construction project is failure to determine relevant CSFs across project phases. Omran *et al.*, (2012) added that improving the effectiveness of projects and achieving project objectives starts by determining the success factors, and at present, CSFs for demolition phase has not been fully explored. Thus, this study seeks to fill this gap.

LITERATURE REVIEW

When an old building reaches its end of life and no longer is able to serve its purpose, the building is taken down to make way for new buildings. The process of taking down buildings and dealing with the end-of-life phase is what is known as demolition (WRAP, 2009). Demolition is complex. Experts in the field require an understanding of waste management, recycling of materials, reclamation, hazardous materials, implosion, landfilling, project management, general contracting as well as knowledge in personnel, equipment, the nature of structures and architectural design and many other aspects to optimise the demolition process (Diven and Shaurette, 2010). Due to its complexity, demolition is considered to be the most dangerous business in construction, as many uncertainties are involved from one project to another, and lack of knowledge regarding areas like hazardous materials or the nature of the structure dealt with could lead to serious incidents (Hare, 2016). An example of this is the collapse of Didcot power plant in Oxfordshire where one person died and 3 others went missing in 2016.

Apart from its risky nature, demolition is also considered to be a wasteful process (Chen and Lu, 2017). This is primarily because the construction and demolition industry predominantly follow a linear economy model; where building materials at their end-of-life are not used for the same purpose they were originally created for (Cheshire, 2016). Such materials are being 'down cycled' into lower grade products and used for different purposes outside of the construction industry (Magdani, 2014). For example, solid timber is chipped or burnt, structural concrete becomes non-structural aggregate, and modular units, such as bricks are crushed rather than reclaimed (Cheshire, 2016). Given that the construction industry demands approximately 40- 50% of the world's extracted natural materials (Hradil, 2014), and demolition waste is considered to be the largest and most significant waste stream in many countries (Chen and Lu, 2017), the linear approach is deemed to be a highly wasteful approach (Cheshire, 2016). The demolition industry is also faced by many challenges that prevent its development:

- Clients impose a lot of pressure on demolition contractors to speed up the process; thus, restricting the demolition contractor in preparing for the demolition process (Clarke, 2009).

- There is a lack of incentive to retrieve materials from demolition projects because raw materials within the sector exist in large quantities and are relatively cheap

(Palmer, 2017), and therefore, demands for second hand materials are considerably low (Rios *et al.*, 2015). This is one reason why designers generally do not priorities designing for deconstruction, as no market exist for second hand materials.

Compared to design and construction phases, demolition lags behind in terms of research (Thomsen *et al.*, 2011), particularly in the areas of information management and communication; this justifies why the use of machinery in demolition has become very advanced, but not in terms of technology and development; for instance, there is little engagement with Building Information Modelling (BIM) as a useful new process and technology for projects at end-of-life (Akinade *et al.*, 2016).

RESEARCH METHODOLOGY

Critical Success Factors (CSFs) are an essential management tools to help businesses implement their strategies and projects successfully (Addy *et al.*, 2017). Rockart (1979) defined CSFs as "areas of activity that should receive constant and careful attention from management". The concept of CSFs has been applied extensively in various industries such as construction, information technology, medicine and production (Yong and Mustaffa, 2013). It proved to be one of the essential ways to understand the core challenges to a particular industry (Rockart and Bullen, 1981). The identification of CSFs for an industry helps to break down the complex nature of the industry into few discrete factors that require most attention (Lu *et al.*, 2008); leading to improving the effectiveness of project delivery. If those factors are satisfactory, it will guarantee a successful delivery of the project (Lu *et al.*, 2008).

The methodology of CSFs, however, has been critiqued by some. Fleisher and Bensoussan (2007) considered CSFs to be too obvious that it would not provide any advantage, or they will be so elusive that they will defy any decision making or action. Additionally, Waugh (2017) noted that if wrong CSFs were identified for a specific industry, it would lead to an opposing result and prove detrimental to the work. However, the methodology of CSFs suits this research because the process of demolition is complex by its nature; the demolition contractor is required to make a lot of managerial decisions during projects which include: Conducting pre-demolition survey, demolition method, separation of materials, disposal of those materials, management of stakeholders, and many others management related decisions (Diven and Shaurette, 2010; Oyedele *et al.*, 2014; NFDE, 2016). Chini and Bruening (2003) mentioned that their decisions are primarily based on past experience; because often when demolition contractors arrive on site, there is significant uncertainty regarding the availability of information provided by the client (Clarke, 2009). Therefore, a CSFs methodology is suitable for demolition to break down its complex nature and pinpoint those activities that require more attention than others.

A methodology that is exploratory in nature is deemed essential for this study as no framework of CSFs exist for demolition projects. Reviews of literature showed that CSFs for demolition projects are scattered in various studies; thus, an extensive literature review was carried out to gather those scattered CSFs for demolition projects into one study. The CSFs approach employed in this study is a popular technique in construction research. Studies have identified five main steps for identifying CSFs: (1) to select a full set of possible success factors; (2) to survey the importance of each selected success factor for a given goal; (3) to calculate the importance index of each factor based on the survey data; (4) to extract CSFs from the selected success factors

according to the important indices; and (5) to interpret and analyse the extracted CSFs (Liu *et al.*, 2012). Therefore, the procedure for identifying the CSFs for a specific industry often begins by conducting an extensive literature review and gathering those scattered factors in one group. This study sought to fulfil specifically the first of the five identified steps. The downside issues for a literature review approach includes lack of practitioners input, and the concern that the data may be out of date as most of the publications are numbers of years old. The literature studies were chosen based on three criteria:

Papers related to demolition projects: CSFs were extracted from those papers based on the researcher judgement.

Critical Success Factors studies on design and construction phases. Papers which covered the whole building life cycle and indirectly included issues of demolition.

Keywords of the papers, these are: Demolition, end-of-life, circular economy, critical success factors, deconstruction, and design for deconstruction.

Subsequently, the study sought to prioritise the identified list of CSFs based on the number of mentions in the literature. After prioritising the factors, the criteria for considering the CSFs in the framework were chosen based on two factors:

1. Factors which were mentioned in four or more studies;
2. Factors which complements the factors chosen in point 1 (only chosen from External Factors category). This will be further explained in the Discussion.

For the creation of the framework, this paper followed Chan *et al.*, (2004) model which grouped the identified CSFs for construction projects under 5 main categories: Project procurement, project stakeholders, project management actions, project-related factors, and external factors. This model was also utilised in various studies including Mustaffa and Yong (2013) and Alias *et al.*, (2014).

RESULTS

30 studies related to end-of-life phase were carefully studied to extract potential CSFs for demolition projects. These include journal papers, articles, government reports, and industrial reports. Then, the identified CSFs were put in spreadsheets, which facilitated the process of organising, analysing and finding insights in the data. Putting all data in one place also facilitated the process of generating the success factors from the conducted literature review and aided in merging similar CSFs together to form one success factor. As a result, 49 potential CSFs were identified and are shown in table 1. The factors are listed and ordered based on their number of mentions under the following categories: Project procurement, project stakeholders, project management actions, project-related factors, and external factors.

DISCUSSION

Procurement and Project-Related Factors

Very little information was found regarding demolition project procurement in the literature. However, one CSF that was mentioned in several studies was the importance of comparing different demolition methods prior to selecting the optimal option. This would therefore link to the project-related factors identified in this study such as: 1) Complexity of the project, 2) Duration given by client, 3) Building type, 4) Building age, 5) Building location, and 6) Building size.

Project Management Actions

Many CSFs were identified in the project management actions category for demolition contractors. The highest-ranking CSFs in this category cover the issues of: 1) Effective communication; 2) Clean separation on-site; 3) Running pre-demolition audits assessment to check the suitability of elements in an existing building or structure; and 4) Clearly defined goals and objectives. This category mainly represents the role of the demolition contractor/project manager during the delivery process of the project. Factors like effective communication and clearly defined goals align with previous studies of CSFs on the role of the contractor during construction projects (Chan *et al.*, 2004; Yong and Mustafa, 2013; Addy *et al.*, 2017).

Table 1: List of Critical Success Factors developed from the literature

Description of critical success factor	Relevant Literature
Project Procurement	
1. Compare alternative demolition methods prior selecting the optimal one.	Arham (2003); Clarke (2009); Chen and Lu (2017).
2. Involve the structural engineer at the planning stage	Clarke (2009)
3. Consult waste recycling company to discuss how the waste will be managed and taken out of site	Instant Waste Management (2017)
Project Stakeholder	
1. Client to give sufficient time for demolition contractor to create an incentive to deconstruct rather than demolish.	Chini and Bruening (2003); Chan et al. (2004); Endicott et al. (2005); ICE (2008); Clarke (2009); Rios et al. (2015).
2. Designers to consider the end-of-life in their designs	Chini and Bruening (2003); Endicott et al. (2005); BAM (2014); Adams (2015); Rios et al. (2015); Akinade et al., (2016).
3. Government to provide financial incentives for demolition contractors for adopting less wasteful demolition methods	Chini and Bruening (2003); Endicott et al. (2005); Oyedele et al. (2014); Akinade et al. (2016); Chen and Lu (2017).
4. Government incentives through standards to create a market for reused/recycled materials	Chini and Bruening (2003); Endicott et al. (2005); Tingley and Davison (2011); Oyedele et al. (2014); Rios et al. (2015)
5. Government legislations requiring consideration of design for deconstruction to facilitate future deconstruction	Thomsen et al. (2011); Tingley and Davison (2011); Rios et al. (2015); Akinade et al. (2016)
6. Client to provide an integrated set of as built drawings or any relevant information regarding the project	Chini and Bruening (2003); Clarke (2009); Diven and Shaurette, (2010); Tingley and Davison (2011)
7. Stringent legislation from government on the use of recycled materials in new construction projects	Jeffery (2011); Oyedele et al. (2014); Akinade et al. (2016).
8. Engaging demolition contractor at the design stage at early stages of the project.	Rios et al. (2015); Ulyatt (2015) Akinade et al. (2016).
9. Top management support to project team	Chan et al. (2004); Addy et al. (2017)
10. Designers to increase their preference for recycled products in their specifications.	Oyedele et al. (2014); Adams et al. (2017).
11. Engage the structural engineer at the planning stage	Clarke (2009)
12. Project team leaders commitment to meet cost, time, and quality.	Chan et al. (2004)
13. Motivating skills of the project team managers.	Chan et al. (2004)
Project Management Actions	
1. Effective communication among project stakeholders	Chan et al. (2004); Clarke (2009); Tingley and Davison (2011); Liu et al., (2012); Yong and Mustafa (2013); Amade et al. (2015); Addy et al. (2017).
2. Clean on-site separation of materials	Chini and Bruening (2003); Clarke, (2009); Tingley and Davison (2011); Jeffery 2011); Chen and Lu (2017).

3. Run pre-demolition audits assessment to check the suitability of elements in an existing building or structure	Clarke (2009); Oyedele et al. (2014); NFDC (2016); Instant Waste Management (2017).
4. Clearly defined goals and objectives	Chan et al. (2004); Yong and Mustafa (2013); Akinade et al. (2016); Addy et al. (2017).
5. Careful and safe storage for recovered materials	Clarke (2009); Tingley and Davison (2011); Akinade et al., (2016)
6. Continuous site management and supervision during demolition process.	Clarke (2009); Yong and Mustafa (2013).
7. Project managements skills of demolition contractor	Amade et al. (2015); Addy et al. (2017).
8. Consult waste recycling company to discuss how the waste will be managed	Instant Waste Management (2017).
9. Involvement of different project stakeholders in the early planning of projects.	Yong and Mustafa (2013).
10. Emphasis on high quality workmanship instead of low and quick demolition	Yong and Mustafa (2013).
11. Use modern well-maintained demolition plant which use low fuel consumption	Clarke (2009).
12. Provide guarantees for reused materials	Tingley and Davison (2011).
Project related factors	
1. Complexity of the project	Chan et al. (2004); Yong and Mustafa (2013)
2. Building Type	Chan et al. (2004); Chen and Lu (2017)
3. Project Size	Chan et al. (2004); Addy et al. (2017)
4. Duration given by client	Yong and Mustafa (2013); Chen and Lu (2017)
5. Building Age	Chen and Lu (2017)
6. Building Location	Chen and Lu (2017)
External Factors	
1. Government/Industry programmes supporting deconstruction	Guy and Shell (2002); Chini and Bruening (2003); Rios et al. (2015); Akinade et al. (2016).
2. Provide training for demolition contractors and builders to deconstruct with minimal damage	Chini and Bruening (2003); Endicott et al. (2005); Tingley and Davison (2011); Rios et al. (2015).
3. Educate clients on the long-term benefits of deconstruction.	Tingley and Davison (2011); Rios et al. (2015); Akinade et al. (2016).
4. Use tracking technologies for each component at the construction stage (e.g. RFID) for future reference	Chini and Bruening (2003); Tingley and Davison (2011); BAM (2014).
5. Nature (weather conditions)	Yong and Mustafa (2013); Amade et al. (2015); Chen and Lu (2017).
6. Educate the public on the benefits of using salvaged building components	Chini and Bruening (2003); Tingley and Davison (2011)
7. Award of more points for building deconstructability in sustainability appraisal	Oyedele et al. (2014); Akinade et al. (2016)
8. Educate clients on the importance of the preparation time prior demolition	Clarke (2009); Jeffery, (2011)
9. Increase the awareness of architects to the use of second hand materials	Guy and Shell (2002); Chini and Bruening (2003)
10. Available resources and advanced technologies of the firm	Chan et al. (2004); Addy et al. (2017)
11. Social Environment	Chan et al. (2004); Yong and Mustafa (2013)
12. Economic Environment	Chan et al. (2004); Yong and Mustafa (2013)
13. Professionals bodies to improve the awareness and benefits of recyclable materials and products among their members	Oyedele et al. (2014)
14. Waste management capabilities	Chen and Lu (2017)
15. Increased academic research in the field of demolition and end-of-life	Thomsen et al. (2011)

Stakeholders and External Factors

It was noticed that factors identified under project stakeholders are linked and substantially affected by external factors category, thus both categories were merged together in the framework. For instance, for the client to give sufficient time for the demolition contractor to deconstruct rather than demolish, relies on educating clients on the importance of deconstruction. Similarly, once clients realise the long-term benefit of deconstruction and its positive impact on the environment, designers will subsequently begin to consider deconstruction in their designs because their customers

are interested. Therefore, the successful delivery of demolition projects starts at the early stages of designing and planning for the building; where clients and designers make their decisions.

The majority of clients however, consider traditional demolition to be the most cost-effective method to knock down a building and therefore the majority of clients are satisfied with the current situation (CEW, 2014). This explains why almost all existing buildings are not designed to be deconstructed (Akinade *et al.*, 2016). This indicates that some clients might not be interested in taking on the burden of extra costs and may resist any changes. Therefore, many authors believe that the government has to provide financial incentives and set standards to encourage clients to use second hand materials and to consider design for deconstruction in their buildings (Chini and Bruening, 2003; Endicott *et al.*, 2005; Tingley and Davison 2011; Oyedele *et al.*, 2014; Rios *et al.*, 2015). Providing government backed incentives for second hand materials and running programmes supporting deconstruction would increase the demand for second hand materials taken from demolition projects. This would result in encouraging demolition contractors to shift their preferred method to deconstruction to retrieve as many materials as possible with minimal damage hoping to make extra profit. This justifies why educating clients, the public, and architects on the importance of deconstruction is highlighted in this study as being important.

A number of other points of interest can also be highlighted. Few studies emphasised the importance of engaging a new stakeholder at the early stages of planning and designing of a building (i.e. the demolition contractor) (Rios *et al.*, 2015; Ulyatt, 2015; Akinade *et al.*, 2016). Engaging the demolition contractor at the design stage would reflect positively on the end-of-life of the building, as the majority of the decisions will involve considering the end-of-life phase. Another fundamental factor which was found in one study is to increase academic research in the field of demolition and end-of-life (Thomsen *et al.*, 2011). Without linking research and practice, the demolition industry is unlikely to move forward and develop.

The results of the CSFs exercise are brought together and illustrated as a conceptual framework in Figure (1).

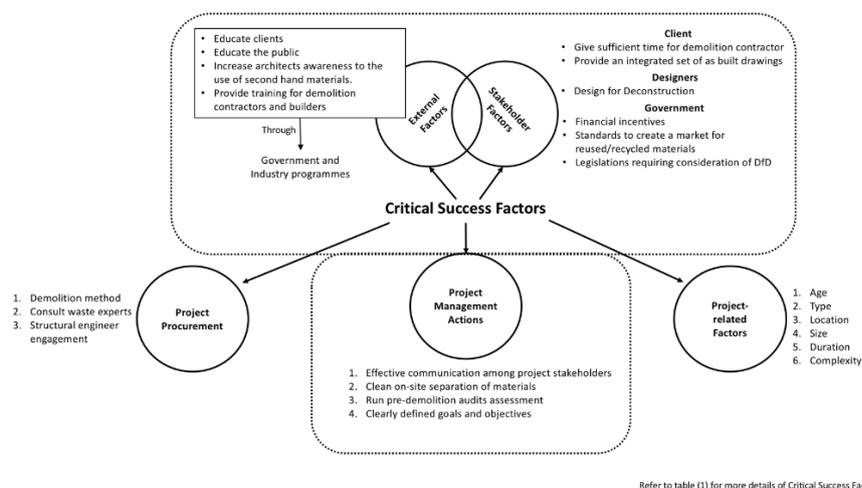


Figure 1: Conceptual Framework

This allows the interrelated logic of the various groups of CSFs to be clearly visualised. Project management actions represents the role of the demolition

contractor during demolition projects. Stakeholder factors represents the role of project stakeholders mainly from the beginning of life of the project. If those factors were considered, it will positively reflect on the performance of the demolition contractor, and therefore substantially increase the success rate of the project. For stakeholders to recognise the importance of considering the end-of-life of projects; relies heavily on External factors such as: Educating clients, architects, and the public on the importance of second hand materials. Thus, stakeholders and external factors categories were interlinked in the framework. Finally, project procurement and project-related factors were all considered in the framework due to their limited number.

CONCLUSION

A new conceptual framework for demolition projects was developed which contain five main categories: Project procurement, project stakeholders, project management actions, project-related factors, and external factors. This was achieved by following an exploratory research approach by reviewing 30 demolition-related studies. As a result, 49 factors were identified and prioritised based on their number of mentions, of which six main factors were highlighted due to their frequent appearance, these are: 1) Effective communication among project stakeholders; 2) Client to give sufficient time for demolition contractor to deconstruct rather than demolish; 3) Designers to consider the end-of-life in their designs; 4) Clean on-site separation of materials; 5) Government to provide financial incentives for demolition contractors for adopting less wasteful demolition methods; 6) Government incentives through standards to create a market for reused/recycled materials.

The framework will increase the awareness of the complex nature of demolition projects and assist demolition contractors to recognise those factors that are essential for project success. Also, the external factors found in this study can act as guidelines which points out the important areas that require attention for further development for the organisation and the industry as a whole. Furthermore, as demolition projects are filled with uncertainties, the critical success factors identified in this study can act as a roadmap for senior leadership and management to stay focused on the essential activities and not be diverted away from what is important. Finally, the presented framework opens opportunities for further research in the area of demolition and sustainability, and the opportunity to link academic research with industry professionals through refining and categorising those CSFs found in this study. This paper forms the first work package in a PhD project, where the second part will look to validate and refine the list of critical success factors found in this study with industry professionals.

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ARE RETROFITTED SOCIAL HOUSES SUFFICIENTLY REFLECTING THE HOLISTIC HEALTH AND WELLBEING REQUIREMENTS OF OLDER PEOPLE?

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Energy efficiency improvements require robust decision-making processes due to their complex and demanding interconnections, and the associated impacts to health and wellbeing. This is of particular importance to the elderly population with regards to the requirement for integration within the social care agenda and the known vulnerabilities to their immediate and surrounding environment. The complexity of delivering this agenda through a social housing focused strategy requires holistic integration across a range of service providers on a multitude of complex factors. A need is emerging to examine the relationships between energy, health and housing sectors to determine and understand the appraisal procedures in social housing and the unintended consequences that can arise. This research presents the findings of a preliminary study through a series of in-depth interviews conducted with key stakeholders under a constructivist grounded theory approach, exploring the extent to which the requirements of an older person's health and wellbeing are holistically being addressed during the retrofit of social housing. By exploring the findings through the lens of Foucault's theory of governmentality it was determined that the ideological barriers within governance prevent a holistic retrofit process and inhibit the potential to create collaborative decision-making across public services.

Keywords: ageing population, energy efficiency, social, strategic collaboration

INTRODUCTION

Due to economic growth and advances in health care, people are living longer than ever, with 25% of the population in Europe expected to be over 65 by 2020 (Boerenfijn *et al.*, 2018). Within the UK's fuel poverty strategies, the elderly, alongside low income families and disabled people, are recognised as the most vulnerable within society (DECC 2015). An ageing population poses great challenges in terms of providing appropriate housing facilities and creating sustainable living environments. Furthermore, the poorest and most marginalised individuals tend to be those living within the most inefficient, lowest quality of housing and have the least power or resources to invoke change (Krieger and Higgins 2002). This paper presents the first phase of research undertaken to evaluate the success of collaborative efforts within government to perform domestic retrofit practices for health and energy efficiency. The ageing population in the UK is presenting great challenges and there

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is a need to examine the processes and expertise available within the housing, health and social care sectors, as well as within the construction industry to better understand the consequences of the current retrofit agenda on the health and wellbeing of the elderly. Presented are the findings of an analysis of nine stakeholder expert interviews through a constructivist grounded theory approach determining the short comings and requirement of a holistic approach within governance for the retrofit agenda.

LITERATURE REVIEW

The Importance of Housing

Housing holds a fundamental relationship with mental health, creating either long-term security or insecurity; impacting social cohesion, trust, a sense of belonging, and therefore, the wellbeing of an individual (Bullen *et al.*, 2008). It has become an area of policy development which often cuts across a number of government ministries and departments, with the provision of decent housing overlapping welfare, health and social support (Imison *et al.*, 2017). Since the 1990s, supporting the elderly to retain independence in their homes has become prevalent in policy; such as the Shifting the Balance of Care agenda which seeks to provide a tailored service repositioning care from hospitals to individuals homes (Imison *et al.*, 2017). However, the lack of suitable and accessible dwellings is acknowledged to be a future challenge. Whilst there are different forms of sheltered housing and care facilities available, they are presented as a final resort instead of their own houses when the individual's health and wellbeing are considered to be at risk (Vasara 2015; Van Leeuwen *et al.*, 2014).

In the UK, social housing is generally divided into two main categories: council housing organised by the local authority and not-for-profit housing association dwellings (Kenneth *et al.*, 2016). Whilst new build construction is able to consider the diversity of future residents, the existing building stock must be flexible to changing health needs whilst also supporting the environment (Boerenfijn *et al.*, 2018). Social housing must meet the needs of the vulnerable on a continuous basis, whilst simultaneously considering environmental requirements to create and maintain sustainable retrofit practice. To achieve sustainability, there must be an understanding that human health and the environment are two inextricably linked components that support one another.

Ageing Population and the Need for Adaptation

As people age, declining mobility and illness related to ageing can mean that their residence is no longer suitable without support or adaptation; forcing individuals to either move into specialist accommodation or have adaptations which often they cannot afford. Ageing in place, or “the ability to live in one's own home for as long as confidently and comfortable possible” is the ability to be self-reliant at home for as long as it is viable (Shelter 2007). Housing adaptations have the ability to empower individuals by allowing independence and creating accident prevention, whilst reducing hospital and care home admissions and delays (Adams and Ellison 2014). Moreover, major adaptations such as the installation of a wet room or the lowering of structures within a home can have a significant impact on the quality of their life and their wellbeing (Wane 2016). However, the Older People's Commission for Wales (2015) found the UK's current housing standards are below acceptable levels, with 23% of the elderly believing that they require social care retrofits in their homes. Moreover, Age UK (2014) estimated that there were 1,004,000 people aged over 65 (10.35%) with unmet social care needs in England. These figures display the extent of

the problem and highlight the need for improved governance in order to secure independence and comfort within the elderly's homes. The elderly are more likely to spend a greater amount of time in their homes than other age groups, estimated at between 70-90%. Consequently, the environmental conditions these individuals are exposed to are a key influencer of health. Older people are more vulnerable to the effects of cold weather; this is partially due to pre-existing medical conditions and financial constraints meaning they are twice as unlikely to be unable to afford fuel in winter (Van Hoof *et al.*, 2017).

Environment and Energy Efficiency

In 1997, the Kyoto Protocol brought energy efficiency to the forefront of political agendas, intended as a means of reducing CO2 emissions. However, since then, energy efficiency has seen other social consequences such as reducing winter deaths, fuel poverty and decreasing the incidences of cold related morbidity. Excess winter deaths are highest amongst older people and related to dwellings with low ambient home temperatures and ineffective energy initiatives (Clinch and Healy 2001). Fuel poverty is connected to poor physical health through a variety of pathways such as inadequate ambient temperatures, a deterioration of dwelling conditions through increased moisture content and having resource scarcity - through food or heating thrust upon them (Camprubi *et al.*, 2016). The UK Government and devolved administrations have attempted to tackle this through the improvement of energy inefficient housing, reducing fuel bills and attempting to tackle low incomes. However, affording adequately warm homes is still problematic for older people, with nearly two thirds of single pensioners spending 18% of their income on fuel, with many still living in poor quality housing (Burholt and Windle 2006).

Joined-Up Government

Joined-up government (JUG) is the development and structural reorganisation of internal policy coordination to improve the efficiency of service delivery (Darlow *et al.*, 2007). By simplifying the number of intermediaries, it allows greater collaboration between the state and society by reducing the complex landscape that confronts the population when accessing public services. JUG seeks horizontally and vertically coordinated thinking and action; removing undermining policies, better utilising resources, creating greater stakeholder collaboration and empowering the population (Pollitt 2003). This increased partnership allows the establishment of a more agile and responsive government based on a holistic methodology of action between partners and users (Darlow *et al.*, 2007). However, due to historic investment there is a reluctance to disinvest or reorganise current structures (Hood 1991). The market-led response of new public management from 1985-2005 exacerbated the government's inability to develop and direct increasingly distant multi-agency arrangements that are target driven rather than cooperative (Pollitt 2003). By utilising a JUG approach, it draws more deeply on the establishment of shared problems and agreed solutions; improving conditions and responding directly to the needs of people. Furthermore, Foucault's (1982, 1991, 2007) concept of governmentality has the potential to provide an understanding around the challenges that this agenda faces by examining the strength of actions and mechanism that underline the decision-making within governance and will be explored through subsequent data analysis.

The Need for Collaborative Retrofit Practice

Whilst environmental health is closely related to, and affected by, socioeconomic status, public health research has given less attention to the complex relationship between housing and health within retrofit practice and the implications of this upon public health policy improvement (Willison 2017). Housing as part of health improvements is often implicit within policy and the evaluation of housing enhancements, however, unlike health service interventions, the main aim of housing improvements are not improvements made to health. The complex relationship between poverty, poor housing and health creates difficulty in creating adequate control due to lack of understanding within social care and primary care of how housing conditions can cause poor health impacts (Thomson and Thomas 2015). With an ageing population, great challenges are presented to the healthcare system across the world regarding increasing acute and long-term requirements. There is a need to maintain and improve the elderly's mental and physical wellbeing, whilst lowering the cost for state and healthcare. Many social care and health experts within industry have confessed the lack of linkages with, and understanding of, planning within housing which has meant many older people's need have not been considered or prioritised (Zhang *et al.*, 2018). Therefore, policy makers and practitioners have an opportunity to address a key social detriment of health through housing, with wide reaching implications for health and social care across Scotland and the UK.

METHODOLOGY

The aim of this study is to explore the extent to which retrofit practice within social housing holistically meets the health and wellbeing requirements of an ageing population under a constructivist grounded theory (C-GT) approach. The results presented from this initial phase will provide a base for the second phase of research which seeks to widen the sample through further interviews. This research takes an exploratory approach to understanding with a view to allowing compilation of recurring observations and data to help shape the later stages of research.

Methodological Approach

Grounded theory is defined as the inductive conceptualisation of data through a systematic, constant comparative method of simultaneous data collection and analysis to establish theory (Charmaz 2014; Glaser and Strauss 1967). In selecting which variation to use, the philosophical and practical approach of both classical and constructivist were considered for this research. Classical grounded theory is often defined as positivist; seeing the researcher as independent from the participants (Glaser and Strauss 1967). Conversely, within constructivist grounded theory, the researcher is central with their participation and seen across data collection, analysis and theory construction creating a relativist and pragmatic approach towards the methodology (Charmaz 2014). Within classical and constructivist, data collection and analysis are systematic and iterative, limiting theory generation until themes and relationships are developed (Charmaz 2014; Glaser and Strauss 1967). Strauss and Corbin (1990) argued for professional literature to be reviewed before data collection begins and throughout analysis and theory generation, however the researcher was to remain objective, whilst Charmaz (2014) saw an abductive process where the research becomes active. When grounded theory is combined with a constructivism paradigm, it embraced the existence of multiple individual realities; ensuring meaning is co-constructed to produce an interpretation adept in explaining these realities. Having considered both approaches and the requirement for philosophical compatibility

between researcher and methodology, constructive grounded theory was selected. Due to constructivist’s abductive reasoning, creating a logical inference to find the most likely explanation from data presented and its allowance to create greater flexibility in the methodology, with a more literary writing style whilst upholding the analytical process of formal research.

In line with the methodology, sampling was purposeful. Participants were aged 26-67 years with at least three years’ experience in the industry. In total 9 industry experts gave written consent to participate; their demographic details are shown in Table 1. The initial participants were selected for their experience and ability to reflect on the interconnections between different retrofit practices amongst service providers. In line with C-GT, theoretical sampling began when early concepts and categories emerged, with adaptation of interview questions and adding additional participants to explore gaps in the developing categories (Charmaz 2014).

Table 1: Interview participants

Code	Gender	Stakeholder	Position
C1	Female	Energy	Area Based Scheme Researcher
C2	Female	Health	Nurse
C3	Male	Government	MSP
C4	Male	Energy	Eco Support Manager
C5	Male	Built Environment	Architect
C6	Female	Built Environment	Housing Association Manager
C7	Male	Government/Energy	MP
C8	Male	Energy	Director at Energy Action Scotland
C9	Male	Government/Health	MSP

Data was collected through one to one in-depth interviews. A neutral approach was taken, ensuring no leading questions were asked. Each interview began with the same opening question, “What do you believe are the biggest issues facing housing with an ageing population?” Initial interviews were open and free-flowing to give participants the freedom to discuss their experiences, with follow-up questions asked when showing statements were made that required further analysis. Later interviews were driven by data analysis and theoretical sampling to expand categories and relationships between them. Interview transcripts were coded word-by-word, then line-by-line, using gerund verbs to stay close to the data (Charmaz 2014). Initial coding involved categorising each line of the written date, initial codes were integrated and refined to develop concepts, categories and sub-categories. Initial coded transcripts underwent focused coding using NVivo software to develop the relationships and build categories into conceptual themes. Moving from initial coding to a more focused coding, allowed generation of the senses and processes that occurred from the narrative. Throughout this process, theoretical memoing was undertaken, enabling theoretical development and deeper understanding of the data.

DATA ANALYSIS

From analysis, three main categories arose, ‘misaligned decision-making’, ‘disjointed collaboration’ and ‘changing perceptions’. Through data analysis, the concept of governmentality emerged as a concept. Due to the abductive nature of C-GT, patterns and ideas were identified and investigated through literature. From this, the potential for governmentality as a lens to analyse the data was uncovered due to the processes and decision-making within governance which impact the structures and viability of progressive change across housing, health and energy.

Misaligned Decision-Making

It is suggested that a potential lack of comprehension of energy efficiency procedures exists amongst social care professionals. Within health, there is an understanding of the relationship between home and happiness and the potential health impacts resultant from adverse environmental conditions. However, this statement from C2 is indicative of a wider problem of deficient knowledge or understanding of energy efficiency improvements, “there are none, I don’t know of any. I don’t know of any at all”. This statement creates two questions: if the industry as a whole lacks awareness of basic energy enhancements or if this particular professional is disconnected from the industry; arising from a lack of resources to afford the services or a general lack of implementation knowledge.

Intellectual connections between the two industries is further constrained by budgetary cuts, as C3 states, “everyone is given a job to do and a budget to do it in, which are declining...therefore people don’t think outside the box...your concern is day to day health. Is it their heating is working? Probably not”. C3 reinforces this issue by commenting that, “one would like to think there is a joined up approach being taken but I can see why it doesn’t, these people feel rushed off their feet because they have more to deal with than they can cope”. This demonstrates the increasing pressure within healthcare, restricting intellectual and proactive connections being made across industry. It prevents optimum improvements being made and impedes widening the field with a greater breadth of knowledge and skills. It displays an understanding that progressive change through collaboration is beneficial, but also a contradictory stance, through a feeling that it is unrealistic and idealistic. This is particularly interesting, as C3 represents the government which in principle is in control and has the power to invoke this change.

Disjointed Collaboration

An unexpected theme which arose through analysis reflected a lack of awareness in government of the realities of the construction industry in relation to retrofitting houses. C7 understood, “I think common sense would prevail...I think the health visitor should know and I am sure would know who to contact, if the first person they contact was not the right person, they would continue to find the right person who could make that house more energy efficient”. Representing not only a misunderstanding but an apparent detachment of the reality of the pressure social care feels from budgetary constraints. Contrastingly C7 reported “there is an understanding that need to be done, I wouldn’t go as far to say it’s all connected up” and C4 observed “I’d imagine a social worker might pick that up and raise it as a concern but I don’t think it is entirely dealt with”. These differing understandings relating to the level of efficacy and successful interconnections between health and energy showcase that there is little understanding of the extent of the problem and the degree of separation currently present within the current model of public services.

Stakeholders displayed an understanding of the gaps within implementation and the requirement for greater levels of collaboration as C9 stated, “if you said to them and asked the question, they would say yes but that is a different thing to doing it in your day to day” with C5 reinforcing that, “health care sees the effects but won’t necessarily understand the mechanisms and the interconnected chain of dependence...it’s too long and potentially fragmented for that connection to happen”. These statements display an understanding that there are fundamental barriers to succumb which require transformation at a macro level in order to increase awareness

and understanding of the relationship between health and energy within industry to create hands-on, enshrined knowledge between health and housing.

Changing Perceptions

Although earlier discussion queried the lack of understanding within social care workers, it is proffered that they would go out their way to make positive change, “sometimes we are the voice, no we are the voice for the residents...it is us that needs to do something...doing this interview gets you thinking gosh these things could be getting done and who do you go to? I don’t know but I am going to find out...they need to be looked at together so it’s not one leaving it to another for somebody else to sort out”. The social care profession and those who work within it are focused around improving the health of others. This statement demonstrates a clear desire and a personal responsibility to do more, seeing it as their duty to make great positive changes within other’s lives and within the industry. However, this view is one individual and will require further investigation to explore if it is representative of the wider social care sector.

These improvements to public services have the potential for much wider implications for the state. Throughout, the implications for holistic collaboration on primary health care was discussed, such as C4 acknowledging, “the danger would be discharging someone into a cold house and coming back in, then you get more bed blocking, whereas that could have been avoided with energy efficiency”, C5 commenting “discharged from hospital and returning too soon because the conditions they are returning to are actually aggravating the very thing they were first admitted to hospital to be treated for” and C8 reinforcing this statement, “this could be a public health issue...you put someone into a warm, dry home then think of it as preventative medicine”. These statements were derived from three different experts within energy and the built environment. This illustrates a vital understanding of potential impacts for the NHS and displays a greater degree of knowledge of the benefits, emphasising the requirement to strengthen collaboration across the key stakeholders within health and energy retrofit practice.

Discussion

Government occupies a unique position within health and wellbeing. Through policies and regulations they shape the economy, environment and society for both the current and future generations. Therefore, there is a need to ensure that these policies are progressive to protect the health and wellbeing of the population. Through data analysis, the diffused structures of government coupled with the government’s neoliberal ideological approach, displayed a strong disconnect of collaboration and knowledge share between health, housing and energy services. With regards to Foucault’s view of governance through the concept of governmentality, there is a requirement for the power of knowledge to be passed down to an individual level to successfully enforce change and create independence from state. Governmentality was not restricted to state, but applicable to all institutions governing social life. It is prepared to concede certain levels of autonomy to individuals, groups and populations to reduce costs and maximise personal freedoms and responsibility (McKinlay and Pezet 2017). Until the 17th century, state exercised power in the form of a right over both life and death of the population, but did not consider maintenance of life as an aspect of its duties (Foucault 2007). Later Foucault affirmed a new sort of power; the need to care for the maintenance of life and therefore, the wellbeing of population. Population became the most valuable national resource and thus the centre of attention

(Guizzo and de Lima 2015). Whilst health care has not been privatised in the UK, new organisational forms have emerged with weaker command and control power. Loosening control is apparent through various areas of health care and housing, mixing accountability with professional self-regulation; operating internally at a micro level, but with decision-making and economic prioritisation operating largely at a macro level (Ferlie *et al.*, 2012). Furthermore, Governmentality refers to a particular power/knowledge nexus which is associated with neoliberalism. Within this research it became clear that the current neoliberal socio-economic model prioritises a calculative rationality and establishes instruments to secure increased economic growth, and that this has inhibited the relationship between retrofit practices in public service (Schweber 2017). The establishment of new public management, coupled with fiscal restraints in public services and a target-driven culture that is reluctant to take on institutional responsibility. This results in a lack of collaboration on all levels which inhibits the capacity to take on the joined up approach which JUG strives for and potentially creating greater societal dependency through increased reliance on key resources such as the NHS.

As Foucault discussed, if the understanding of energy efficiency was seen by industry and population alike as 'preventative medicine, the "power of public opinion" would create a normalised practice, which is monitored, protected and promoted by public judgement. Nonetheless health is not, and should not, be seen as the sole responsibility of the health ministries. Government must balance the requirements of the population today, whilst responding to the evolving challenges of maintaining and caring for an ageing population in the future. Government can enforce significant change, enabling a shift from management of the delivery of single sector services, to a much broader, more inclusive agenda. However, this requires strong leadership centrally and locally. Governments across the world are going through severe financial constraint but it is of optimal value for the state to ensure health and wellbeing is considered consistently and coherently in every domain of government (Hunt 2012). There is an initial requirement for greater investment, however there is potential for long-term savings from reducing pressure on key assets and balancing consignment across different bodies through an approach of joined up governance. Therefore, in line with Foucault (1982), converting strategy into an open-ended communication is necessary if the concept is to travel across different types of institutions, but it requires analytical clarity, organisational coherence and clear practical routines. Thus, there must be understanding and acceptance that health, housing and energy all have the potential to improve and promote good health, stimulate change and promote resilience through the retrofit industry.

CONCLUSIONS

There is a requirement for greater collaboration and communication within national retrofit agendas to protect the wellbeing of the elderly and prevent unintended consequences arising. Significant change must occur within government structure; increasing flexibility and alliances to create a means of viable interaction and collaboration to create solutions and improve implementation throughout the system. Whilst housing, energy and health may share features of neoliberal techniques such as the reliance upon outcomes to determine success, the inability to easily quantify collaborative practice renders a move towards a joined up approaches to retrofit practice futile within the current governance paradigm inhibiting the prospect of increased investment. However, with people continuing to live longer and with the maintenance of the existing housing stock remaining the dominant response to meet

pressure on resources, a change in mind-set is required which recognises the value of investing in collaborative approaches.

Key areas of future research include the exploration of the structural barriers within governance that prevent holistic collaboration from occurring; investigating the cultural, knowledgeable and economic restrictions currently in place. By studying the level of knowledge and comfort within healthcare regarding energy efficiency methods, it allows for increased understanding of the current comprehension of sustainability literacy amongst stakeholders and service providers. This would create a basis to determine the level of progress and solutions required; such as CPD, a restructuring of current higher education course content or determine if the best course of action is the creation of new jobs or fields. Furthermore, there is a need to examine the current infrastructure between housing and health sectors that allow for a collaborative retrofit approach, through investigation of practice in place and the viability of the development of a framework to permit a holistic approach between various stakeholders.

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A COMPARATIVE ANALYSIS OF KEY ELEMENTS OF THE STRATEGIC DECISION-MAKING PROCESS ACROSS CONSTRUCTION PROFESSIONAL SERVICES FIRMS: EVIDENCE FROM THE IRISH CONSTRUCTION INDUSTRY

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The Irish construction industry is experiencing a well-established growth phase following a prolonged recession. While the economic impact has been well documented, there remains less emphasis on discipline-specific studies pertaining to strategy within construction firms in Ireland. Additionally, evidence regarding strategic management within the construction sector is predominantly concentrated on contracting organisations, with less emphasis on highly knowledge intensive professional service firms (PSFs). As the construction sector in Ireland continues its sustained growth, there have been increased calls within the industry for further collaboration between key stakeholders. However, exploring collaboration within project-centric firms without understanding the individual strategic decision-making processes within them may be problematic. In the construction industry in particular, collaboration needs to be integrated into the overall strategy of individual stakeholders to be effective. Therefore, this study reports a unique insight pertaining to the strategic choices and characteristics of the decision-making process within consultant engineering (CE) and Quantity Surveying (QS) practices in Ireland as part of an ongoing study. The paper reports on findings from the first phase of a two-stage data collection, namely a widespread surveying of QS and Consultant Engineering practices in Ireland. The study provides two specific contributions. First, it adds to the body of knowledge by identifying key considerations in the strategic decision-making process within the context of highly knowledge intensive firms in a turbulent construction sector environment. Secondly, it addresses the recommendations of earlier studies about the need for cross-profession comparative analysis within PSFs, by comparing the process across two key disciplines within a significantly changed industry. The findings of the study contributes current insights into the state of competitive strategy and decision-making in the highly turbulent construction environment in Ireland.

Keywords: strategy, professional service firms, consultant, engineering

INTRODUCTION

The Irish construction industry has undergone substantial change over the last decade after experiencing a deep, lengthy period of recession. As the economy continues its

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path to recovery, there is increasing concentration on investigating the competitiveness and the survival of firms operating in the sector through future economic cycles. Murphy (2012) explored strategic process characteristics related to quantity surveying (QS) practices in Ireland, recommending cross-professional analysis of the strategy process in professional service firms (PSFs). There has been no follow-up study exploring these firms, despite the fact that the industry has changed significantly and has returned to growth (CSO, 2018). The reason for the under-investigation of the strategy processes in Irish PSFs may be due to the following reasons:

The already established complexity involved in the study of strategic management as a field of enquiry within construction (Cheah and Chew, 2005)

The turbulent nature of the construction industry, making it difficult to analyse (Flanagan *et al.*, 2007)

The focus of strategy research on manufacturing and non-construction sectors (Murphy, 2012)

Unique characteristic of professional service firms, i.e. intangibility of output, client involvement, highly professionalised workforce (Løwendahl, 2005)

Recent calls within the construction sector in the Farmer Review (2016) and the McKinsey report (MGI, 2017) have stressed the need for construction industry professionals to rethink their strategy. In the same vein, the Rodrigues de Almeida and Solas (2016) in a World Economic Forum (WEF) report on Shaping the Future of Construction emphasised the need for new perspectives in thinking for the construction sector, but there is yet lacking a multidisciplinary approach employed to the topic of strategy in PSFs. More importantly, there has been no cross-professional study exploring the strategy processes within consultant engineering (CE) firms and QS firms within Ireland, despite the fact that these two professions are key, interrelated professions within the sector.

Within Ireland, only two known empirical studies in strategy have been conducted among construction professionals i.e. Architectural firms (Flemming, 2011) and QS firms (Murphy, 2012), with CE firms being largely ignored in empirical research, despite being a critical component of the AES sector in the Irish construction industry. As a response to the improving prospects in the industry, it becomes essential to align with recent research directions within strategy research by exploring the decision-making process within PSFs in Ireland. This follows from the recommendations of Murphy (2012) on the need for cross-professional studies in PSFs, therefore warranting this investigation. We address this recommendation by investigating the selected characteristics of the process within these firms and comparing them across professions. The most recent inquiry into strategy in Irish CPSFs was conducted by Murphy (2012), with the only other study carried out by Tansey (2014) focused on contracting firms only, which are significantly different from CPSFs.

In the following section, a review of key literature on characteristics of the strategic decision-making process in CPSFs is presented. Afterwards, the methodology adopted for the study, particularly the research design, sample size and data collection process is outlined, followed by the data analysis. A comparative analysis is then undertaken. In conclusion, brief discussion of the implications of the study is presented, with possible future research directions proposed.

LITERATURE REVIEW

Mintzberg (1978; 935) outlined that ‘strategy in general and realised strategy, in particular, will be defined as a pattern in a stream of decisions’ and further asserted that ‘the field of strategic management cannot afford to rely on a single definition of strategy’ (Mintzberg, 1987a; 11). There is still no one agreed definition of strategy, with several researchers providing differing viewpoints and definitions in line with the evolving nature of competitiveness. Porter (1996) also posits that ‘competitive strategy is about being different. It means deliberately choosing a different set of activities to deliver a unique mix of value’ (p. 64). This unique mix of value is what is often considered as competitive advantage and there is considerable evidence to suggest that engaging in the strategic management leads to superior firm performance (Pamulu, 2010), hence making it crucial to investigating the processes involved within the context of construction PSFs. Although several process characteristics have been espoused in strategy literature, this paper will concern itself with four central themes, ergo; strategic types (Miles and Snow, 1978), business strategy (Porter, 1980, 1985), risk attitude (Ingram and Thompson, 2012) and planning horizon (Alogan and Yet[*idot*], 2006). Although Murphy (2013) explored these four themes within the Irish context, the industry has changed significantly since then and the study was carried out on a single profession (QS firms). Therefore, an opportunity exists to re-examine the strategy processes and conduct a comparative analysis between two key professions within Ireland.

Strategic types

Miles and Snow (1978) posit that a firm's approach to strategy will have an impact on the formality of the process and they named these approaches strategic types. They argue that although each firm may adopt different strategies based on their unique characteristics, their behavioural patterns will centre around four organisational types namely: prospector, analyser, defender and reactor. Oyewobi (2014) outlined that these typologies enhance understanding of how organisations perform in their interactions with their environment. Leitner and Guldenberg (2010) also found in their study of Austrian SMEs that most of the firms investigated fell under the analyser's type, i.e. firms which combine both prospector and defender types into a single system, via defending existing market share while seeking new market opportunities by offering new products. While a considerable number of construction professional service firms (CPSFs) will fall under the SME category, it would be important for the study to understand what strategy type they adapt within the Irish context and the implication on their decision-making process particularly within a multidisciplinary context, i.e. QS firms and CE firms. These typologies have previously been applied within the Irish context (e.g. Murphy, 2013), but not within a cross-professional context and more so, not within the last five years. Anikeeff and Sriram (2008) established that while the Miles and Snow (1978) strategic types deal mainly with a firm's product-market domain, it is also important to explore the business level strategies, which are concerned primarily with competition and maintaining distinct advantage. The two are inextricably linked and the latter will be explored further in the next section.

Business Level Strategy

Business-level strategy is primarily built on the seminal work of Porter (1980, 1985), who espoused three generic strategies; cost leadership, differentiation and focus. The core of business strategies is related to a business's overall competitive direction; the

way it positions itself in the marketplace to gain competitive advantage and the different positioning strategies that it can use in different industry settings (Tansey *et al.*, 2014). The Porter (1980,1985) model is widely accepted as a means of outlining the strategic options/choice pursued by firms, as evidenced by the number of studies in construction which utilise same in the Irish context (Murphy, 2013; Flemming, 2011; Tansey *et al.*, 2014). The focus strategy is sometimes extended to become cost-focus and differentiation-focus (Tansey *et al.*, 2014). These business strategies is explored in CPSFs, in tandem with the risk attitude, which is a major consideration when making strategic choices (Connaughton *et al.*, 2015)

Risk Attitude

The risk attitude of a firm is primarily concerned with how the firm takes decisions within the business environment. Although Baird and Thomas (1990) note that there is a lack of an accepted model of measuring risk-attitude among decision-makers, one can explore the interplay between organisational processes and the business environment to understand attitudes to risk. Ingram and Thompson (2012) proposed four categories for assessing risk attitudes. These categories include: Pragmatists, who view the world as being uncertain and unpredictable; Conservators, who believe the world is at high risk and adopt a conservative approach; Maximizers, who embrace risks and explore potentials by viewing the world as fundamentally self-correcting; and Managers, who believe the world is moderately risky, but not too risky for firms that have proper guidance. Therefore, these four risk attitudes are adopted in assessing Irish CPSFs attitudes to risk, particularly within the context of the turbulent business environment in construction in Ireland. Since the business environment is continually changing, it is also vital to examine the timeframe within which strategic decisions are made.

Planning Horizon

Harrison (1995) argued that planning horizons represent time spans over which strategy will be accomplished, resulting in the attainment of the strategic objectives. The time horizon for strategic planning differs from annually to as much as five years (Alogan and Yet[.], 2006). Murphy (2013) established that within the context of a changing business environment, the content of the strategic plan cannot stay the same, making the time horizon of the strategic decision-making important for consideration. With no recent planning horizon within the literature for Irish CPSFs, an investigation into the duration of planning within the significantly changed business environment is warranted.

METHODOLOGY

The research purpose for this study is exploratory, i.e. investigates what is happening within the firm and seeks new insights without investigating reasons (Robson, 2002). The approach employed is inductive, as it employs a 'bottom-up' approach and seeks to gain a close understanding of the strategic decision-making process (Easterby-Smith and Lowe, 2002). Also, the research philosophy employed is pragmatic while the research strategy is a quantitative survey (Saunders, 2012). The sampling technique adopted is purposive sampling (Bryman, 2012) and the participants were selected based on personal judgment of the researchers. The Association of Consulting Engineers Ireland (ACEI) and the Society of Chartered Surveyors Ireland (SCSI) supported this study, facilitating dissemination of the survey to member practices. The sample size involved senior members of each practice, who were

selected to ensure that only those who are considered are particularly informative and knowledgeable about the topic being investigated (Neuman, 2006). The survey was administered an online survey tool and data exported to Microsoft Excel for analysis. While online surveys are reputed to garner low responses from respondents, care is taken to ensure that the average response rate was above 21%, which is the average suggested by Dillman (2002).

DATA ANALYSIS

The data was gathered over a period of three months (January-March, 2018), with the QS sample size being 236 companies and that of CE firms being 99 firms. The QS sample returned a response rate of 27.96% (66 responses) while the CE firms recorded a response rate of 43.43% (43 responses) with only 42 usable responses. Table 1 presents the profile of respondents to the online survey.

Table 1: Demographic data of respondents' organisations

	QS Firms		CE Firms	
	Frequency	% responses	Frequency	% responses
Respondent type				
Managing Director/ CEO	49	74.24	34	79.07
Director	13	19.70	9	20.93
Associate director	3	4.55	0	0.00
Senior Mgr (QS/Eng.)	1	1.51	0	0.00
Years of operation				
1-5 years	7	10.60	2	4.65
6-10 years	17	25.76	6	13.95
11-20 years	11	16.67	4	9.30
more than 20 years	31	46.97	31	72.10

Strategic Types

Table 2 below outlines the strategic types of both professions, highlighting nearly similar characteristics. While QS firms are mostly reactors (ranked 1st), CE firms are predominantly a mix of both reactors and defenders (both typologies have a similar percentage response rate of 40.48% of respondents respectively). Miles and Snow (1978) however warns of the dangers of the reactor typology, outlining that these firms are unable to efficiently respond to environmental change and uncertainty.

Table 2: Miles and Snow Strategic Types

Strategic types	QS Firms		CE Firms	
	% Response	Rank	% Response	Rank
Prospector	16.92	3rd	7.14	3rd
Defender	15.39	4th	40.48	1st
Analysers	29.23	2nd	11.90	2nd
Reactor	38.46	1st	40.48	1st

Firms within the reactor typology are exposed to the dangers posed by environmental pressure and Brunk (2003) states that reactors are often late to change and often their lateness to change results in subpar performance in the industry. García-Pérez *et al.*, (2014) outlined that strategic reactor types would likely record worse strategic outcomes than analysers, defenders and prospectors. CE firms, on the other hand, are primarily reactors and defenders. Defenders seek ways of defending current market share in some sectors while exploring promising opportunities in others after a careful review of the market (Murphy, 2011). This is understandable for CE firms, given the

deep, lengthy period of recession experienced within the construction sector and these firms seek to maintain their current market share while carefully observing the market for more opportunities. Prospector firms also rank third within the CE profession, similar to the QS firms who have only a small number of their population as prospectors. Overall, QS firms appear to be more reactive and adopt a wait and see approach while CE firms are predominantly reactors and defenders. The next section will now build on the strategic types, exploring what strategic choices both professions take in the decision-making process.

Business Level Strategies

The highest business strategy pursued by QS firms in Ireland is differentiation. The three pure strategies being pursued are low-cost, differentiation and focus strategies. The differentiation strategy ranks highest, with 55.38% of QS respondents seeking to differentiate their service offerings from competitors (see table 3). This is surprising since professional service firms have been reported to pursue differentiation strategies ahead of others (Amonini *et al.*, 2010). The second highest ranked strategy is the combination strategy, which is further illustrated in table 3. In the combination strategy, five (5) firms select the cost-focus strategy, while four (4) firms choose the differentiation-focus strategy, with the third being cost-differentiation with three (3) respondents only.

Table 3: Business level strategies of QS and CE firms

Answer Choices	QS Firms (%)	Rank	CE Firms (%)	Rank
Low-Cost	13.85	2nd	0.00	-
Differentiation	55.38	1st	19.06	2nd
Focus	12.31	3rd	7.14	3rd
Cost-Differentiation	7.70	4th	0.00	-
Cost-Focus	4.60	5th	0.00	-
Differentiation Focus	6.16	6th	71.42	1st
Stuck-in-the-middle	0.00	-	2.38	4th

CE firms are very different from QS firms in their business strategy, mainly since none of them engages in pure low-cost business strategies (see table 3). The implications are that CE firms may choose not a bid for projects with low fee potential, reducing the possibility for price wars. A large percentage of CE firms pursue combination strategies and only 26.19% of them follow pure strategies with 19.05% pursuing differentiation strategies and 7.14% aligning with the focus strategy. The unique nature of CE firms is further reinforced in the fact that one of the respondents select that they pursue a combination of all three pure strategies plus a combination, which is interpreted as being stuck-in-the-middle as espoused by Porter (1980). This is because the firm said they pursue more than one generic strategy in the same area, making their strategy seem confusing and hard to decipher. This stuck-in-the-middle firm is an outlier within the sample and their choice of this strategy will make it difficult to define what distinguishes them from other firms.

The reason why CE firms are averse to the low-cost route of business strategy is inconclusive from the quantitative data alone, but from the comments section by respondents, they are more agreeable with offering superior differentiating services while focusing on a niche area of service offerings. One possible explanation may be, however, that since the firms surveyed are consulting firms and not ordinary CE firms,

the low-cost business strategy may be undesirable due to the high level of expertise held by these firms.

Risk Attitudes

Based on the risk attitudes proposed by Ingram and Thompson (2012), managers are the most common category exuded by QS firms (47.69%). These firms believe the world is moderately risky, but not too risky for firms that explore incrementally. These firms manage risk via taking necessary steps to mitigate it but that does not stop them from exploring opportunities. CE firms are different from QS firms in that there are more risk-takers among the population with 35.71% of CE firms ranking highest among respondents. This highlights that CE firms are more willing to take risks above QS firms.

Table 4 Attitudes to Risks

Answer Choices	QS Firms (%)	Rank	CE Firms (%)	Rank
Maximisers	26.16	2	35.71	1
Conservators	18.46	3	28.57	3
Managers	47.69	1	33.34	2
Pragmatists	7.69	4	2.38	4

A notable pattern between both professions is the inverse nature of their risk attitudes. Harland *et al.*, (2003) outline that risk attitude changes with experience, i.e. an individual or firm used to taking risks may change their attitude after experiencing shocks or substantial losses. With the construction industry in Ireland having experienced a deep, lengthy recession between 2008 and 2012, Murphy (2013) had reported that most of the QS firms investigated were predominantly risk-averse. However, the current study has shown a change in risk attitude of firms in the industry, suggesting a shift in the risk attitude of firms in the industry i.e. CPSFs have become less risk-averse. The third-ranked risk attitude category are the conservators (18.46% QS; 28.57% CE). The Farmer report (2016) emphasised the risk-averse nature of the construction industry and this continued caution on the part of Irish firms may be due to the aftershocks of the recession. Although, Seaden *et al.*, (2003) explained that smaller firms in construction tend to be more risk-averse, as they do not have the capacity or safety net to absorb shocks posed by risks, but this study does not explore peculiarities based on firm size. The last and final category of firms are pragmatists, who adopt a cautious wait and see approach, taking up only a small percentage of both professions. This turnout is not unexpected given the consistent growth recorded in the Irish construction sector over the last three years. In the next section, the timeframe for strategic decision-making will be considered, as strategic decisions are made and renewed on an ongoing basis within changing business environments.

Planning Horizon

From Table 5, it is evident that both QS and CE firms predominantly plan annually, with the ad-hoc planning horizon ranking second across both professions. Brock and Barry (2003) outline that plans that are longer than a year may be beneficial, but they cost more over the long term and difficult to justify. Thus, it is not strange that just a limited number of firms have a planning horizon of beyond a year. The high number of firms that review their strategy as often as required is commendable, because as Blumentritt (2006) outlined, managers may be forced into either conforming to an

obsolete strategic plan or acting as mavericks when change in the business becomes evident. Neither of these are attractive options, thus making the notion of long-term plans beyond a year undesirable for both professions. Therefore, it can be deduced that most CPSFs plan annually or on-demand, based on the nature of the industry and its susceptibility to change and economic cycle induced fluctuations.

Table 5: Planning Horizon

Planning horizon	QS firms		CE Firms	
	Response%	Rank	Response %	Rank
Annual cycle	46.88	1st	40.48	1st
Biennial	6.25	3rd	9.52	3rd
Triennial	3.13	4th	9.52	3rd
Quinquennial	1.56	5th	9.52	3rd
Ad Hoc/as often as needed	42.18	2nd	30.96	2nd

CONCLUSIONS

This study set out to explore four key elements of the strategic decision-making process in two professions within construction (QS and CE firms) in Ireland. The findings can be summarised thus: First, QS firms are primarily reactors, employing a responsive posture to decision-making rather than being proactive. CE firms on the other hand have an equal distribution of reactors and defenders, exploring opportunities while defending their market share at the same. Secondly, QS firms are predominantly differentiators in terms of business-level strategy, distinguishing themselves via offering unique services to clients. CE firms on the other hand do not adopt a low-cost strategy at all. Instead, they adopt differentiation-focus strategy as a proxy, delivering value on a dual front while charging a fair price.

Thirdly, the risk attitude of QS firms (managers) shields them from shocks and environmental uncertainties, but may also have its disadvantages, as lesser risk does not equate better competitiveness. CE firms are typically risk-takers, embracing risks with potential for high returns. The consequence of this is that CE firms will be more entrepreneurial and looking for new opportunities and exploring new markets above QS firms, who would rather wait and receive proper guidance before taking risks. Lastly, QS and CE firms are similar in their planning horizons, with both professions adopting the annual planning cycle for the most part and with the ad-hoc/on-demand planning cycles ranking second. Hamel and Prahalad (1994) outlined that planning horizons spanning long time spans are impracticable, thus making it understandable that both professions choose to plan annually or as often as required.

In conclusion, this study found that the decision-making process differs across QS and CE professions in construction. Since these firms are being encouraged to collaborate, we have pointed out key differences in decision-making on a strategic level that may affect these firms working together on a project-level. The scene has been set for further analysis to understand why these professions make different strategic choices and how this may be understood within the broader context of the complex, changing construction sector.

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KEEPING UP WITH THE DIGITAL AGE

DIGITAL INNOVATION IN EUROPE: REGIONAL DIFFERENCES ACROSS ONE INTERNATIONAL FIRM

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Comparing the implementation of Building Information Modelling (BIM) across geographies has emerged recently as an important discussion area, but it has been rarely researched. Research of BIM maturity across countries is vital for observing similarities and differences in adopting innovations and establishing strategies to transfer lessons across national boundaries. This is addressed by comparing BIM implementation in 146 projects of seven European countries: Denmark, Germany, Ireland, Italy, the Netherlands, Poland and Spain (respectively 2, 21, 70, 11, 13, 15, 14 projects). These projects were from one international firm that works on different aspects of the built environment. A BIM maturity assessment, the BIM Maturity Measure (BIM-MM) was applied on these projects. Findings show that in overall, BIM maturity is the highest in Spain, followed by the Netherlands. However, when looking individually at the measured criteria, it has been observed that regions tend to do better than others in certain areas. Denmark and the Netherlands, for instance, have the highest percentage of projects with high maturity levels in 'Open Standard Deliverables'. Therefore, the various digital artefacts that fall under the umbrella of BIM, are adopted at varying levels across countries. It is hoped that this study will deepen the understanding of BIM maturity across regions and influence new research and policies that build a collective approach to explore digital innovation in Europe.

Keywords: Arup, BIM, Maturity Measure, Europe, regional studies

INTRODUCTION

There has been a considerable interest in studying how different regions adopt and implement digital innovations, such as tools, technologies and processes (Smith, 2014, Cheng and Lu, 2015). In the Building Information Modelling (BIM) literature, the field of regional performance measurement has focused on several themes. These include an analysis of noteworthy BIM publications in multiple countries (Kassem *et al.*, 2015), comparison of the BIM adoption status across continents (Jung and Lee, 2015) and countries (Gerges *et al.*, 2017) and exploration of the critical initiatives to implement BIM across regions (Wong *et al.*, 2010). However, little research has been based on quantitative methods to map how different regions are implementing BIM and digital innovations in projects, moving beyond studies on BIM adoption. Comparative approaches are of vital importance to create a comprehensive account of

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how BIM is applied on a country level and how countries could transfer knowledge and learn from the successes and challenges of each other.

Policy work to drive BIM innovation have been developed across countries. In 2011, the UK's Government required a fully collaborative 3D BIM as a minimum for all Government projects by 2016 (GCCG, 2011) A BIM Task Group was established to raise awareness of BIM in the Architecture, Engineering and Construction (AEC) industry. In Europe, a similar approach has been followed where a BIM Task Group was formed to encourage the common use of BIM, as 'digital construction', in public works with the common aim of improving value for public money, quality of the public estate and for the sustainable competitiveness of industry (EUBIM, 2016). Despite this wide strategic approach in Europe, countries also create own BIM mandates. For instance, the German government will request a mandate for public infrastructure projects by 2020. Spain has a BIM Commission sponsored by the Ministry of Public Works to implement BIM in buildings in 2018 and in infrastructures in 2019 (McAuley *et al.*, 2016). Denmark will have a mandate for all projects in 2022.

Targets, mandates and strategies on national and regional levels have led to an increased interest in BIM Assessment Methods (BIM-AMs). Over the last decade, researchers and professionals have developed seventeen BIM-AMs globally to assess BIM in projects, organisations, individuals and teams (Azzouz *et al.*, 2016). However, the introduction of these methods has failed, in most studies, to compare country-to-country evaluations. BIM is not only software; however, due to their development years ago, some BIM-AMs fail to capture fully all functionalities and artefacts of BIM-based process and technologies. This paper, addresses these knowledge gaps by applying the BIM Maturity Measure (BIM-MM) to 146 projects in seven European countries. It aims to deepen the understanding of digital capabilities across countries through the lens of one international company. In particular, this comparison will focus on the 'hard' aspects of BIM, such as the use of Common Data Environment (CDE) and the Virtual Design Reviews (VDRs) rather than soft skills, e.g. leadership and collaboration, because they are easily captured through quantitative analysis.

Digital Innovations Diffusion and Implementation

3. BIM as a digital innovation

Innovation entails a new product, service or process (Abernathy and Clark, 1985) and is usually observed in projects (Shenhar and Dvir, 2007) BIM has evolved through decades of push and pull strategies and efforts to standardise the representation of building information (Papadonikolaki, 2017). Thus, it is not entirely novel as it has evolved from efforts for structuring and representing information about buildings, a predominant line of thought in the 1970s (Eastman, 1999). These advancements in building product modelling shaped a long-standing debate on the computerisation and construction digitalisation (Eastman, 1999). Nevertheless, BIM could still be seen as an innovation because the associated processes and methods to implement it are novel and challenging and require change at both organisational and institutional levels.

BIM is at the forefront of construction digitalisation. Apart from digital representation of buildings, BIM relates to artefacts that affect the processes that technologies are adopted and implemented through. BIM is a multifunctional set of instrumentalities for specific purposes (Miettinen and Paavola, 2014: 86) and affects various actors across the AEC, while policies, processes and technologies interact to

generate a digital building (Succar *et al.*, 2012) BIM is a set of existing and new digital technologies for generating, controlling and managing building information. Various digital artefacts such as CDE, BIM-specific contracts, BIM Execution Plans (BEP) and so forth could form criteria to evaluate the extent to which digital innovation is used.

4. *Diffusion of digital innovation*

BIM diffusion studies facilitate better understanding of how BIM innovation unfolds across contexts and whether it is evolutionary or revolutionary (Burns and Stalker, 1961). In Europe, to control the various nuances and artefacts of BIM and prescribe BIM implementation to reap its acclaimed benefits, various initiatives from the government and professional industry associations suggest quasi-contractual means of BIM-related agreements among actors. For example, pre-contract BIM Execution Plan' (CPIc, 2013) under the efforts of the UK BIM Level 2 mandate and 'BIM Protocol' Norm issued by the Dutch Government Building Agency (GBA) (Rijksgebouwendienst, 2012). Both are inspired from the Norwegian 'BIM Manual' (Statsbygg, 2011). Also in the UK, many mandates in the form of Publicly Available Specification (PAS) have been issued to prescribe BIM use in project delivery, such as the family of PAS 1192.

At the same time, a European BIM Task Group is working on developing policy and advising countries on BIM adoption (EUBIM, 2016). The work of the EU Task Group has been published in a handbook with a conclusion on the need to harmonise a European wide common strategic approach of BIM and a recommendation that encourages government policy and public procurement as 'powerful tools' for this (EUBIM, 2016: 16). As noted in the report, without this top-down leadership, the sector's low and uneven adoption of information technology is likely to continue which would limit its opportunity to improve significantly productivity and value for money.

Scholars have acknowledged the need for evaluating digital innovations across geographies to improve BIM capabilities. According to Kam (2015: 278) international comparisons shed light on the sophistication of BIM implementation and challenges encountered by those regulating or purchasing BIM-enabled services. A comparison of several countries also helps to define the capability development, research and development, procurement and project delivery of those providing services.

Kam (2015) carried out research on country level BIM use by applying the Virtual Design and Construction (VDC) scorecard to 130 projects in over thirteen countries. The VDC Scorecard is a BIM-AM developed by researchers at Stanford University (Kam *et al.*, 2013). The VDC Scorecard has four categories of comparison: planning, adoption, technology and performance. The study, however, did not explain in detail how different countries implement BIM but only provided a snapshot of top ranking countries per category. For instance, Singapore is leading in 'planning' and Finland and Norway have general attainment of best practice status in deploying 'technology'.

Another study that focused on technology diffusion and adoption across geographies is by Jung and Lee (2015). They studied the status of BIM adoption across the six continents (Jung and Lee, 2015). Findings were built upon an online survey with total of 150 valid responses from countries, for instance in Europe, responses were received from 17 countries. The survey is built on four main set of indexes. One of them was concentrated on hard aspects of BIM; the '*use frequencies of BIM services*' in each

continent that included seven criteria: 3D coordination, cost estimation, existing conditions modelling, design authoring, structural analysis, maintenance scheduling and building system analysis. The study attempted to establish a global survey of BIM status, but one of its main limitation is the small number of collected responses.

5. *Implementation of digital innovation*

Greenhalgh *et al.*, (2004) distinguish four categories of innovation in service firms: diffusion, dissemination, also referred to as adoption, implementation and sustainability, until the innovation becomes mainstream. Drawing upon this, research on digital innovation from BIM unfolds in three wide categories:

1. Adoption of isolated firms, based on individual perceptions of employees;
2. Implementation in projects, from case study analyses of projects and
3. Diffusion at a macro-level, by targeting specific professions or countries.

Scholars on the geography of BIM tend to focus on how nations or regions adopt BIM, yet they rarely investigate the 'project' as a unit of analysis, which this paper will address. Naturally, in innovation adoption studies 'soft' aspects, such as leadership and communication activate socio-technical processes to align actors and information (Liu *et al.*, 2016, Papadonikolaki, 2016). In projects with various BIM-using firms, implementation varies, as firms display various BIM capabilities, due to heterogeneity in service and size (Succar *et al.*, 2012, Succar and Kassem, 2015). Even within the same country, BIM implementation also might vary due to the different levels of adoption of the various associated digital innovations and artefacts, such as BEP, CDE and virtual design reviews (VDR). At a project-level though, these 'hard' aspects, such as the implementation of specific processes, use of sophisticated tools and methods could be considered measurable criteria and easy to capture. Therefore, there is room still for understanding how various countries implement digital innovation after adopting BIM. This paper addressed the question: how do countries implement the various digital artefacts and functionalities of BIM innovation?

RESEARCH METHOD

A comparative case study research has been selected to demonstrate how BIM is implemented in different countries in Europe. For this, the BIM Maturity Measure (BIM-MM) (Schofield, 2015) was applied to 146 projects in seven countries: Denmark, Germany, Ireland, Italy, the Netherlands, Poland and Spain (respectively 2, 21, 70, 11, 13, 15, 14 projects) BIM comparison in regions was conducted for two reasons. First, most studies on BIM maturity models tend to introduce new models or apply them to a small number of case studies. However, they rarely explore how artefacts of digital innovation, e.g. tools, processes and technologies are adopted and applied. Second, this paper attempts to not only compare the overall BIM maturity but also operationalise it through the use of multiple BIM criteria with an emphasis on the hard aspects of BIM. Such comparisons are crucial for professionals, scholars and policy-makers to better understand similarities and differences of BIM implementation and how, accordingly, knowledge, lessons and successes can be transferred across regions.

Because the implementation of BIM and digital innovation across regions depends on both institutional and organisational aspects (Papadonikolaki, 2017) the study uses a single case of an international firm. This firm employs around 13000 staff based on 38 countries. This firm is a multi-disciplinary design, engineering and management consultancy, employing staff across a number of disciplines. The organisational

culture of a multinational firm varies (Kostova and Roth, 2002) as firms adjust their corporate culture across contexts (Schneider, 1988). To this end, to explore how countries implement digital artefacts associated with BIM innovation, data were collected only from countries where BIM use is not mandated and thus more organically developed. Data from the UK are purposely excluded from the sample, as the British BIM implementation practices are heavily tinted by the public mandates.

Quantitative data

Currently, there are 16 BIM Assessment Methods (BIM-AMs) developed by scholars and professionals (Azzouz *et al.*, 2016). These methods measure BIM in terms of projects, organisations, teams or individuals. The BIM-MM was chosen as it measures BIM in 'projects' and developed inside the firm where the projects were undertaken (Schofield, 2015). The BIM-MM measures two parts: 'project' and 'disciplines', to assess how the varied disciplines use BIM. This study focuses only on the assessment of the 'project' part through 11 criteria. These criteria are formed by the existence of the following artefacts: (1) BIM Design Data Review (BDDR) (2) BIM champions (3) Common Data Environment (CDE) (4) BIM Execution Plan (BEP) (5) Document/Model referencing and version control (6) knowledge sharing (7) Open Standard Deliverables (OSD) (8) Virtual Design Reviews (VDR) (9) BIM contract (10) Employers Information Requirements (EIRs) and (11) Project Procurement Route (PPR). Among those, only the 6 'hard' criteria were included in the quantitative analysis, as leadership (BIM champions) knowledge sharing, procurement, contracts and employers' requirements are not compatible with quantitative data collection and analysis and could in the future form part of a future mixed methods study.

The study builds upon a quantitative approach and uses descriptive statistics. Through the BIM-MM, each assessed project gets an overall BIM score. This score is extracted from the weightings scored in the 11 criteria, 6 are used at the second part of data analysis. To complete the assessment, key project actors, such as the project or the BIM manager, assign maturity level from 0 to 5 to each criterion. Maturity Level 0 is when a criterion is not applied and Level 5 when the criterion is most advanced. It is important to note that numbers of projects measured in each country vary based on the available ongoing projects of the firm in each region at the time of the study.

Data Presentation and analysis

4. Overall BIM maturity scores across Europe

Regional comparisons of BIM provide a comprehensive snapshot of how digitalisation in construction is applied, in countries that have varied policies and diverse social and cultural contexts. An initial analysis of the data shows that average overall scores of BIM maturity vary across regions, as illustrated in Figure 1.

The data from Table 1 show that maturity levels are the highest in Model Referencing and Version Control as 79% of projects in Europe have maturity levels 2-5. Over three quarters of projects use good practice of file naming, version control and comply with requirements. Another highly applied criterion in Europe is BEP, which is used to formalise goals and specify roles and information exchanges. The data shows that advanced BEP Levels 2-5 is used in 45% of projects in Europe. BEP is mostly applied in Denmark, where all 2 projects used it and Spain where 93% of projects used it.

Highest BIM maturity level is found in Spain and the Netherlands. These are followed by Italy and Germany that have similar overall BIM maturity scores. Lowest scores are seen in Ireland and Poland. Due to data sensitivity, the average scores per country are kept confidential.

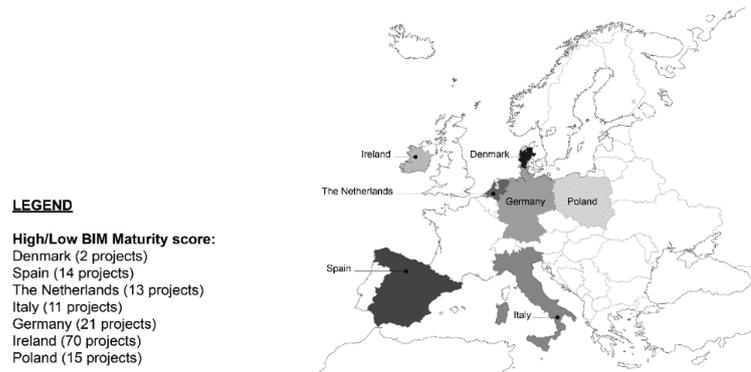


Figure 1: Overall score of BIM maturity across countries.

Apart than looking solely at the overall BIM maturity scores, a more focused analysis can demonstrate how countries apply different digital artefacts of BIM. Therefore, in each country and for each criterion, an average score is calculated on the percentage of projects that are allocated a maturity between Levels 2-5. BIM maturity Levels 0-1 are excluded from the analysis, because they indicate criteria not applied at all or applied on rudimentarily. Levels 2-5 maturity levels have been chosen instead as they represent advanced implementation of the digital artefacts of BIM. Table 1 presents the six out of the eleven criteria of the BIM-MM, which represent the hard aspects of BIM. Soft aspects as leadership and knowledge sharing were the focus of this study.

Table 1: Percentage of projects with Level 2-5 maturity in each criteria across each country.

Country	CDE	BEP	VDR	OSD	Model Referencing	BDDR
Denmark	50%	100%	50%	100%	100%	50%
Germany	29%	29%	67%	52%	71%	24%
Ireland	26%	46%	24%	26%	79%	16%
Italy	36%	45%	27%	36%	82%	9%
Netherlands	38%	54%	69%	69%	77%	15%
Poland	27%	7%	27%	40%	73%	13%
Spain	57%	93%	29%	36%	93%	29%
% in Europe	32%	45%	36%	38%	79%	18%

5. Spotlight on digital artefacts of BIM across countries

The maturity of the digital artefacts of BIM will be explained next to identify trends and patterns across their use in Europe. Namely, BEP, CDE and VDR will be analysed in higher detail. These three artefacts were selected for being relevant to the whole project team, whereas model referencing, OSD and BDDR relate to information exchange. Although Table 1 and the previous analysis focused on mature Levels 2-5 of using BIM, this sub-section will unpack the data for all maturity levels to identify missed opportunities and room for improvement. All criteria, are assessed through six maturity levels ranging Level 0-5, where 5 is when the criterion is most advanced.

BEP is a document that prescribes how project teams work together and how data is shared. For example, BEP Level 0 (**L0**) is when there is no BEP in the project, BEP Level 1 (**L1**) is when a traditional 2D drawing management plan is used. BEP Level 2 (**L2**) is when a BEP created and used by designers, BEP Level 3 (**L3**) is when a BEP used by whole project team. BEP Level 4 (**L4**) is when a project-wide BEP is driven

by the client and BEP Level 5 (**L5**) is when a project-wide BEP is driven by client and the team collaboration needs. Table 2 shows the levels that projects apply BEP. Over half of the projects in Europe do not apply BEP; 74 projects have BEP Level 0 where the criterion is not applied. The rest 72 projects have BEP but most of them are allocated to BEP L2, which means it is used mainly from the design disciplines.

Table 2: Number of projects allocated to BEP maturity levels across countries

Country	BEP L0	BEP L1	BEP L2	BEP L3	BEP L4	BEP L5	Total
Denmark				1	1		2
Germany	14	1	4	1	1		21
Ireland	35	3	18	7	3	4	70
Italy	5	1	4		1		11
Netherlands	6		4	1	2		13
Poland	11	3	1				15
Spain	1		5	5	3		14
Total	74	10	42	15	11	4	146

Following a similar logic to define the maturity levels of CDE and VDR, Tables 3 and 4 contain how these digital artefacts are used from project teams across Europe. CDE is an online platform for storing, exchanging and managing digital information among the project team, where all actors can have access. Table 3 shows that typically around half of projects do not use it. The outlier of this is Spain, where all projects used CDE.

Table 3: Number of projects allocated to CDE maturity levels across countries

Country	CDE L0	CDE L1	CDE L2	CDE L3	CDE L4	CDE L5	Total
Denmark	1				1		2
Germany	14	1	1	5			21
Ireland	32	20	1	8	2	7	70
Italy	2	5	1	2		1	11
Netherlands	5	3	1		4		13
Poland	6	5	1	3			15
Spain		6	2	4	2		14
Total	60	40	7	22	9	8	146

Table 4 shows the data about the maturity levels that VDR are implemented across countries. VDR is a session where different disciplines come together to digitally view, collaborate and coordinate their designs and optimise their work. The data on VDR maturity is evenly distributed and show that around two thirds of projects use VDR. In Germany and the Netherlands more than half projects are L2 to L5 mature.

Table 4: Number of projects allocated to VDR maturity levels across countries

Country	VDR L0	VDR L1	VDR L2	VDR L3	VDR L4	VDR L5	Total
Denmark		1			1		2
Germany	5	2	10	3	1		21
Ireland	30	23	8	6	2	1	70
Italy	3	5	2			1	11
Netherlands	3	1	5	1	2	1	13
Poland	5	6	2	2			15
Spain	2	8	4				14
Total	48	46	31	12	6	3	146

DISCUSSION

Assessment of BIM maturity across geographies has been increasingly the focus of growing attention from academia and industry. Studies have contributed significantly to BIM assessment literature (Wong *et al.*, 2010, Davies *et al.*, 2015). To further this

contribution, there is need to move beyond evaluating BIM adoption. The paper added to knowledge by operationalising BIM and highlighting its digital artefacts and functionalities for construction digitalisation and how these are used across countries.

Regional studies on technology adoption and diffusion observe how technologies and processes are applied and how regions respond to the dynamics and changes affecting AEC. Scholars explain that the differences are due to institutional forces such as national policies (Kam *et al.*, 2013, Papadonikolaki, 2016). For instance, Kam (2015) explained that Singapore's leading position in 'planning' is largely due to an architectural BIM e-submissions programme which is 'one of the strongest BIM mandates in the world'. Similarly, the maturity of the Netherlands in BEP and OSD could be attributed to recommendations of their GBA (Rijksgebouwendienst, 2012).

The data showed that digital functionalities of BIM innovation, such as model referencing, which are related more to information exchange are implemented to an advanced level (Table 1) as opposed to BEP, CDE and VDR. These three digital artefacts and functionalities relate to the whole project team, as BEP is a document plan, CDE an online exchange platform and VDR a session for virtual coordination. Although these criteria are at the heart of multi-disciplinary collaboration that BIM and digital work requires, are not used at an advanced level (Tables 2-4). Namely, around half of the sampled European projects do not use BEP and CDE, whereas VDR is not used from one third, which clearly reflects common practice in regions.

The practical implication is that it reveals that in some regions BIM and digital are still approached as software, rather than as an additional novel digital collaborative process. Whereas this study set out to explore the extent to which countries implement the various digital artefacts and functionalities of BIM, it focused only on the 'hard' and measurable criteria, omitting the influence of soft factors, such as knowledge sharing, leadership and procurement schemes. It is thus concluded that even the 'hard' criteria such as BEP, CDE and VDR are challenging to implement as they need engagement and coordination by the whole project team; they are thus socio-technical.

In addition to the above socio-technical reasons for low digital maturity, it is vital to acknowledge the influence of project type, budget and clients. This limitation was addressed by sampling from a single firm to ensure consistency among the assessors of BIM maturity, as they had shared organisational culture and same briefing and training on BIM-MM. As stated in the methodology, culture in multinational firm varies due to the influence of context and national policy (Schneider, 1988, Kostova and Roth, 2002). However, the data showed clear associations between digital maturity and institutional context. Naturally, addressing these limitations can show the path for further research and validation and enrichment of the existing findings.

CONCLUSIONS

Digital innovation across different geographies has emerged as an important theme in research. This is due to the popularity of BIM and digital innovation in construction as well as driven by a need to attain results by exploring state-of-the-art across regions. Industry players, policy-makers and users are keen to learn from one another and transfer lessons to improve their productivity. This study compared digital maturity in BIM use across seven European countries and revealed two important findings. First, this study operationalised digital innovation through various digital artefacts and functionalities that are of both 'soft' and 'hard' nature, the latter of

which was quantified and studied further. Second, when assessing digital maturity, project teams tend to use only some digital artefacts and functionalities, e.g. model referencing, more than others, such as BEP, CDE and VDR (Table 1) which are paramount for multi-disciplinary digital coordination and work. It appears that even these ‘hard’ aspects of digital innovation are applied in an advanced manner only in half to two thirds of projects and thus, require additional engagement and are of socio-technical nature. Further research will delve into a larger sample using mixed methods to define the relation between context and BIM maturity and how it can be accelerated.

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THE ROLE OF DIGITISATION IN THE STRATEGIC PLANNING PROCESS OF IRISH QUANTITY SURVEYING (QS) PRACTICES

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Digitisation is important to the transformation of many aspects of the construction industry such as strategic planning process in QS practices. Quantity Surveying (QS) Practices largely apply digital technologies in construction project delivery, while neglecting the use of digital technologies in the strategic planning process. The aim of this paper is to investigate the role of digitisation in the strategic planning process of QS practices operating in Ireland. The study adopts a quantitative research methodology which is the first phase of an ongoing research project, by administering survey questionnaires to senior management of QS practices in Ireland. The findings of the study provide valuable insights to senior management on the role of digitisation and the application of digital technologies in the strategic planning process of QS practices. Theoretically, the paper provides a new direction for digitisation studies in construction industry by demonstrating the usefulness, influence and value creation of digitisation in specific aspects of strategic planning process in quantity surveying firms.

Keywords: corporate strategy, quantity surveying, competitiveness, IT

INTRODUCTION

The World Economic Forum predicts a significant increase in digitisation by 2025 due to the connection of one trillion sensors through the internet (World Economic Forum 2016). According to Bughin *et al.*, (2017) digitisation involves the application of digital technologies to connect people, devices and data to improve and transform business processes. Digitisation is projected to influence organisational process in 93 per cent of construction firms (Russo 2016). The influence of digitisation in the construction industry is due to integration of sensors, robotics, automation and increased use of social media platforms in construction firms (Oesterreich and Teuteberg 2016). According to Hoar *et al.*,(2017) digitisation is driving rapid transformation in many sectors, however in the construction industry digitisation is occurring at a slower pace compared to other industries such as manufacturing, healthcare, banking and finance (Boon and Prigg 2012; Friedrich *et al.*, 2011). According to McKinsey and Company (2017) using traditional methods of doing business in competitive markets without digitisation and strategic planning process leads to low revenue and profit.

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Gajendran *et al.*, (2005) notes that digitisation in QS practices ensures the provision of services to clients at minimum cost, improved performance, profitability, growth and competitiveness. In addition, Hassan *et al.*, (2007) state that the competitiveness of QS practices depends on their ability to analyse the dynamic environment of the construction industry to gain enormous advantages over rivals, part of which may include digital technology. Shen and Chung (2007) recommend QS firms adopt digitisation to address the challenges of rapid changing and competitive market in the construction industry. Despite this recommendation, successive studies continue to largely focus on digital technologies for project delivery as demonstrated in studies such as Ibironke *et al.*, (2011), and Matipa *et al.*, (2009) where less attention is given to digitisation and strategic planning process in QS practices. Thus, the aim of this study is to investigate the role of digitisation in the strategic planning process of QS practices in Ireland.

LITERATURE REVIEW

The literature review provides both a conceptual and an empirical background to the study by focusing on digitisation in QS practices; digitisation in Irish context; and the strategic planning process.

Strategic Planning Process

The strategic planning process involves formal and informal human interactions in organisations to achieve strategic outcome (Lyles and Lenz 1982). The nature and scope of a strategic planning process in organisations depend on the size of firms (Barron and Chou 2017). Despite the nature and scope of strategic planning processes differ across organisations; however, there is general agreement within existing literature that the strategic planning process involves the combination of resources and dynamic process by firms in order to exploit opportunities (Reid 1989).

Generally, the strategic planning process comprises an analysis of the internal and external environment; formulation and selection of strategic alternatives; implementation of strategic decisions; and monitoring of strategic alternatives (Barron and Chou 2017; and Hopkins and Hopkins 1997). The success of the aforementioned stages of strategic planning process depends on the effectiveness of internal communication in organisations (Lorange and Vancil 1995; Andrews 1980). Again, Miller and Cardinal (1994) note that the strategic planning process provides better understanding of the competitive environment in which organisations operate, while Ansoff (1991) states that strategic planning process in organisations facilitates the identification of new opportunities. Digitisation is one of the areas that QS practices can utilise in strategic planning process to deliver services to clients in a competitive construction environment.

Digitisation in Irish Context

A number of publications have analysed the level of digitisation in the construction industry (Hore *et al.*, 2017). In a survey involving 100 leaders in Architecture, Engineering and Contracting (AEC) organizations in Ireland, Enterprise Ireland and CITA (2016) found 75 percent increase in demand for digital technologies. However, the study failed to highlight specific client requests for the use of digital technologies to address critical issues of clients such as collaboration in project and service delivery.

Recent publications by the Irish government focus on critical areas for the development of the country in particular its competitiveness at global level, which is

evident in the recently published National Development Plan 2018-2027, and National Planning framework: Ireland 2040.

In addition, the Roadmap to Digital Transition for Ireland's construction Industry launched by The National BIM Council (NBC) of Ireland focuses on using digital technologies for construction project delivery, a phenomenon consistent with existing scholarly works investigating the use of digital technologies to maximise the value of project and service delivery. The National BIM Council (NBC) of Ireland launched the 'Roadmap to Digital Transition for Ireland's construction Industry 2018-2021 in 2017 (NBC 2017). This document consists of seven key areas notably roadmap principles and philosophies; goals; key performance targets; digital transition and implementation; recommendations and outcomes. The roadmap is expected to provide strategic vision and leadership for digital technologies implementation; effective clients and stakeholder engagements; and digital alignment with the European Union (EU), central and local government regulations. Thus, the successful implementation of the roadmap should improve digitisation in QS practices. The aforementioned national publications demonstrate the commitment to investment over the next numbers of years, which includes factors shaping competitiveness, with digitization being a central component.

Digitisation in QS Practice

Digitisation is transforming the roles of the QS profession to improve the performance and economic use of resources in construction business (Reddy 2015; and Cartlidge 2011). However, the transformation of the roles of QS practices partly depends on the decision of senior management to use available tools of digitisation to transform the roles of the QS which have existed for over 170 years (Ashworth and Hogg 2007). Currently QS practices are using digital technologies to help with various activities such as the measurement of construction works to ensure precision and accuracy (Musa *et al.*, 2010; and Shen *et al.*, 2003). Existing studies on digitisation in construction and QS largely focus on project delivery (Alwan *et al.*, 2017) leading to paucity of discussion on strategic planning and digitisation. For instance, digitisation studies in QS hugely focus on Building Information Modelling (BIM) capabilities for QS practice (Ismail *et al.*, 2016); the potential to leverage BIM to increase efficiency in construction project and service delivery by QS practices (Smith 2016); and BIM opportunities for QS (Crowley 2013). Drawing from the above studies it is clear that there remains a paucity of empirical investigation into the relationship (and potential benefits) of digitisation and strategic planning process in QS practices. Although previous studies explore a number of success factors for collaboration in construction industry (Akintoye and Main, 2006; Leverick and Littler, 1993), these studies failed to investigate the critical role of digitisation in strategic planning process and the impact on collaboration. For instance, Akintoye and Main (2006) identify 'project planning with defined schedule' as a success factor for collaboration but failed to consider digitisation as a key driver of collaboration during strategic planning process and project planning in construction firms. Thus, the gap in existing knowledge in this regard is apparent. Collaboration is a mutual engagement of participants to solve a problem together in a coordinated manner (Roschelle and Teasley 1995).

The World Economic Forum (2015) notes that 25% of business revenue would be generated through collaboration and innovation by 2030. This implies that firms investing in innovation and collaboration through strategic planning process and digitisation would have the competitive advantage in generating 25% of their revenue

in the future. According to Asad *et al.*, (2005) innovation is fundamental to creation of competitive advantage in construction industry. This is equally the case within the context of Irish QS practices, giving rise to the need of the current study.

RESEARCH METHOD

This study adopts quantitative research approach, which is the first phase of an ongoing research project investigating strategic planning process in Irish QS practices. The focus of the paper examines the role of digitisation in the strategic planning process of QS firms in Ireland. Using purposive sampling, survey questionnaires were administered to 382 senior quantity surveyors registered with Society of Chartered Surveyors Ireland (SCSI) in top management positions of QS practices. A small research grant was provided by the SCSI in support of the research. One single key informant from each QS practice within the SCSI membership was target to respond. This ensured that the person was at sufficiently senior level to be in a position to respond with authority in relation to the strategic planning process. Furthermore, targeting one key informant eliminated the risk of double counting.

The questionnaire consisted of both closed-ended and open-ended questions focusing on the roles of digitisation adapted from the review and analysis of existing literature. In order to determine the level of digitisation in respondent firms, a 5- point Likert scale comprising 1= strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, and 5= strongly agree were used to ascertain the level of agreement respondents placed on the various roles of digitisation in strategic planning process of QS practices in Ireland.

The questionnaire was pilot tested and amended based on feedback received from respondents. The administration of the questionnaire was internet mediated using an online survey tool.

One hundred and two (102) responses were received and analysed with an overall response rate of 26 per cent. According to Nulty (2008) online surveys yield much lower response rate than paper-based surveys. Again, Fincham (2008) states that online surveys with 25 to 30 per cent response is adequate for data analysis.

Ethical considerations are critical to ensuring professional conduct during research. Thus, the ethics of the institution were adhered to and anonymity of respondents was assured. Completed responses were stored using encrypted files. Early stage analysis utilised basic statistics for preliminary analysis to observe the underlying trends in the data followed by using Excel and SPSS for analysis using descriptive statistics.

The involvement of senior management in the study is an indication that the findings of the study were based on responses from valid and reliable participants.

DISCUSSION OF RESULTS

The analysis of data revealed four main roles of digitisation in strategic planning process of QS practices including:

- communication between participants and stakeholders during strategic planning process;
- collaboration between staff and other stakeholders during project and service delivery to clients;
- innovation in the organisation internally and externally; and
- collection of market and industry data for decision making.

The results of the study presented in table 1 below show the mean, ranking; and total number of valid responses (N) of each variable to provide a detailed insight into respondents' perception of digitisation in the strategic planning process.

According to Field (2005) a variable is important if it has a sample mean of 3.5 or more when Likert rating scale of measurement is used. Thus, variables with sample mean of 3.5 or more in table 1 below tend to be important. Furthermore, Field (2005) suggests that low standard deviations (SD) close to zero indicate that the sample mean is an accurate reflection of the population involved in a study.

Table 1: Role of Digitisation in Strategic Planning Process

Roles of digitisation in Strategic Planning Process	N		Std. Dev(SD)	Ranking	Missing	Total
	Valid	Mean				
1. Drives innovation in the organisation internally and externally	91	3.92	.71	2nd	11	102
2. Encourages collection of market and industry data for decision making	92	3.67	.72	4th	10	102
3. Ensures collaboration between staff and other stakeholders during project and service delivery to clients	92	3.79	.74	3rd	10	102
4. Improves communication between project participants and stakeholders	91	3.99	.71	1st	10	102

Respondents were asked to indicate their perception on the role of digitisation in strategic planning process in their organisation. Respondents' ranking show that digitisation in strategic planning process improves communication between project participants and stakeholders with a sample mean of 3.99, and SD of .71. Since the sample mean is greater than 3.5 and the SD is close to zero, the result is an accurate reflection of the target population of the study. The use of social media platforms such as WhatsApp, Twitter, Facebook, intranet create a channel of communication for stakeholders and employees in QS practices to provide suggestions, feedback and ideas to improve the strategic planning process. The application of social media platforms ensure participation and comprehensiveness of the strategic planning process. Participation in strategic planning process refers to the involvement of owners, suppliers, customers, local community, and employees in the strategic planning process (Papke-Shields and Boyer-Wright, 2017). Comprehensiveness is the inclusion of wide range of issues in the organisational environment into the strategic planning process (Campbell and Fainstein, 2003). Since the core business of QS practices involves projects and service delivery to clients, improved communication as a result of digitisation in QS practices would drive efficient communication between project participants and stakeholders. In addition to improving communication between project participants and stakeholders, digitisation in strategic planning process may result in greater efficiency in downward, upward and lateral communication in QS practices.

Collaboration is essential to the delivery projects and services in the construction industry (Rahman *et al.*, 2014), however, achieving a high level of collaboration during the strategic planning process in the construction industry remains a challenge to professionals such as the QS (Hai *et al.*, 2012). Respondents' ranking of digitisation improving collaboration in the strategic planning process of QS practices in table 1 above shows a sample mean of 3.79 with SD of .74. This variable with a sample mean above 3.5 shows that digitisation enhances collaboration during strategic planning process in QS practices. Again, the low SD of this variable shows less variability in responses indicating that the result is an accurate reflection of the study

population. Collaboration is critical to the success of strategic planning which involves interaction between people in an organisation. For instance, crowdsourcing provides digital toolkits (Amrollahi *et al.*, 2017; and Amrollahi *et al.*, 2014) for enhancing collaboration between employees and stakeholders in strategic planning process. Crowdsourcing is using the collective talents and wisdom of people within and outside the firm to perform organisational tasks such as strategic planning process (Pedersen *et al.*, 2013). Digital tools for crowdsourcing such as 99 Designs, X Prize and Quirky drive brainstorming; and encourage stakeholders and staff to collaborate in finding solutions to organisational problems and decision making during strategic planning process in QS practices.

Respondents' ranking of digitisation as a driver of innovation internally and externally during strategic planning process indicates a sample mean of 3.92 with SD of .71. This result demonstrates that digitisation is critical to innovation in strategic planning process of QS practices. The adoption of digitisation in the strategic planning process leads to internal and external innovation to mitigate the challenges of project and service delivery in QS practices such as increasing complexity of clients. Therefore, QS practices that adopt digitisation in the strategic planning process are able to innovate internally and externally to address the challenges confronting them in the construction industry. Digital technologies such as virtual reality (VR) play important role in the strategic planning process of QS practices through simulation of the various stages of the strategic planning process to top management and other stakeholders such as employees. For instance, VR has the potential of demonstrating the activities required at each level of strategy formulation in QS practices. QS Practices need to exploit market and industry data to enhance their decision making process for competitiveness in the construction industry.

Respondents' ranking regarding the role of digitisation in the collection of market and industry data for decision making in table 1 shows a sample mean of 3.67 with SD of .72 indicating digitisation in strategic planning process of QS practices is important to the collection of market and industry data for decision making. The availability of comprehensive market and industry data to QS practices enable top management to make realistic and reliable decisions for successful outcome. The use of digitisation to collect market and industry data enhances the development of new business models based on current situations in the construction industry by QS practices. Big data technologies such as internet of things (IoT) or machine-to-machine communication (MMC); cloud technologies; data visualisation; and deep machine learning are digital technologies for collection of industry and market data for strategic planning in QS practices. For instance, the use of dig data technologies to collect industry and market data for strategic planning process in QS practices has the potential of eliminating intuition from the decision making on key issues such as client acquisition and retention; market segmentation. Using digital technologies to collect industry and market data enable the senior management of QS practices to identify and predict opportunities in the business environment. In addition, big data technologies organise and process the unstructured data within QS practices to increase business intelligence of QS practices to improve their performance in client acquisition; and service delivery. Business intelligence is a process of turning information into knowledge that supports the strategic planning process for profitable business in organisations such as QS practices. Thus, QS practices using big data technologies have advantage

over their rivals in terms of key information on potential projects which enable them to prepare for procurement ahead of their competitors.

CONCLUSION

The aim of this study was to investigate the role of digitisation in the strategic planning process of quantity surveying practices in Ireland. The findings show digitisation in the strategic planning process drives key activities in quantity surveying firms. In addition, the findings suggests that digitisation in quantity surveying practices improves efficiency in project and service delivery; drives internal and external innovation; and ensures faster delivery of projects and services to clients. The findings provide valuable insights and understanding of top management in QS practices on the use of digitisation in strategic planning process to address the current situation where use of digitisation in the construction industry largely focus on its application in construction project delivery. In addition, QS practices are currently investing in technology would be able to innovate and digitise their strategic planning process to create competitive advantage for improved revenue generation and growth.

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FROM INFORMATION TRANSMISSION TO ENGAGEMENT IN PRACTICE: A STUDY ON BIM ENABLED CONSTRUCTION PROJECTS

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Building information Modelling (BIM) is proposed as a way of dealing with fragmentation through improving information transmission within project working environments. In early studies information transmission was seen objectively as transferring data from one place to another. However, mere information transmission is not enough to improve engagement in practice. Instead, using information transmission need to create meaning for project participants to carry out their work. Increasingly, BIM is been used to deal with the complex actives in construction projects. However, there have been questions on challenges during transmitting information and its failures. This research establishes challenges of information transmission and explores how meaning is created from information in BIM enabled construction projects. Data has been collected through conducting twenty semi-structured interviews and a case study approach which encompasses two fully integrated BIM enabled construction projects which fall between £30-100 million. Findings showed that information overload, information retrieval and information asymmetry are common problems faced in BIM enabled construction projects which make information difficult to transmit within the project environment. It is concluded that communicative, inherent, symbolic and contextual meanings need to be considered together with information to enable engagement in practice.

Keywords: BIM, engagement, information transmission, meaning

INTRODUCTION

Information transmission is important in construction projects where success of the project depends on identifying, collecting, transferring and storing quality and efficient information. Thus, information transmission is considered as a major activity to maintain and transfer an efficient information throughout the whole lifecycle in construction projects. Nyquist (1924) initially established the information theory through focusing on the intelligence and line speed of the communication systems. Later, Harley (1928) concentrated on transmission of words as a measurable quantity and how it affects receiver's ability to differentiate sequence of symbols from others.

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With this fundamentals Shannon-Weaver (1949) has been motivated by problems in communication and considered Information transmission as a process of sending information from one person to another or from one source to another source. In other words, his intention was to identify the quickest and most efficient way to transfer information from one place to another through communication process. In this fast-moving world most information is becoming digital which means they have started to move away from analogue systems. Even though using information technologies has been highly promoted in information management, its uptake has been slow in construction practice and it is seen as delivering only a partial communication. At the same time, solely considering Shannon-Weaver's model of information transmission is not sufficient in this digital world due to drawbacks such as linearity, no allowance for dynamic change, ignorance of unintentional and social communication, less importance for context. Hence, the aim of the study is to explore how meaning is produced and improved beyond information transmission in BIM enabled construction project.

LITERATURE REVIEW

Information Transmission

Information in early days has been defined in three different ways by philosophers and mathematicians. Firstly, philosophers in a narrowest sense have considered information as a data. Later, they have extended the idea to depict the meaning of the data presented. On the other hand, mathematician Shannon (1948) considered information as a degree to reduce the uncertainty through using symbols. Transmitting is an act of sending the information (message) from one spot to another, from one person to another or from one device to another (Shannon and Weaver, 1949). Therefore, the fundamental idea of information transmission is to carry data to the desired destination. Signals, signs, messages and information are various aspects of information transmission embedded in communication process hence it is inseparable from the process of information transmission (Beijer, 2014). Information transmission is transferred in many ways such as paper documents, drawings, emails, images, videos and voice (eg: discussion, telephone conversations). The quality of the information and the time it takes to reach the other person(s) will depend on the way they chose to transfer the information.

Over the years, number of information transmission models were generated to understand the specific concepts and steps within the process of information transmission. Harold Lasswell's 5W model proposes 5Ws for information transmission which established the basic framework of communication research. 5Ws refer to Who, What, What channel, Whom and What effect (Lasswell, 2012). Shannon-Weaver model proposed the communication system in a different perspective. It sends out the information from the source, transmits and in the third step, channel is interrupted with 'noise'. Then it returns to the information flow process, reach the receiver and gets transferred to destination (Shannon-Weaver, 1949). Schramm model stated that information is transmitted through five stages: source, encode, signal, decode and destination (Schram, 1984). In these models information transmission is considered in a linear way and communication is considered in an objective manner. These views have been criticised for this reasons.

Projects in construction involve number of activities; hence transferring information from one person to the other has become complex and challenging. Otjacques *et al.*, (2003) state that information overload, information retrieval and information

asymmetry are experienced while transferring information from one place to another. Farhoomand and Drury (2002) argue information overloaded is due to two main reasons. Firstly, it happens when people are provided with more information than they can absorb. Secondly it occurs when information demands on additional time of an individual rather than the allocated time for that proceedings to interact more to complete a task. According to Otjacques *et al.*, (2003) information retrieval is related to the information structuring and ease of access. They argue that this happen when information is stored and extents the structure according to the fundamental importance and cognitive effort required by the users. Information asymmetry occurs due to number of people dealing with a given problem and participants having different level of information about the same object. This could lead to distortion due to loss of information integrity and incompleteness due to missing information pieces during communication process. Information asymmetry in most cases results through improper management of the information which is generally poor synchronisation of information while working in groups.

Notion of Meaning

In early days the notion of meaning originated from the art of understanding and the meaning of discourse. Both interpretation of language and thoughts influenced understanding and necessity in terms of both linguistic and subjective representation to appreciate the spoken or written discourse (Schleiermacher, 1998). According to Lash (2003) meaning is fundamentally initiated from the self-productive organic system that is language. In this digital age people, information and activities are connected therefore, generating a meaning is crucial to carry out day-today activities. Meant (2003, 204) has defined meaning as “the connection existing between the received information and the constraint of the system”.

Signals in information process can refer number of interpretation therefore understanding the concept of meaning and information is important. Beijer (2014) in his study has considered the notion of meaning through four different orientations. Firstly, communicative meaning is generated through communication between parties which can be negotiable when the process is not linear (Watzlawick *et al.*, 1967 and Schulz von Thun, 1981). In this validity, conditions and newness of information within the communicative intent are considered during the action of receiving (Weizsäcker and Weizsäcker, 1998). In this notion both pragmatic and supplement information are considered (Watzlawick *et al.*, 1967 and Schulz von Thun, 1981). However, this pragmatic information only makes sense when it is neither entirely new or endorses the past experiences. In this, notion of the meaning is limited to an objective meaning; however inclusion of pragmatic view confirms whether the receiver has understood the message or not. Moreover, this can be evident through the triggered actions or changes of receiver’s structure or behaviour (Schulz von Thun, 1981). Secondly, inherent meaning has a part of communicative aspect however it is not fully depend on the communicative intent. Instead, life pattern of communicators and their background knowledge affects the meaning. In other words, their past experiences drive their thinking and doing (Wittgenstein, 1958). Thirdly, Symbolic meaning is intangible which is beyond the physical objectives such as objects, events and processes. The symbolic meaning is produced in the world which is not physically available; world subjectively created by humans. Although humans can explain the symbolic meaning it is not necessary to follow the purpose of objects, events, processes or purpose of symbols. Symbolic meanings are detached from material utility and generally produced when people are compelled, interested or

thinks that it is worthy for their process (Baudrillard, 1998). Finally, Contextual meaning is created from actor's experience on deeper meaning of ontological structures (Lash, 2002). Even though this is intangible, this is different from symbolic meaning because it considers two-way thinking paradigm where actors produce their meaning by expressing the properties of their past experiences (Lash, 2002). In other words, contextual meaning assumes engagement of subject with objects, events and processes from one-world paradigm. Therefore, contextual meaning is created from clarifications through actor's direct experience where engagements plays an important role. These four notions of meaning can be categorised in to tangible (communicative and inherent) meanings and intangible (symbolic and contextual) meanings. By making meaning out of these objective and subjective ways of information transmission we can enable practice through engagement.

Engagement

In practice, engagement is crucial to deliver tasks and achieve project outcomes. Wenger (1998) believes engagement is beyond a matter of an activity and refers to it as community building, inventiveness, social energy and emergent knowledge ability. Engagement is a direct experience of regimes of competences which can be done as an individual or as a group of people (Wenger, 1998). This experience of identifying the competences or incompetence leads to development of participation or non-participation. Apart from this, engagement allows individuals to interpret their ideas to a group of people while they are engaged with a group. Mutuality, competence and continuity has been considered to form the infrastructure of engagement process (Wenger, 1998). According to Bakker *et al.*, (2008) employees who are engaged have high energy levels and enthusiasm in their works. Even though engagement enables people to learn, it is a narrow concept which does not include any expansive images of history, possibilities or complex systems. Moreover, having a multi-actor engagement and steer agent responsible for effective communication in common platform are challenging (Kraatz, 2014). Constructing an image within this world is vital to position ourselves among others, reflect on the situations and to explore new possibilities (Wenger, 1998). Therefore, from cognitive perspective individual's engagement in most routine activities in workplaces is about reinforcing or improving what is already known (Anderson, 1982). Engagement in practice is important to deliver tasks that are assigned to achieve project goals. However, having information without creating a meaning will not help to move towards engagement. Therefore, meaning needs to be seen beyond communication; this has not been considered in the information transmission models.

Information Transmission in BIM Enabled Construction Projects

BIM plays a key role in construction industry which is primarily a three dimensional digital representation of a building and its intrinsic characteristics. According to Xu (2017) BIM adaptation in construction projects can maintain a meticulous management of information without waste being produced to ensure construction quality and progress. Similarly, Zhang and Hu (2011) believe BIM facilitates an integrated method of information flow in all stages of project through the collaborative use of 3D digital models. Moreover, they believe it also helps to visualise and analyse the construction project to the nearest real-life fidelity. Mitchell and Lambert (2013) believe engagement in BIM construction projects supports decision making, shares knowledge among others, brings all participants together in the early stages (Mitchell and Lambert, 2013). However, BIM enabled construction

projects are affected by several factors such as volume of meaningful knowledge (Forsythe *et al.*, 2013), involvement of software (Barlish and Sullivan, 2012), mature application system for research and development, relevant policies, industrial rules and regulations (Xu, 2017). These challenges show that transferring information is solely not enough and needs to produce meaning out of information for engagement in practice. The next section explains the methodology that has been chosen for this study.

METHODOLOGY

This study has adopted critical realism which is a philosophical view about reality and human knowledge (Bhaskar, 2008). According to critical realist unobservable structures causes the observable events therefore people need to recognise the structured events to understand the social world. This study is concerned with engagement and information transmission in BIM construction environment which is part of studying about human information actions in the context. Therefore, critical realism is considered as most appropriate to distinguish, in the most categorical way, between human actions (interactions) and social-cultural structure (tasks and activities within the context). Therefore, in this research context the perspective of critical realism considers the BIM technology as existing independent of people who interact with it and having influence in development of engagement which are socially constructed. Consequently, a qualitative approach is adopted in this study to address the challenges in information transmission in BIM enables construction projects. In doing so, the study discovers how meaning is produced during information transmission in BIM construction projects and how it can be improved. Data for this study have been collected through conducting twenty semi-structured interviews and a case study approach which includes two fully integrated BIM enabled construction projects which fall between £30-100 million.

Semi-structured interviews for this study were conducted with professionals who had a minimum of two years of working experience in BIM construction projects. The purpose of these interviews is to understand the significance of information transfer among BIM professionals. Interviewees involved in this study falls under the roles of BIM coordinator, BIM technician and BIM managers and interview with each professional took approximately 40-50 minutes. In semi structured interviews open-ended questions were employed to get a wider view of the situation and interpretation was done along the way. Two pilot studies have been conducted with construction professionals working with BIM to refine interview questions. Interview questions focused on collecting BIM professional's views and concerns about information transmission during the implementation of BIM in construction projects. The collected data are transcribed and coded using Nvivo. Nvivo is a tool to organise data and helps to interrogate it.

BIM is highly a practical concept therefore case studies of two different BIM construction projects, focusing specially on the information transmission process during BIM implementation were chosen for the study. The purpose of the case study approach is to understand real-life challenges related to information transmission while providing a meaning to the people involved. Case study one selected for this study is a 100,000-square foot extension to the previous building built in 2015. This is a £31 million project which engages over 3,000 students and members of staff and features more than 650 rooms, a student hub and lecture theatres. This high-tech university project has used Level 2 BIM for its deliver and detailed planning and

anticipated to complete in mid of 2018 for the new academic year. Case study two is conservatoire for a well-known university. This is a £57 million project featuring 9,000 square foot designed for media and art students for teaching, rehearsal and state of art performance space. This building has included facilities such as jazz club, a 450-seat conference hall, an intimate 150 seat recital hall, 100 seat practice and rehearsal hall, organ studio and complete AV digital interconnection. Like case one, this project has also adopted Level 2 BIM and has been completed in September 2017. Both projects chosen for the study is a fully integrated BIM construction projects which has used BIM technology for their day to day activities. Data collected from these projects showed that information transmission has a greater impact on making decisions and defining tasks. However, number of challenges in information transmission were noticed while achieving the desired outcomes.

FINDINGS AND DISCUSSION

Information transmission in projects plays an important role in delivering tasks and to achieve the final project goal. However, information transfer solely does not make desired meaning to the receiver who gets the information. Therefore, following scenarios were purposefully chosen from the case studies to explore the difficulties faced during information transmission especially in BIM enabled construction projects.

Scenario 1: Case study 2: clash detection

A design meeting with the project team was arranged by the BIM coordinator to discuss about issues in the model where the projectors in 'Egg theatre' clashed with everything on its way and following that ceiling also clashed with the frames from both sides. BIM coordinator has identified the clash through clash detection process in 3D BIM model. Team members during this meeting have requested to show the visuals of identified clashes to further discuss about the problem. While discussion was taking place project engineer with his previous experience spotted projectors are also clashing with ductwork, ceilings and finishes. Team felt that this clash is too complicated. Therefore, architect mentioned that it is better to approach a specialist within the organisation to sort out this issue. However, architect suggested that similar to a past project ceiling could be move to the right to avoid the clash between the frames.

In this scenario, team members collecting and sharing the information through the visual representation and verbal discussion show that information is transferred from one place to another where communicative meaning is generated. During this, meaning is negotiable because of the continuous communication between the team members. This is also evident when Interviewer-17 stated "One of the important thing is everyone should have a clear communication between the project participants". Following that, project engineer's identification of related clashes shows his experience on deeper meaning of the BIM model. In this case it helped the team members to identify errors in the early stage of the project. Team members through agreeing to hire the specialist to deal with this complex issue symbolically shows that they are not competent enough to handle this issue themselves even though they have not blatantly said it. However, a solution suggested by architect to move the ceilings to the right illustrates the creation of contextual meaning through his experience. In this scenario, BIM coordinator is more focused on the models and clashes, project engineer in understanding what can affect the overall model and architect is concerned about the design. This shows the inherent meaning produced by

their backgrounds and previous experiences. Even though, meaning is produced through these notions to eliminate the clashing projectors in the model, at the end of the project this issue took longer time to be resolved. This is because of having different views from number of stakeholders and the specialist involved. This has been agreed by Otjacques *et al.*, (2003) and has stated this as 'Information asymmetry'.

Scenario 2: Case study 1: positioning of windows

BIM coordinator in another situation has identified a window which was situated between two columns and discovered that there was no steel work to connect it. Therefore, to clarify this design BIM coordinator arranged a meeting with relevant team members. In the meeting, issue was explained to other team members through the visuals pulled out from the 3D model and 2D drawings. After this was explained to the team members in the meeting, site engineer on site was contacted through a phone call while meeting was taking place. During the conversation with the site engineer BIM coordinator collected more information on the setting out dimensions particularly for window and the steel connected to it. BIM coordinator through talking with the site engineer also double checked that the information they have got is correct. After analysing on the elements on site through site engineer the specification provided was checked against the collected information and the model designed for the window. This exploration with the team members have led the BIM coordinator to identify that the sill needs to be raised to rectify the identified error. Moreover, during this discussion architect suggested that glazing for the window needs to be split into several sizes (six or four, no longer than 3000mm and 1800mm wider including the constraints).

In this scenario the information flow occurred through collecting information from 3D models, 2D drawings and project specifications. During this discussion, having more than one information source not only helped the team members to generate the communicative meaning but also to make connections between the information available in each source. BIM coordinator's conversation with the site engineer to collect information about the window, steel setting out and dimensions shows the direct participation to solve this issue. This clarification generates the contextual meaning during the information transmission process. In this discussion BIM coordinator's suggestion to lift the sill and architect's suggestion to split the glazing into several sizes show that their focus is different to each other to solve this problem. This inherent meaning produced is due to their backgrounds, roles and responsibilities and experiences. Throughout the conversation between the BIM coordinator and site engineer the word 'Setting out' was highly used. Even though setting out can mean different thing, in this conversation it symbolically means the mark ups for windows and steels connected to it. During this situation BIM coordinator referring to the documents and collaborating with other team members after talking with the site engineer shows that he has not got the holistic understanding about the issue. It is mainly caused by loss of information integrity and incompleteness due to missing information pieces during communication process. Importance of holistic understanding is also evident from Interviewer-9 stating " In my opinion I would say that there must be some holistic understanding in BIM overall process". Even though site engineer has given the BIM coordinator all the information he still has not gained the meaning of what he wanted and this challenge is referred as 'Information retrieval' (Otjacques *et al.*, 2003).

Scenario 3: Case study 1: Data assignment

During one of the project meetings, issues related to data assignment to the federated BIM model was picked up. Project manager stated that even though they have set up a federated model and started assigning the data, the problem raised is that they have quite a lot of data to be assigned to the model. Moreover, he said change in the systems and materials is a repetitive process. Therefore, due to this uncertainty he complained that in some situation they must do the exercise from the scratch rather than keep doing the same thing. On the other hand designer mentioned that even though most of the things have been constructed they still get emails regularly about the updates which make the process more difficult. Following this discussion BIM coordinator raised a question to project manager asking when they are going to be in BIM Level 2. For this project manager answered that most of the allocated works complies with BIM level 2 as far as there is no concerns about any updates. However, during this, BIM auditor indicated that information is always passed to the relevant team when they are in the position to do so.

In this scenario information was transferred through verbal communication between the team members presented in the meeting. The communicative meaning produced through this communication process helps to understand the difficulties that other team members are facing in terms of assigning the data to the model. In contrast to scenario 1 and 2 in this situation both project manager and designer are complaining about the same issue which is about huge amount of information while assigning the data to the model. However, project manager is more concerned about the overall data whereas designer is just focused on the data which is related to the design. This inherent meaning generated in this situation is due to different backgrounds and roles and responsibilities. Project manager answering to the question regarding to level 2 BIM shows that he has enough experience to assume that other works in the project will comply with Level 2 BIM. This contextual meaning produced during this meeting helped the other team members to focus and design their jobs in terms of complying with Level 2 BIM. However, according to Interviewer- 8 “it is very rare to find a fresh highly educated practitioners who has deeper experience in the industry”. However, early indication in this scenario helped to minimise the errors in the project. During this discussion BIM auditor mentioning that 'information will always passed to the relevant team when they are in the position to do it' symbolically shows that team members will keep on getting information if that is relevant to them. In this even though BIM auditor did not say that changes are unavoidable he has symbolically said that team members should cope with the changes that happens in the project. As it is obvious the main issue regarding information transmission in this situation is information overload. In this scenario it mainly occurred when providing more information than participant can absorb. According to Farhoomand and Drury (2002) and Otjacques *et al.*, (2003) this is the most common problem faced during information transmission process.

These scenarios discussed above show that making meaning out of the information is not solely through communication. Instead both tangible meanings such as experiences, backgrounds and responsibilities and intangible meanings such as people's views, emotions and thoughts have an impact on meaning making process. This will not only help the receiver to achieve a meaningful information but also helps to produce a meaning without errors. On the other hand, moving information transmission away from an objective view helps participants to think outside their comfort zone. Most importantly this will help to achieve engagement which is crucial

for practice. Furthermore, producing a meaning from an information helps to build community, inventiveness, social energy and developing ability of knowledge. This then enhances engagement in practice. As the scenarios show, challenges such as information asymmetry, information retrieval and information overload are encountered in the process of information transmission in BIM enabled construction projects. However, this could be minimised by holistically considering communicative, inherent, symbolic and contextual meanings while making meaning from information transmission.

CONCLUSIONS

Information transmission in early days was considered solely as transferring information from one place to another. This was considered as a linear process which was highly based on communication between two parties. However, in the fast-moving digital world activities are becoming more complex and challenging. Therefore, engagement is important for practice. Engagement is beyond an activity and includes community building, inventiveness, social energy and emergent knowledge ability. Therefore, seeing information transmission from an objective manner is not sufficient to make a meaning out the information that is transferred. Therefore, process of information transmission needs to be seen beyond the information flow. The scenarios that have been explored in this study show that meaning is created through communicative, inherent, symbolic and contextual meanings. For example, communicative meaning in BIM construction projects is produced through communicating with project team members with the aid of integrated 3D BIM model that has access to all the information related to the project. Subsequently, Inherent meaning in BIM construction projects is noticed when participants apply their experiences and background and professional knowledge to resolve conflicts that arises in the project. However, symbolic meaning is not an easy one to observe, since it resides in the social domains and hard to objectify into events or tasks; however it is generally produced while providing opinions to other team members. Finally, contextual meaning is generated when project participants are directly involved in site visits, project meetings and in workshops to choose the appropriate materials for their project. Therefore, in addition to hard information both tangible (experiences, backgrounds and responsibilities) and intangible meanings (eg. people's views, emotions and thoughts) need to be taken into consideration to produce meaningful information. This can help not only to build up a meaning but also to improve engagement in the project information centric world. Engagement then enables project participants to successfully participate in project practices.

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TOWARDS THE GENERATION OF DIGITAL TWINS FOR FACILITY MANAGEMENT BASED ON 3D POINT CLOUDS

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Advances versus adaptation of Industry 4.0 practices in Facility Management (FM) have created usage demand for up-to-date digitized building assets. The use of Building Information Modelling (BIM) for FM in the Operation and Maintenance (O&M) stages of the building lifecycle is intended to bridge the gap between operations and digital data, but lacks the functionality of assessing and forecasting the state of the built environment in real-time. To accommodate this, BIM data needs to be constantly updated with the current state of the built environment. However, generation of as-is BIM data for a digital representation of a building is a labor intensive process. While some software applications offer a degree of automation for the generation of as-is BIM data, they can be impractical to use for routinely updating digital FM documentation. Current approaches for capturing the built environment using remote sensing and photometry-based methods allow for the creation of 3D point clouds that can be used as basis data for a Digital Twin (DT), along with existing BIM and FM documentation. 3D point clouds themselves do not contain any semantics or specific information about the building components they represent physically, but using machine learning methods they can be enhanced with semantics that would allow for reconstruction of as-is BIM and basis DT data. This paper presents current research and development progress of a service-oriented platform for generation of semantically rich 3D point cloud representations of indoor environments. A specific focus is placed on the reconstruction and visualization of the captured state of the built environment for increasing FM stakeholder engagement and facilitating collaboration. The preliminary results of a prototypical web-based application demonstrate the feasibility of such a platform for FM using a service-oriented paradigm.

Keywords: Digital Twins, BIM, facility management, Point Clouds, visualization

INTRODUCTION

A Digital Twin (DT) is a digital duplicate of the physical environment, states and processes. While a BIM model contains as-is and historical data, a DT can be used to assess the current state and potentially to forecast the future state, of a digital duplicate of the built environment (Posada *et al.*, 2015, Grieves 2014). The data used for a DT

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therefore needs to be representative of both the static physical attributes, as well as the dynamic processes and states of the built environment.

For Facility Management (FM) practices, changes in the built environment that effect the operational status of the work environment need to be recorded and addressed. Current documentation practices for Operation and Maintenance (O&M) procedures within the FM realm include using redundant, often outdated, information that is usually available in paper format only (Teicholz *et al.*, 2013). In order to capture the current physical state of the built environment, 3D point clouds can be used as the basis for as-is BIM and DT representations. The presented research focuses on the design of a primary data acquisition workflow to capture and generate semantically rich data from 3D point clouds, which in turn can be used as basis data for DTs. This allows for routine generation of semantically rich models for enhancing collaboration, decision making and forecasting amongst FM stakeholders. In the initial design stages of the case study, the authors collaborated with FM experts in order to gain insight into the key challenges and requirements. The following key challenges were formed:

- How can 3D point clouds of indoor environments be routinely acquired without using expensive and specialist hardware?
- How can large and complex 3D point cloud be processed in order to create semantically rich as-is representations of indoor environments?
- How can semantically rich 3D point clouds be used to create as-is BIM data?
- How can service oriented methodologies be used to generate classification results and engaging visualization and analytics outputs to further FM stakeholder engagement?

These challenges are addressed using the described approaches based on state of the art methodology and presented in the case study along with initial results.

Related Work

Generation of digital documentation, used to represent the state of the build environment, relies on as-is BIM data, which can be expensive and time consuming to generate manually (Ochmann *et al.*, 2015). Roper and Payant (2014) state that the benefit of BIM integration for FM practices is allowing centralized access to digital documentation for stakeholders, possibly utilizing the trend of web-based and mobile communications platforms for enhanced communication and data exchange. For example, in indoor environments, BIM integration with FM can visualize spatial attributes to facilitate identification of underutilized spaces, forecast space requirements, simplify space analysis, manage relocation processes and compare actual with planned space utilization (Becerik-Gerber *et al.*, 2013). The combined use of data sharing principals provides further benefits that enable FM stakeholders from all other related FM practices to have access to critical building operation information (Kensek 2015). Existing buildings often lack as-is BIM documentation due to omitted updating and unless as-is BIM data is generated, limitations of BIM usage in the O&M phase of existing buildings are expected (Volk *et al.*, 2014). One current method of automated generation of as-is BIM data is with the use of 3D point clouds (Qu and Sun 2015). Dealing with 3D point cloud data comes with specific challenges, as raw point clouds need to be pre-processed before they can be used for generation of as-is digital documentation and reconstructed BIMs and manual reconstruction is still required to some degree (Macher *et al.*, 2017). Most previous research focusing on as-is BIM LOD representations does not include office furniture objects and

machinery for indoor environments (Xiong *et al.*, 2013; Tang *et al.*, 2010). Use of BIM and 3D visualization for FM are still at an early stage of adaptation in comparison to other stages in the building lifecycle, though adopter case studies have been described (Kassem *et al.*, 2015; Teicholz *et al.*, 2013). Reconstruction of semantic data for indoor environments, such as offices, poses a particular challenge as reconstructed geometric data is not classified by default and manual classification is a complex and time-consuming process (Chen *et al.*, 2015). Methods based on genetic algorithms and computer vision to verify and optimize the reconstruction of as-is BIM data using 2D images have been proposed as a possible solution to these challenges (Xue *et al.*, 2018). Research by (Kalyan *et al.*, 2016) proposed methodology for manual generation of as-is BIM data from 3D point clouds using a Google Tango mobile device.

Practicality in terms of user scanning using Google Tango mobile devices and also low costs and easy setup, has been described by (Froehlich *et al.*, 2017). A review of optoelectronic technology developments, applications and benefits for the AEC industry is presented by Pärn and Edwards (2017). Using machine-learning methods, specifically 2D image classification methods known as "multi view classification", the process of generating semantically rich 3D point clouds can be automated, using a trained Convolutional Neural Network (CNN) model to segment and classify point cloud data into as-is BIM representations (Su *et al.*, 2015). In a given scenario, this allows FM personnel to upload point cloud scans of office interiors for classification onto a remote server, with the classification or visualization results being streamed back to mobile devices via an online web application (Döllner *et al.*, 2012).

Singh *et al.*, (2010), have described the description of a BIM-based multidisciplinary collaboration platform, along with specific technical requirements, in detail. The visualization-based analytical output of combined as-designed and as-is BIM, point cloud and sensor data can be combined to create a DT that allows for historical and current real-time representations for FM use within the emerging Industry and Real-Estate 4.0 realm (Lasi *et al.*, 2014). Active industry interest for using DTs has been endorsed by large corporations such as SAP (SAP 2018). A key advantage of DTs is centralized access to all information concerning the operational state of a building. This is in contrast to current practices where the owner and the tenant have separate access to the operational state of the building, thus possibly creating a communication barrier for any routine O&M requirements. Additionally, with the unification of data, access privileges can also be controlled better between stakeholders using digital access managements practices (Heidrich *et al.*, 2017).

METHODOLOGY

The methodology described focuses on O&M stages within the FM operations, particularly on space management. All the research methods outlined in this section, except data fusion (using sensor data) were investigated and utilized in the presented case study. The presented methods were selected based on review, implementation, and evaluation of existing methodology outlined in the literature review. Figure 1 illustrates the proposed workflow for incorporating the discussed methods.

A 3D point clouds provides an efficient, affordable and manageable alternative to capturing the physical state of the built environment (Laing *et al.*, 2015). Scans of varying detail can also be made routinely and can be used to assess physical changes over time. A 3D point cloud consists of what can be defined as non-interpreted data - data that is open to visual interpretation but does not have any semantics associated

with it. Unfortunately, point clouds can only be used as "shell representations" of the current physical state built environment.

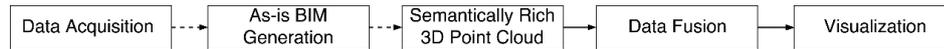


Figure 1: The proposed pipeline for generation of semantically rich 3D point cloud data using a service-oriented approach. The 3D point cloud representation captured in the Data Acquisition stage can be used to optionally create an as-is BIM model in addition to basis data for a DT representation.

Interior representations, such as Mechanical, Electrical and Plumbing (MEP) components cannot be captured practically using the described point cloud acquisition methods. Thus, point cloud representations by themselves can be thought as LOD-0 representations (or as primary BIM representations). Therefore, 3D point clouds can be used by themselves to represent the current state of the physical environment for practical needs (*e.g.* assessment of space usage in a room), but for any further representations and assessment the 3D point cloud needs to be processed in order generate useful semantics. These can then be used as the basis for as-is BIMs or DTs (Figure 2). Although there is overlapping between a DT and BIM representations, for this research DTs are treated as a higher-level representation that includes both as-designed and as-is BIM data and any other associated semantics. A DT representation fuses these as-designed and as-is representations with additional information layers pertaining to the current state of the built environment (such as fusion of sensor data for real-time analysis and forecasting).

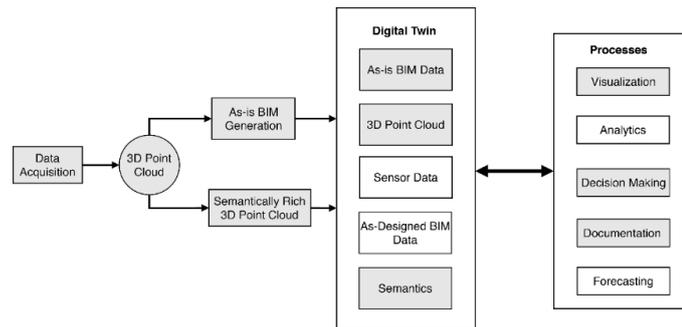


Figure 2: Illustration showing how generation of semantically rich point clouds that can be used as basis data for DTs. The resulting DT can then be integrated with various processes critical to FM using the Industry and Real Estate 4.0 paradigm. The highlighted staged are addressed by the presented case study.

Data Acquisition

With respect to the mentioned points above, the use of mobile phones for capturing and generation of point cloud data has become a viable option (*e.g.* Google Tango specification compatible consumer mobile devices). The main advantage of using consumer mobile devices with depth sensing cameras is that they provide an affordable, flexible and simple solution for capturing 3D point clouds of interiors in comparison to more expensive laser scanning devices (Froehlich *et al.*, 2017). The main disadvantage is that the 3D point cloud representations captured using mobile phones may feature lower fidelity in terms of visual details and contain more noise than using normal 3D scanners for capture. However, very detailed 3D representations of indoor environments are not generally required for routine FM applications. Photometry-based processing methods can be implemented on mobile devices and allow the processing of a sequence of captured images to be converted into a point cloud representation. The visual representation described by a point cloud

can be used to enhance FM practices and fulfils the need to be able to have up-to-date representations of interiors of a facility for enhancing and making informed decisions. The process for capturing point clouds is straightforward and these can be automatically uploaded to a remote server for further processing, documentation and archiving. In order to acquire 3D point clouds of interiors using a Google Tango compatible device, the user has to actively walk around the given room and focus the device on specific items and areas of interest (Figure 3). The device works by comparing the depth and colour values of sequentially captured image frames. A limitation to this approach is that lighting conditions can affect the quality of the capture (if the interior space is too dark or captured using daytime lighting). Additionally, the user may have to walk around the same area of interest a number of times to generate a complete scan. Once the scan has been generated, the resulting 3D point cloud needs to be filtered for overlapping duplicate points and preferably sub-sampled to a reasonable degree in order to decrease processing time while preserving the visual fidelity of the 3D point cloud representation.

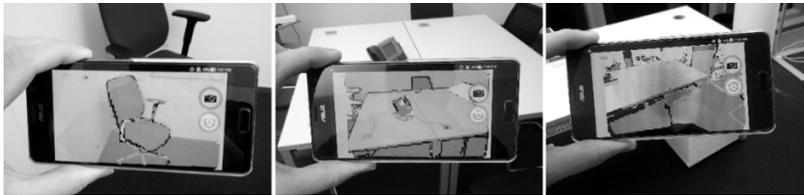


Figure 3: Acquisition of a 3D point cloud of office furniture using a Google Tango compatible mobile phone with the Dot3D app (developed by DotProduct LLC).

As-Is BIM Generation

As stated previously, as-is BIMs are not necessarily required for representation of the built environment within a DT, but are required for conformation to BIM practices and more complex representations (such as MEP representations). Captured 3D point cloud data can be used to generate as-is BIM datasets that represent the “core” structural and spatial features of the built environment. The main physical characteristics and major deriving structures can be captured using point cloud to as-is BIM reconstruction. However, as-is BIM reconstruction can generally be thought of as representing global characteristics (*e.g.* comparison of as-built vs as-designed room layouts), but omits local characteristics such as layout of furniture in an office room for example. Current general research in the Architecture, Engineering and Construction (AEC) industry is focused on efficient geometry reconstruction at appropriate levels of detail using segmentation and geometry reconstruction methods. One of the key operations for successful reconstruction of as-is BIMs from point clouds is segmentation. Point cloud segmentation is the process of classifying point clouds into multiple homogeneous regions. The segmentation is challenging because of high redundancy, uneven sampling density and lack of explicit structure of point cloud data (Nguyen 2013).

Semantically Rich 3D Point Clouds

In order to be able to enhance the representation of indoor environments for FM use, an advanced method is required that can automatically approximate the segmentation and semantic labelling of point cloud representations of indoor environments. This can be accomplished using image-based machine learning approaches. Since point cloud scans of indoor environments feature a near-photorealistic representation of the environment, 2D images of 3D point clouds can be used to train and classify images for object recognition tasks (a process known as “multi-view classification”, based on

Deep Learning image classification principals). An example scenario may include selecting a point cloud cluster of an office containing multiple chairs and tables. To classify this scene using a multi-view classification approach, the scene would be discretized into smaller partitions. At each partition, a number of images would be generated and sent to a server, where the image classification algorithm is running. The algorithm would then return a probability of the classified object contained in that partition, based on the images sent for classification. The classification model would be trained using similar images so it can recognize up to a certain degree of accuracy the object represented by the 2D images of point cloud clusters. This classification label can then be applied to the corresponding 3D point cloud cluster and allow that cluster to be segmented and labelled. This allows for automated segmentation and classification of 3D point cloud clusters of indoor environments. The segmented and labelled point cloud can then be used to generate an as-is BIM representation, or as basis data for a DT representation.

Visualization

The use of interactive 3D visualization can benefit FM stakeholder engagement by allowing real-time display and analysis of 2D and 3D visual outputs generated from the acquired data sources. Using modern computer graphics rendering approaches, complex visualizations can be presented to users in real-time on various configurations including commodity and older hardware. Service-based interactive visualisation can enable streaming of complex visualisation results to thin clients, such as smartphones and tablets. Some mobile devices may be older generation and may not have the ability to process visualisation data in real-time using their native hardware, thus data can be pre-processed and streamed from a server in real-time to the mobile device using an implemented service-oriented architecture solution. Apart from visualization, this approach can also be used for complex computation such as the image-based point cloud classification approach that is outlined in this paper.

Figure 4 shows a high-level flowchart to illustrate this concept.

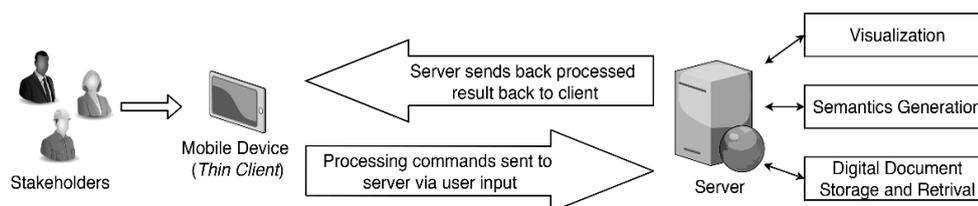


Figure 4: High-level overview for a service-oriented approach for 3D visualization of BIM data.

Real-time sensor data can also be overlaid over the semantically rich point cloud representation to allow for a generalized representation. This allows for point cloud attributes such as shape and colour to be changed over time. This approach can be used for visualization of recorded changes in the built environment in real-time (Khan and Hornbæk 2011).

Case Study

The case study addresses the presented challenges outlined in the introduction section and provides an overview of the approaches for the implementations of the Visualization, Decision Making and Documentation processes (Figure 2). The following possible solutions to the challenges were derived from the case study:

6. The adopted methodology is focused on using mobile phones for capturing 3D point clouds. Using Google Tango compatible mobile devices allows for routine capture and generation of point cloud representations of interior spaces (e.g. office spaces, conference room and storage spaces).

Once 3D point clouds have been captured, using segmentation algorithms the 3D point clouds can be processed to extract and classify features such as walls, floors and ceilings. For more complex items such as chairs and desks, multi-view classification is used. This allows for the generation of semantically rich point cloud representations of interior spaces.

Semantically rich point cloud data can then be processed and converted to IFC data representative at BIM LOD-300 or used as basis data for a DT representation. For the case study, we have used two different point cloud data sets (one of an empty hallway and another of an office interior with furniture objects).

The classification and visualization of semantically rich point cloud was implemented using a service-oriented approach as a web-based prototype application.

RESULTS

Generation of As-Is BIM Data

For first part of the case study, a result from an as-is BIM reconstruction of a point cloud scan of an office hallway to the IFC format at LOD-300 is presented. Using a combination of automated segmentation of planar surfaces (walls, floors and ceilings) and manual selection, bounding areas of segmented clusters were labelled and converted to IFC representational hierarchy components manually (Figure 5). The interior of the office hallway was scanned using commercial indoor laser scanner (this scan was provided as test data by FM stakeholders). Removal of scanning artefacts (e.g. noise and other outlier point data), was accomplished manually, though can be automated as well with varying degrees of success. The segmentation of a point cloud of this size (1 053 735 points) takes a few minutes using a modern GPU-based processing pipeline (Richter *et al.*, 2015). For verification of reconstructed geometry, deviation analysis methods previously investigated by the authors can be used (Stojanovic *et al.*, 2017).

Generation of Semantically Rich 3D Point Cloud Interior Representations

For the second part of the case study, a prototype web-based application was implemented that is able to process and analyse given 3D point clouds of typical indoor office spaces and create corresponding up-to-date approximations of classified segments and object-based 3D models. The presented 3D point cloud of an office interior with furniture was first manually segmented to detect walls, floors and ceilings and then using machine learning the furniture objects were detected and classified. To enable clear, efficient and direct stakeholder engagement, a platform for collaborative generation and review of as-is representations and associated digital documentation is required. The approach is based on the author's previous research (Stojanovic *et al.*, 2018). The results in Figure 6 show that the multi-view classification system (based on machine learning) is able to provide a sufficient description of the composition of objects in the scene. The multi-view classification approach is used for fast labelling and extraction approximations of indoor spaces. In the test case a scan of an office was created (featuring 27 331 points). This 3D point cloud scan was captured in a few minutes using a Google Tango compatible mobile

device (Asus ZenFone AR). This scan was then uploaded for classification via a custom web-based application to a server running the classification model. In terms of performance, a scene with approximately 30 000 points can be classified within two minutes average using a commodity PC with a modern CPU and GPU. Additionally, the reconstruction of classified point clouds is possible by placement of 3D furniture models. This allows for a better visual approximation of the spatial arrangement of furniture objects.

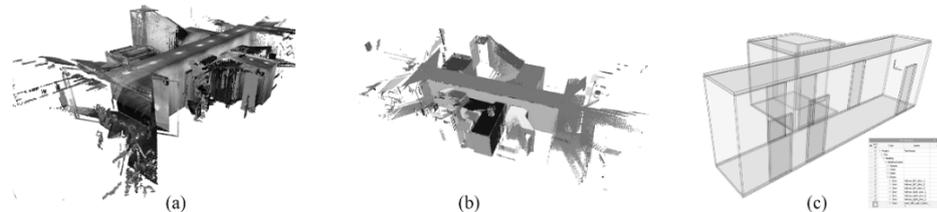


Figure 5: (a) Shows the original point cloud, while (b) shows the segmented point cloud that includes different coloured planes to denote different point cluster orientations in comparison to other cluster regions in the point cloud data set (c) Shows the initial results of segmentation and reconstruction of an office hallway from a 3D point cloud at LOD-300.

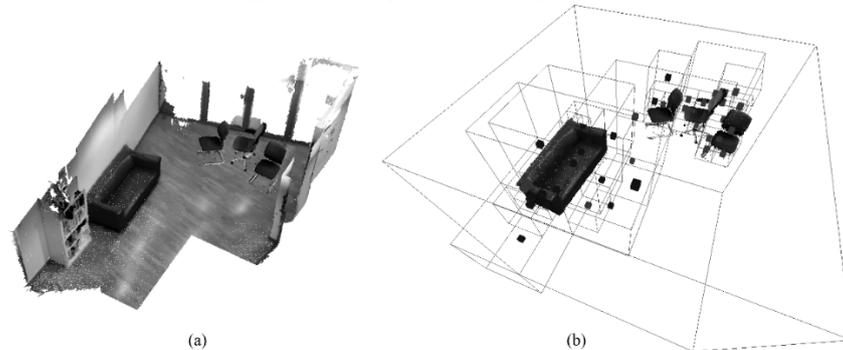


Figure 6: Classification results of an indoor office area containing a sofa and chairs (a) Shows the input point cloud and the segmented region that is to be classified and (b) shows the classification output. In the classification output, the blue cubes indicate possible spatial location of a sofa and the red cubes indicate possible spatial positions for chairs.

CONCLUSIONS AND FUTURE WORK

The results have demonstrated the feasibility of generating as-is data representations of indoor environments with commodity hardware for FM use (specifically space management). The described approach has potential to increase engagement and enhance decision making for FM practitioners who are currently adopting BIM practices. Using a service-oriented paradigm, the scanned indoor environments obtained using consumer mobile devices can be reconstructed as semantically rich as-is BIM data and as basis data for DTs. The described methodology provides a detailed overview of the processes required for acquiring, generating and presenting this semantically rich as-is data. There are limitations of the described methods and approaches. First, for the generation of as-is BIM data from point clouds, the selection and labelling of segmented areas to be converted to IFC components still required manual user input. Second, for the generation of semantically rich point clouds using multi-view classification, additional user annotation and correction is required after the classification stage for most cases. To address this, the development of a web-application for centralized access to 3D point clouds and capability for visualizing sensor data is ongoing. With this web-based application, multiple users can collaboratively review, annotate and comment on the segmented and annotated as-

is point cloud representations of interior environments. The third limitation is routinely captured 3D point clouds can require increased computer storage space and computer networking, thus appropriate IT infrastructure is required. Further investigation of incorporating sensor data analytics for the "data fusion" stage is also planned. A pilot study with FM practitioners using the described methodology workflow is planned for later stages of this research.

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MENTAL HEALTH, STRESS AND WELLBEING

DETERMINANTS OF AIDS KNOWLEDGE AMONG CONSTRUCTION WORKERS

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Accurate knowledge about AIDS transmission is pivotal to combating the spread of HIV infection and the risks of re-infection. Using multiple linear regression, the determinants of AIDS knowledge were investigated in a survey of 512 site-based construction workers in the Western Cape. Over a third of survey participants indicated poor levels of AIDS knowledge. Ethnicity, level of education, employment status and acquaintance with an HIV+ person were significant in predicting AIDS knowledge. Gender, age, multiple sex partners in the preceding 3 months and condom use at last sex were not found to be significant determinants of AIDS knowledge. Workplace interventions by employers, whilst focusing on all employees, should concentrate their efforts on identifying and targeting those demographic sub-populations that are at greatest risk of having poorer levels of AIDS knowledge.

Keywords: HIV/AIDS, AIDS knowledge, construction workers, South Africa

INTRODUCTION

HIV/AIDS is not an officially notifiable disease in South Africa, but the latest National HIV Prevalence, Incidence and Behaviour survey (Shisana *et al.*, 2014) indicated that the national HIV prevalence in 2012 was 12.2% (6.4 million persons) UNAIDS (2016) reported that South Africa had an estimated 7 million people living with HIV in 2015. Bowen *et al.*, (2008), in an analysis of data collected from 10,243 construction workers (2002-2005), estimated the infection rate in the industry to be 14%. More recent research, using data collected through voluntary testing of 54,496 construction workers (2012-2014), estimated infection to be 10.1% (Bowen *et al.*, 2017). Whatever the prevalence, it is sufficient for the disease to be regarded as pandemic.

The South African National Strategic Plan (NSP) for HIV, TB and STIs has called for deeper involvement of the private sector in combatting HIV/AIDS (SANAC, 2017). The construction industry is disproportionately adversely affected by HIV/AIDS

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(BER/ SABCOHA, 2004), but one of the slowest to respond (Meintjes *et al.*, 2007). To better structure intervention packages and target them more effectively, construction firms need to identify employee groups at greatest risk of infection.

HIV transmission is positively associated with poor AIDS knowledge, inconsistent or incorrect condom use, attitudinal fear of testing, multiple or concurrent sexual partners and stigmatizing attitudes as barriers to testing (Shisana *et al.*, 2014). HIV testing is pivotal to controlling disease transmission and providing care (Kaufman *et al.*, 2014). A factor positively related to testing behaviour in South Africa is a person's level of AIDS knowledge. Accurate AIDS knowledge does not necessarily result in behavioural change and efforts to prevent HIV infection; however, it is a prerequisite for engaging in HIV prevention practices (Shisana *et al.*, 2014).

BACKGROUND TO THE STUDY

Various studies have explored the determinants of AIDS knowledge (e.g. Glick, 2008; Rahman, 2009; Misrohmasari *et al.*, 2016; Shisana *et al.*, 2014; Yaya *et al.*, 2016). Shisana *et al.*, (2014) reported 'accurate' knowledge (no incorrect answers) in the general population to be 27%. Levels of knowledge were found not to vary by gender but to vary significantly by age, race, locality type and province. Specifically, older participants aged 50 years and older were more likely to be less knowledgeable than younger participants and 'Black' Africans were more likely to be less knowledgeable than all other race groups. Participants living in urban formal locality areas were more knowledgeable than those living in other locations.

Misrohmasari *et al.*, (2016) stress the pivotal role of education and literacy in predicting HIV/AIDS awareness and knowledge. O'Mara-Eves *et al.*, (2015) report that the factors that influence AIDS knowledge and the utilisation of that knowledge to adhere to healthy behaviour (e.g. use of condoms) are usually associated with an individual's socio-economic and community conditions and their family environment. Factors negatively associated with AIDS knowledge include: residing in less-educated neighbourhoods (Yaya *et al.*, 2016); residing in rural versus urban communities (Rahman, 2009); and urban poverty (Odhiambo *et al.*, 2003). Anderson *et al.*, (1990) found an inverse relationship between AIDS knowledge and having multiple sex partners. Carey *et al.*, (1997) reported that increased AIDS knowledge strengthened intentions to adopt safer sexual practices and engagement in fewer acts of unprotected intercourse. Glick *et al.*, (2008) found condom use to be positively associated with AIDS knowledge. Alwafi *et al.*, (2018) and Hong *et al.*, (2012) reported a positive association between AIDS knowledge and having a friend or family member living with HIV compared to those who do not know anyone with HIV.

No studies have investigated the extent and determinants of AIDS knowledge among construction workers. This study addresses that shortcoming.

RESEARCH METHOD

The epistemological assumptions underpinning this study are of a positivist nature. Moreover, the analysis and interpretation of the data adopted an objectivist / determinist ontological paradigm in that it is possible that the AIDS knowledge of workers is partially or completely determined by the socio-economic environment in which they find themselves.

Participants and Setting

A survey questionnaire was used to collect data. Convenience sampling was used for the selection of construction firms and sites, as well as the workers interviewed. Participant characteristics, notably gender, age and ethnicity, were determined by the sample. Participants (n=512) were site-based unskilled and skilled workers and site office-based staff drawn from 6 firms on 18 construction sites in the Western Cape. The sample frame consisted of all employees present when the researchers visited the sites by prior arrangement. No inducements were offered to participants. Ethics clearance was obtained from the University of Cape Town.

Questionnaires were available in English, Afrikaans and isiXhosa (an indigenous African language), the most commonly spoken languages in the Western Cape. Participants were briefed on the nature of the study, assured that their participation was entirely voluntary and anonymous and informed that they could withdraw at any time. Workers who provided informed consent then proceeded to complete the questionnaires, usually in site office containers. Between them, the field researchers administering the questionnaire were proficient in all three languages.

Measures

Demographic and behavioural characteristics: The list of characteristics is given in Table 1. Age was measured in actual years and then grouped into four discrete age categories (based on Shisana *et al.*, 2014) 26 or younger; 27-36; 37-49; and 50 years or older. Ethnicity was captured in terms of the following classifications: 'Black' African; 'Coloured' (mixed race); 'Indian'; and 'White'. The predominance of 'Black' Africans in the sample necessitated the latter three classes being combined as 'Others' in the statistical analysis. Highest level of education was categorised as 'primary or less', 'secondary' and 'tertiary or higher'. Employment status was classified as 'permanent', 'temporary / contract', or 'casual'. Participants reported whether or not they knew at least one HIV+ person ('yes' or 'no'). In terms of behavioural (risk) characteristics, participants reported whether or not they had had sex with multiple partners in the preceding three months and whether or not a condom was used at last sexual act. These demographic and behavioural characteristics were drawn from Kalichman and Simbayi (2003, 2004). Participants were also asked to indicate their HIV serostatus: HIV+ (tested); HIV- (tested); and 'not tested'. Serostatus was not included in the bivariate and multivariate analyses but is reported by way of background information.

AIDS knowledge: Table 2 lists the seven items used to compile the AIDS knowledge scale. The items were drawn from Kalichman and Simbayi (2003). Response options were 'yes', 'no' or 'do not know'. The scale was scored for the number of correct responses: 1=correct; 0=incorrect; 0='do not know' (score range 0 to 7; higher score=higher levels of knowledge); $\alpha=0.76$.

Statistical Analysis

The data were analysed using IBM SPSS Ver. 24.0 for Macintosh (IBM Corporation, 2015a) A confirmatory factor analysis (CFA) using AMOS Ver. 24.0 for Windows (IBM Corporation, 2015b) was conducted on the items measuring AIDS knowledge. Four critical fit indices were applied to determine the degree of fit of the measurement model as follows (with index values reflecting good model fit indicated in parenthesis) χ^2/df ratio (less than 4); Comparative Fit Index (CFI of 0.95 and greater); Root Mean Square Error of Approximation (RMSEA 0.05 and less); and Hoelter critical N (CN

index 200 and greater). Model improvements and parsimony were tested using the Chi-Square Difference Test.

Chi-square (χ^2) tests were used to examine bivariate relationships between AIDS knowledge and categorical demographic and behavioural characteristics. Ethnicity was used as a differentiating variable in the χ^2 tests. The independent samples t-test and ANOVA were used to compare the mean scores for AIDS knowledge of participants with their demographic and behavioural characteristics. Multiple regression and AMOS were used to explore the determinants of AIDS related knowledge.

RESULTS

Missing Value Analysis

Missing value analysis indicated that missing items were missing at random and that the proportion of the sample with missing values on all of the items of interest was less than 5%, with most items having less than 2% missing values. The low frequency of missing values meant that these could be addressed by listwise deletion.

Confirmatory Factor Analysis

No correlated errors were specified in the initial measurement model of AIDS knowledge. Output indices indicated a poor fit to the data (χ^2 /df ratio=18.975, $p < 0.001$, CFI=0.736, RMSEA=0.188 and Hoelter (95%)=46). All factor loadings were statistically significant ($p < 0.001$). The modification indices indicated the need for correlated error terms of AK1 ('Can men give AIDS to women') with AK2 ('Can women give AIDS to men?'). With this path specified, the resultant model (not depicted here) presented an excellent fit to the data (χ^2 /df ratio=1.431, $p=0.136$, CFI=0.994, RMSEA=0.029 (90%: LO=0.000; HI=0.056) and Hoelter (95%)=615), with all factor loadings statistically significant ($p < 0.001$).

Participant Characteristics

The demographic and behavioural characteristics of participants are shown in Table 1. Most participants in the full dataset ($n=512$) were male (91%; $n=461$). Ages ranged from 18 to 69 years (mean=36, SD=10.9), with most being in the 27-36 year age group (34%; $n=175$). Almost two-thirds (62%; $n=313$) of participants were 'Black' African (as distinct from the other ethnic groupings). Over a quarter (29%; $n=144$) had at most primary level education, whilst 52% ($n=260$) had secondary level education. Permanent employees accounted for 62% ($n=304$) of participants; while 34% ($n=167$) were contract workers (employed on a project basis); and 4% ($n=22$) occasional (casually hired) workers.

Sixty-six per cent ($n=320$) claimed to be HIV- (tested); 7% ($n=34$) reported being HIV+ (tested); 27% ($n=131$) had never been tested. More than half (51.2%; $n=242$) of participants reported personally knowing at least one HIV+ person. Twenty per cent of participants (20.4%; $n=102$) reported having had multiple sex partners in the preceding 3 months and half (49.7%; $n=248$) claimed not to have used a condom at last sexual act.

The mean knowledge score for the sample was 4.8 (SD=2.0). Over a third (35%; $n=171$) of construction workers scored less than the sample mean and less than a quarter (23%; $n=110$) of workers answered all questions correctly.

Bivariate Analysis

The association between level of AIDS knowledge and the demographic and behavioural characteristics of participant workers was examined (not depicted in Table 1). Firstly, the independent samples t-test was used to examine the association between level of AIDS knowledge and each of gender, ethnicity, acquaintance with an HIV+ person, two or more sex partners in the previous 3 months and use of a condom at last sex. Secondly, ANOVA was used to analyse the association between level of AIDS knowledge and each of age, level of education and employment position.

The t-tests indicated significant differences in the knowledge scale scores for females ($M=5.61$; $SD=1.78$) and males ($M=4.75$; $SD=2.02$; $t(55)=-3.03$, $p<.05$); 'Others' ($M=5.70$; $SD=1.51$) and 'Black' Africans ($M=4.23$; $SD=2.10$; $t(475)=8.92$, $p<.001$); and workers personally knowing HIV+ persons ($M=5.27$; $SD=1.71$) and workers not being acquainted with HIV+ persons ($M=4.38$; $SD=2.19$; $t(420)=-4.85$, $p<.001$).

Specifically, females, workers who were not 'Black' African and workers acquainted with HIV+ persons were significantly more knowledgeable about AIDS than were their counterparts. Workers not having had two or more sex partners in the previous 3 months and workers having used a condom at last sex did not indicate significantly better AIDS knowledge that did their colleagues.

ANOVA indicated a statistically significant difference in mean knowledge scores for the four age groups, $F(3, 466)=4.13$, $p<.05$. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for age group 4 (≥ 50 years) ($M=4.23$; $SD=1.83$) was statistically different ($p<0.01$) from group 1 (≤ 26 years) ($M=5.34$; $SD=1.77$). Groups 2 (27-36 years) and 3 (37-49 years) did not differ significantly from either group 1 or group 4. In essence, despite a general inverse relationship between age and mean knowledge scores, significant differences in mean scores only existed between the youngest and oldest age groups. Similarly, the results indicated a statistically significant difference in mean knowledge scores for the three education level groups, $F(2, 475)=43.60$, $p<.001$. A positive association between education and AIDS knowledge was indicated. Post-hoc comparisons pointed to significant differences in mean knowledge scores between the three education groups (all $p<.001$) *i.e.* primary or less ($M=3.66$; $SD=2.16$); secondary ($M=4.98$; $SD=1.85$); and tertiary or higher ($M=5.96$; $SD=1.41$). Significant differences were not apparent between the mean knowledge scores and the three employment categories.

In comparing participants' demographic and behavioural characteristics with respect to ethnicity (see Table 1), significant differences were evident with respect to age, level of education and use of a condom at last sex act. Specifically, 'Black' African workers reflected proportionately more older and less-educated workers and less use of condoms at last sex act than did workers in the 'Others' group.

Participants' responses ('correct' or 'incorrect' answers) in relation to the seven AIDS knowledge questions were examined in terms of ethnicity of respondent (see Table 2). Significant differences (not shown here) were indicated for each item ($p<0.001$), except for item AK3: 'Must a person have many different sex partners to get AIDS?' ($p=.17$). Participants varied in the extent to which they provided incorrect answers across the items.

Finally, the relationship between the 7 items of the AIDS knowledge scale was examined using correlation analysis (results not depicted here). All items were positively associated, the vast majority $p<.001$.

Table 1. Bivariate association between participant construction workers' characteristics and ethnicity

Characteristics	Total	%	'Other' (n=193)		'Black' African (n=313)		χ^2 p-value
			n	%	n	%	
<i>Demographic</i>							
<i>Gender</i>							
Male	459	91.3	173	90.6	286	91.7	.745 ^b
Female	44	8.7	18	9.4	26	8.3	
<i>Age</i>							
26 and younger	100	20.4	60	31.9	40	13.3	<.001
27 to 36	175	35.8	61	32.4	114	37.9	
37 to 49	144	29.4	45	23.9	99	32.9	
50 and over	70	14.3	22	11.7	48	15.9	
<i>Level of education</i>							
Primary or less	143	28.7	23	12.0	120	39.2	<.001
Secondary	259	52.0	103	53.6	156	51.0	
Tertiary or higher	96	19.3	66	34.4	30	9.80	
<i>Employment position</i>							
Permanent	304	61.9	107	56.3	197	65.4	.121
Temporary / Contract	166	33.8	73	38.4	93	30.9	
Casual	21	4.3	10	5.3	11	3.7	
<i>Know any HIV+ people?</i>							
None	231	48.8	91	49.5	140	48.4	.851 ^b
At least 1	242	51.2	93	50.5	149	51.6	
<i>Behavioural</i>							
<i>Have you had 2 or more sex partners in the last 3 months?</i>							
No	399	79.6	159	82.8	240	77.7	.173 ^b
Yes	102	20.4	33	17.2	69	22.3	
<i>Did you use a condom the last time you had sex?</i>							
No	248	49.7	61	31.8	187	60.9	<.001 ^b
Yes	251	50.3	131	68.2	120	39.1	

Notes: ^aReported for the past three months; ^bFisher's Exact Test; ^cIndependent-samples t-test.

Multivariate Analysis

Multiple regression analysis was used to assess the ability of the demographic and behavioural characteristics of participant workers to predict levels of AIDS knowledge of workers. Preliminary analyses were conducted to assess violations of the assumptions of normality, linearity, multicollinearity and homoscedasticity. Listwise deletion of cases with missing values resulted in 425 cases for use in the regression analysis. The results of the regression analysis are depicted in Table 3.

The total variance explained by the model was 25.5%, $F(8, 417)=17.86$, $p<.001$. After controlling for all covariates, four variables proved statistically significant predictors, namely, ethnicity ($\beta=-.26$, $p<0.001$), level of education ($\beta=.24$, $p<0.001$), personal acquaintance with HIV+ persons ($\beta=.21$, $p<0.001$) and employment position ($\beta=-.09$, $p<0.01$). Worker age and AIDS knowledge proved to be substantively associated, but not significantly so ($p=.07$). The beta values indicate that ethnicity, level of education and acquaintance with an HIV+ person made the strongest unique contributions to explaining AIDS knowledge of workers.

Table 2: AIDs-related knowledge of participant construction worker - ethnic differences

Knowledge questions	Total	%	'Other'		'Black' African		χ^2 p-value
			n	%	n	%	
<i>AK1. Can men give AIDs to women? (Yes)</i>							
Incorrect answer	106	21.3	13	6.8	93	30.5	<.001 ^a
Correct answer	391	78.7	179	93.2	212	69.5	
<i>AK2. Can women give AIDs to men? (Yes)</i>							
Incorrect answer	81	16.3	10	5.2	71	23.1	<.001 ^a
Correct answer	417	83.7	181	94.8	236	76.9	
<i>AK3. Must a person have many different sex partners to get AIDs? (No)</i>							
Incorrect answer	259	51.5	91	47.4	168	54.0	.168 ^a
Correct answer	244	48.5	101	52.6	143	46.0	
<i>AK4. Does washing after sex help protect someone from getting AIDs? (No)</i>							
Incorrect answer	166	33.1	34	17.7	132	42.7	<.001 ^a
Correct answer	335	66.9	158	82.3	177	57.3	
<i>AK5. Can a pregnant woman give AIDs to her baby? (Yes)</i>							
Incorrect answer	176	35.4	30	15.6	146	47.9	<.001 ^a
Correct answer	321	64.6	162	84.4	159	52.1	
<i>AK6. Can the use of vitamins and healthy foods cure AIDs? (No)</i>							
Incorrect answer	189	37.9	44	22.9	145	47.2	<.001 ^a
Correct answer	310	62.1	148	77.1	162	52.8	
<i>AK7. Can traditional African medicines cure AIDs? (No)</i>							
Incorrect answer	150	30.1	30	15.7	120	39.0	<.001 ^a
Correct answer	349	69.9	161	84.3	188	61.0	
<i>AIDs-related knowledge (knowledge scale)</i>	M	SD	M	SD	M	SD	<.001 ^b
AIDs Knowledge scale score (range 0-7)	4.81	2.02	5.70	1.51	4.23	2.10	

Notes: Incorrect answers include 'Do not know' responses. ^aFisher's Exact Test; ^bIndependent-samples t-test. For AIDs-related knowledge, correct responses are indicated in parentheses.

Table 3: Multiple regression analysis of the determinants of AIDs-related knowledge of participant construction workers

Variables	β	t	p-value	R ²	ΔR^2	ΔF
<i>Demographic and behavioural</i>						
Gender	.017	.376	.707	.255	.255	17.855***
Ethnicity	-.263	-5.455	.000***			
Age	-.086	-1.798	.073*			
Level of education	.237	4.844	.000***			
Employment position	-.091	-2.013	.045*			
Know any HIV+ people?	.211	4.901	.000***			
Multiple sex partners? ⁺	.001	.012	.990			
Condom use at last sex?	-.010	-.230	.818			

Notes: ⁺Reported for the past three months; *p<0.05; **p<0.01; ***p<0.001

In essence, 'Black' African workers, workers with lower levels of education, workers subject to greater job insecurity (temporary and casual workers) and workers not personally acquainted with HIV+ persons indicated lower levels of AIDs knowledge than did their counterparts. Gender, age, number of sexual partners in the preceding 3 months and use of a condom at last sex were not found to be significant in the multivariate model. Examination of the adjusted R2 value reveals little loss in predictive power when compared to the R2 value (.26 versus .24), which indicates a lack of overfitting that would have been evidenced by a more marked difference between the two values. Moreover, with eight independent variables in the model, a

good ratio of observations to variables in variate is maintained. This explanatory model was tested using path analysis with AMOS (not shown here). The path analysis supported the regression model, although the regression weights differed slightly. Possible reasons for this might be that SPSS uses the Generalized Least Squares (GLS) algorithm while AMOS uses the more efficient and accurate Maximum Likelihood Estimator (MLE) AMOS also permits predictors to vary, giving different estimates to when the Ordinary Least Squares (OLS) method is used, where predictors are assumed to be independent.

DISCUSSION

This study examined determinants of AIDS knowledge among South African construction workers. Generally, our findings resonate with similar studies in southern Africa. AIDS knowledge was generally 'poor' (35% below the mean score), with less than a quarter of workers (23%) possessing 'accurate' knowledge. This is similar to the national findings (27%) of Shisana *et al.*, (2014). No association was found between AIDS knowledge and gender, but 'Black' Africans were found to be less knowledgeable than the combined ethnic group. These findings align with those of Shisana *et al.*, (2014) for the general population. In contrast to Shisana *et al.*, (2014), however, no association was found between AIDS knowledge and worker age in the multivariate analysis. The bivariate analysis did provide evidence of an inverse association between age and AIDS knowledge, but this was restricted to differences between the youngest and oldest age categories. One possible explanation for this could be the strong relationship between age and education ($p < 0.001$), whereby the effect of age is 'masked' by education level. As with Shisana *et al.*, (2014) and Misrohmasari *et al.*, (2016), education was identified as a pivotal determinant of AIDS knowledge.

Although our study did not establish the residential location of workers, nor their socio-economic and family environments, in this regard education arguably serves as a suitable proxy - especially in relation to older, 'Black' African and poorly-educated workers. These workers typically originate from rural environments, experience urban poverty, are employed on a more casual basis, tend to perform unskilled tasks on site and possess low levels of AIDS knowledge. These findings align with those of Yaya *et al.*, (2016) and Odhiambo *et al.*, (2003). As previously reported by Alwafi *et al.*, (2018) and Hong *et al.*, (2012), this study found positive associations between AIDS knowledge and that of being HIV- and that of knowing HIV+ persons.

This study did not establish an association between level of AIDS knowledge and either of having had multiple sexual partners in the preceding 3 months and use of condoms at last sex. These findings are in direct contrast to the findings of Anderson *et al.*, (1990) (inverse relationship with multiple partners) and Glick *et al.*, (2008) (positive association with condom use) A possible reason for this may lie in ethnic cultural diversity and also in different attitudes between survey participants from rural backgrounds compared to those with only urban upbringing. The findings of this study provide pointers to construction firms regarding better structured intervention packages that target more effectively employee groups at greatest risk of infection.

Our findings need to be tempered by the following limitations: the cross-sectional nature of the survey; the reliance on participants' self-declarations (including possible recall and social desirability bias); the potential under-reporting of risky behaviours; the use of a self-reporting survey instrument; and response validity (35% of participating workers had at most primary level education). The dichotomous and

multiple-choice tick-box format of the questions may have led some of the more illiterate construction workers to mask their disadvantage by completing the questionnaire on a more or less random basis; condom use was only measured for the last sex act and did not account for respondents' attitudes towards condoms nor the consistency or correctness of condom use.

CONCLUSIONS

The results of this study conducted in the SA construction industry demonstrate overall levels of HIV transmission knowledge in workers comparable to those demonstrated in the general population. A greater lack of knowledge was observed among especially vulnerable individuals affected by combinations of lower education and poverty. Our findings should alert construction industry intervention providers that, although overall levels of general HIV transmission knowledge may appear 'good', some vulnerable groups may continue to be at an increased risk due to incomplete or contradictory AIDS knowledge - particularly lower-educated 'Black African workers employed in non-permanent positions.

The link between workers' ethnicity, level of formal education and the extent of their AIDS knowledge has important implications for the actual HIV/AIDS interventions implemented by construction firms. It suggests a need for more carefully structured interventions specifically designed to reach 'Black' African workers with lower levels of education and poorer AIDS transmission knowledge. A "one size fits all" approach is unlikely to be effective and highly nuanced HIV knowledge delivery will be needed to embrace different literacy levels, language use, culture, traditional beliefs, work status and peer group pressures.

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A PARTICIPANT OBSERVATION STUDY OF GENDER DYNAMICS ON CONSTRUCTION SITES

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While the working population of women in the UK is 47%, in construction this drops to less than 10%. There are significantly more women working in a professional than operative capacity. This has led to investigations into why women do not enter the industry, and why they leave it. However, too little work has been done to explore the day-to-day experiences of professional women whilst employed in construction, particularly those in site-based roles. This paper details the findings of participant observation on a £16M construction project in Scotland between June 2017 and March 2018. The site employed an average of 30-40 workers per day and the researcher, who was employed as a trainee student engineer, was the only woman in a site-based role at the time of the study. Via Kanter's theory of tokenism, the research considers a number of issues surrounding the presence of women on construction sites. The results highlight the issues of traditional gender role assumption and the objectification of women that need to be addressed and changed to aid the industry in encouraging, welcoming, and retaining more female operatives into the sector whilst gaining a better gender balance in the workplace.

Keywords: careers, ethnography, gender, participant observation, women

INTRODUCTION

There is a lack of female employees within the construction sector and a growing need to gain a better gender balance (Goodrich, 2016). In the UK, females account for 9% of engineers and 2% of construction workers (WES, 2014). An increase of women into the sector can bring many benefits, such as: more innovative problem solving; improved productivity alongside a more cohesive working group; and alleviating skills shortage within the industry (Agapiou, 2002). Current research has led us to understand and appreciate some of the issues that women face entering the construction industry, and why they leave. However, there is still a large research gap when considering the lived experiences of women in construction.

This paper will first introduce and explore current understandings of women within the construction industry, before detailing the ethnographic research approach used. Within the findings and discussions section the data will be presented as three themes: mentoring; traditional roles; and objectification. The conclusion will highlight suggestions for further research and industry.

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Background

Construction currently has a greater ratio of men to women in both professional and operative roles. In a Western European comparison, Byrne *et al.*, (2005) found that countries which focused on qualifications rather than experience had greater levels of female participation. Further, when compared to their male counterparts, they found that women find it harder to enter the industry, and to gain additional qualifications when working due to family commitments. Similarly, Fouad *et al.*, (2017) concluded that women would be more likely to leave the engineering sector if their needs in achievement, status, and comfort are not met. The results noted that a demanding work environment played a crucial factor in their decision to leave the industry. Respondents felt that workload and travel expectations within engineering impact on family life, particularly for women with young children. Dainty *et al.*, (2010) also found that such work and family conflicts led women to progress at a slower rate than their male counterparts. Further, in a study of work-life experiences, Lingard and Francis (2004) found that long working hours, high levels of conflict and emotional exhaustion resulted in family issues. Women participants reported significantly better home life relationships than their male counterparts. Surprisingly, their findings suggested women who are site based do not experience greater difficulty than office based staff in regards to work-family interference.

Employment conditions are critical to retention, specifically the wage structure. Men are often afraid that women will reduce overall pay rates (Byrne *et al.*, 2005), and women can also be seen as added competition and a threat (Dainty *et al.*, 2010), both of which can result in exclusion and poor retention levels of women in the industry. Worrall *et al.*, (2010) found an overarching perception that women are initially seen as being less capable or are assumed to be working in administrative roles. In addition, Agapiou (2002) and Eisenberg (1999) both found the perception that women should not be involved in structural aspects of the construction site, as this is deemed to be “too dirty”. Instead, women should be involved in the finishing trades, which are considered more feminine. It is suggested that to retain women in the industry then, “there are fundamental attitudinal changes towards non-traditional entrants” (Dainty *et al.*, 2010, 11).

Thus, there are barriers to women entering the industry, and limited ideas of the types of work they may carry out. The research presented thus far does not however describe the situations which women are faced with on a day-to-day basis when working in construction.

LITERATURE REVIEW

Assigning Gendered Roles

With an increase of women being attracted into construction (Office for National Statistics, 2017), one of the main obstacles that women must overcome is ‘macho’ attitudes that are found here (Gale, 1994). Agapiou (2002) suggests that men assign gendered roles to women often through the means of smart remarks. In response to this, the women that he interviewed thought that “[women] who cannot take a joke should not be on the site” (9). In her analysis of women in the military, Herbert (1998) found a similar situation, highlighting the presence of a gender ideology which was used to define whether a particular gender is suited/appropriate to complete a job. She also noted that women in male-dominated sectors must develop strategies to cope with the hostile working environment that can be posed by their male colleagues.

Through interviews with women engineers, Fouad *et al.*, (2016) found that feelings of being an outsider to the “boys club” contribute to women leaving. Whilst many believe that women are subjected to traditional roles it has been found that there are different communication methods by both genders. Loosemore and Galea (2008) found that the difference in communication stems from childhood and continues on to adulthood. Male communication can be characterised by interruption where there is a focus on orderly conversation and fending off interruptions by speaking over the person. Between women, conflict can be characterised by fewer monologues which symbolises solidarity rather than individualism, and there are lower levels of conflict when a woman was present. Thus, an increase in women could have a positive impact on the communication and leverage aspect of the construction industry.

Objectification and Harassment

Tran (2016), who has the distinct perspective of being a transgender woman, suggests that men are subconsciously taught to objectify women from a young age. She suggests that the media portrays women as a prize or reward to be gained after being "chased", and notes that this characterisation might encourage men to mistreat women. Saguy *et al.*, (2010) explored the consequences of the objectification of women by men and how this can impact on their social behaviours. They note that objectification can lead to women narrowing their social presence which can hinder performance in mixed sex situations such as the workplace. Objectification can also impact on women's mental health. Objectification may be ingrained in some cultures, reinforced by media stereotypes, teaching, and upbringing as experienced by Tran (2016); but, as concluded by Saguy *et al.*, (2010), its effects are quite often real and lead to issues that go further than just workplace dynamics.

Hoffer (2017) identified how two female construction workers were sexually harassed in various forms, including men exposing themselves, stalking, and sexist comments. Meanwhile, Alderson (2017), shows an incident where a client took hold of a female architect and made his sexual intention clear; this led the architect to worry about the repercussions of saying no. However, Powell *et al.*, (2006) found that women were reluctant to admit that they had been discriminated against and further justified the actions of their colleagues. They also found that women were less likely to report sexual harassment due to the perceived impact it may have on their career. In a survey by Opportunity Now it was found that, of women within the construction industry, 22% and 59% have been sexually harassed and bullied; and harassed excluding sexual harassment, respectively (Nawrockyi *et al.*, 2014). Indeed, with a sexual harassment rate of 59% (ibid) there is much to improve about the image of construction to be able to gain a better gender balance. Sexual harassment within construction can tarnish the image of the industry, and lead people to leave it completely, contributing to the perception of the construction industry as a male environment.

Supporting Women in Construction

Both Francis (2017) and Parker (2016) researched the effect of mentoring and networking on the progression of women's careers. Their findings are in agreement suggesting that networks and mentoring do retain women within the industry but they do not advance women's careers. They explain that good early experience, further education and a company with a greater gender balance will influence women's career advancement. The studies don't take into account women that have left the industry after having children. Bigelow *et al.*, (2016) however found that mentoring was a

positive influential factor in the retention of female construction management students. Worrall *et al.*, (2010) found that an increase in CPD training and the availability of mentors and networking events would help in the retention of women. However, a lack of mentoring in the workplace can lead to feelings of isolation and marginalisation within the company which leads to a lack of ambition to advance.

RESEARCH QUESTIONS

Whilst previous research has let us understand some of the challenges that women face entering the construction industry, and why they leave, there is still a large gap in the research when considering the lived experiences of women in construction. The identified research questions are as follows:

- Does having a woman on a construction site affect the working relationships?
- In what ways might women be treated differently on a construction site when compared to their male counterparts?
- What might be done to improve the inclusivity of the workplace in construction?

METHODOLOGY AND METHOD

The research here provides an insight into the dynamics and workings of a construction site; as a woman training to be an engineer, the researcher was granted an opportunity to undertake participant observation during which she was both a trainee, and the only woman on site. Participant observation is a method of data collection whereby the researcher immerses themselves within the environment to study the cultures and practices that through observational methods (McKechnie, 2008). Fetterman (2008) states that “participant observation characterises most ethnographic research” (6). Observational research allows the researcher to check for non-verbal interactions and to experience fully the interactions between people that would not necessarily be possible through alternative approaches, such as interviews (Kawulich, 2005). Some of the advantages of this approach include (Kawulich, 2005):

- detailed descriptions of interactions and situations
- unseen viewpoint of the environment that the researcher is interested in
- improves the quality of data collection which can facilitate new research questions

The method has started to gain traction in the construction industry - particular examples being Pink *et al.*, (2013), Best (2012) and Oswald *et al.*, (2018) who have used it to generate fresh insights into the social and cultural aspects of construction sites. It also allows a detailed description of the events which occur, giving the reader a fuller appreciation and understanding. For this project participant observation allows an in depth and first-hand look into the experience of a woman on a construction site. The researcher’s role as a worker makes this approach similar to an autoethnography; however, being also a student engineer meant that she was not an already established member of the study community.

Research Approach

The researcher was employed on a £16M district energy network construction project in Scotland between June 2017 and March 2018. Works included the installation of district heating pipework and the refurbishment of an existing energy centre. The site employed approximately 30-40 workers per day, with a demographic of males aged 18-72. Research was undertaken using overt observations whilst employed as a

female student site engineer, the role consisted of general site management duties, providing permits to work, overseeing sub-contractors and maintaining health and safety on site. The code of ethics that ethnographers must adhere to specifies that no harm is to be caused, neither to the people nor the community under study (Fetterman, 2008). Consequently, access to the site and informed consent was gained from the gate keeper, in this case the project director and research ethics approval was granted by the university; all names have been changed to preserve anonymity.

Data Analysis and Theoretical Framework

Traditionally, data is recorded in the form of field notes, which are written up away from the subjects of the research (McKechnie, 2008). In this project the data was recorded as soon as possible after the event had taken place, either in a notebook or on a mobile phone, which the researcher was seen using on site. At the end of the day, the field notes were expanded on and inputted onto the computer. Kanter's theory of Tokenism (1977) has provided the framework for analysis. Kanter argues that an imbalance of groups creates preconceived perceptions of tokens by dominants; a dominant is someone from the majority group, whilst a token is someone from the minority group. In the case of construction, this is male dominants to female tokens. Kanter's theory is split into three themes: visibility, assimilation, and polarisation.

Visibility is where tokens capture a larger awareness share from dominants, and Kanter found that tokens try to minimise their visibility. Whittock (2002) however, in a study of women in non-traditional roles including construction suggests that some tokens utilise their visibility through performance pressure by either over performing or dropping out.

Kanter (1977) demonstrates assimilation in relation to stereotyping, for example, the use of the stereotype of men as protectors in order to retain dominance. Assimilation within UK engineering culture was explored by Powell *et al.*, (2006) when considering the achievement of critical mass. There is an argument that once a critical mass ratio is achieved there can be a shift in tolerance of difference and a change in women's token status. Powell *et al.*, (2006) question whether this is achievable in terms of women in construction. They conclude that the key to change is the support of persons in structural positions of power, who act as gatekeepers and thus either deter women from entering or encourage conformity to masculine engineering culture.

Finally, polarisation is where there is a tendency to exaggerate the differences between dominant and token groups. Kanter (1977) found that tokens in non-traditional employment may act in accordance with the majority group and thus reinforce rather than challenge the dominance of the majority group. For example, positioning women as outsiders reinforces men as the dominant group. Whittock (2002) utilised this theoretical framework in her analysis of women's involvement in manual trades. She found that women act in accordance with Kanter's ideas and that being thick skinned, having a sense of humour and being 'one of the boys' are key to succeeding in non-traditional employment.

FINDINGS AND DISCUSSION

The following data present early compilations from the participant observations made on site; these are explored according to three themes which have emerged from the analysis: mentoring and visibility, assimilation through traditional gendered roles and objectification as a consequence of polarisation.

Mentoring and Visibility

With mentoring comes the idea of protection by senior figures; this became clearly apparent whilst the researcher was eating dinner with fellow workers:

Dinner had been eaten and the plates taken away when the conversation moved on to how Harry wanted to take me under his wing to mentor me. It was at this point when he turned around to Ron and let him know that he was no longer mentoring him but me instead. This did not go down well with Ron who put up a bit of a tantrum and was not a fan that I was the “new favourite”. (Field note no.3)

Harry in this instance is showing his preference for the female mentee with Ron not being happy about being let go. The following vignette shows how having a mentor to guide and teach enhances the learning of the student.

I had finished taking measurements on site so went back to the office to draw the elevations up on CAD. Once I was done I sent them off to Ron who came back saying that they were fantastic and that he would pass them on to Harry. (Field note no.9)

Here the researcher had been left with a task which was completed and sent to Ron for approval who then passed the work on to the mentor. Bigelow *et al.*, (2016) found that mentoring was a positive influential factor in the retention of female construction management students and this was found to be true with positive reinforcement. Nevertheless, during the researcher’s time on site, this positive reinforcement extended to protection:

It started raining and Rob asked if I wanted to stand under the umbrella so I didn’t get wet, I said no as its only rain and that I wouldn’t melt, Peter said I don’t want you catching a cold I could see that he was just protecting me from the rain. (Field note no.1)

Here, the operative is offering the researcher protection from the rain in the form of his umbrella. This demonstrates the heightened visibility of the researcher, who, as the only female on site, receives additional focus. In this case it is a positive reinforcement of heightened visibility through the application of mentorship and protection shown by colleagues. It was felt that having a mentor helped the researcher in understanding the industry and the day to day practices of working on a live construction site. This also meant that the researcher had someone of whom they could ask questions, expand their knowledge and thus could help to progress within the company. This is contradictory to Parker (2016) and Francis (2017) but in keeping with the findings from Bigelow *et al.*, (2016) with the positive influence of mentorship on the progression of female careers. Despite these positive mentoring experiences, there were also elements of assimilation regarding traditional gendered roles.

Assimilation through the Assignment of Traditional Roles

Traditional roles for women in construction often consist of administrative duties. Observations suggest that this idea persists in different aspects of work on site as demonstrated in the following case:

I started to gather cups up one at a time till my hands were full when a guy, who I had met only the day before, placed his cup at the end of his desk and nodded at me. I responded with ‘I’m washing up not making a round’. Muttering under his breath, he replied, ‘but that’s what women do’. (Field note no.3)

Assimilation is evident here as there is the stereotyping of a woman working in the kitchen. This is just one of the attitudes that women working in the industry must overcome to succeed. The assignment of gender roles was not just confined to relaxed

informal exchanges but was experienced in a more formal setting between the researcher and a sub-contractor, for example:

I was sat minding my own business when Dave a subcontractor came into the office. The conversation had started about the work that was going on and then he turned to me. He started asking me questions about why I was here and what I was doing in construction. I turned this around on him by asking if I should be on a construction site as a female, to which he answered that women should not be on construction sites in the first place. (Field note no.19)

This vignette shows how some of the men in the industry still believe that women should retain traditionally observed female roles, away from the construction site. Similar ideas were seen elsewhere, for example, when the mentor suggested that he and his assistant needed a woman on the team to keep them organised. Observations also suggest that ideas of women's roles as administrative duties still persist within construction:

Simon ended up screwing it up and couldn't sort it so Dave said "Don't give a man a woman's job" and proceeded to come over and ask me to print the drawings properly. (Field note no.22)

Similarly every now and then Jack would come out of the meeting room and ask me where specific pieces of paperwork were as he had no idea. (Field note no.26)

In another instance both Simon and Duncan turned around to me and asked if I was the new Linda doing the admin and ordering side of the job. (Field note no.33)

A further example, Harry turns around and says, 'I don't want to treat you like a secretary but can you print this off for .me?' 'Well it seems like I'm PA to everyone else so why not you?' (Field note no.34).

The assumption in these cases seems to be that women are most suited to organisational roles, whilst men are more suited to the technical aspects of the job. The notion of women specifically organising men also alludes to women nurturing men and enforcing gender stereotypes. Assimilation is evident here with the stereotyping of the researcher's social type; this can lead to role entrapment. These data are in keeping with Herbert's (1998) finding of gender ideology within the workplace. Whilst there is an increase of women into the industry there are still the traditional thoughts on the jobs that women should be undertaking. Beyond ideas of the roles that women should play, the researcher experienced challenges with objectification whilst on site.

Objectification as a Consequence of Polarisation

Objectification was a regular occurrence for the researcher within the construction environment:

I was just heading up to the site to put up banners and posters for an impending inspection. There were lots of people milling about but there was one man that caught my eye. He must have been in his 50's and 6ft tall. He had been staring at me from when I had been about 50m away till after I passed him. It was a creepy feeling that I could not shake and made me feel like I shouldn't be there. (Field note no.1)

Another example of this was on the way back from site when the researcher walked past another construction site where two men in their mid-20s were on scaffolding. As the researcher walked towards them and then past they both stopped their work and watched. The researcher avoided eye contact and kept her head down (Field note no.8). Here the researcher was stared at whilst walking along the street by two operatives from another construction site. In another instance, on the way into work the researcher noticed a sub-contractor staring at her as she hurried into the office.

These were not isolated incidents but rather an accumulation. These events fit with the notion of polarisation and could perhaps be brushed off as the type of actions that just require a sense of humour or ‘thick skin’ to manage. Although these events might be perceived as insignificant, the problem can shift into harassment:

Me and Pete were stood in the living room looking out of the windows at the snow when he turned to me and said, "You could get me into a lot of trouble you could" with a smirk on his face while he put his arm round my waist. It was at this point that I froze. I couldn't move and just awkwardly stared out of the window. When we sat back down at our laptops he apologised for making me feel uncomfortable. (Field note no.47)

However, Pete reiterated his desires later in the evening:

We were stood at the lift waiting for it to arrive when Pete put his hands on my hips, turned me towards him more, and drew me in. He looked at me and as he said, “you know you're hot, really hot” I looked away. I froze. I couldn't move, I couldn't do or say anything. He said “you are. Slap me if I'm being bad. Go on.” (Field note no.47)

This is another example of unwarranted attention and physical contact with the severity of the incident increased. In both of these instances there was unwanted physical contact with inappropriate comments. Saguy *et al.*, (2010) explored the consequences of when women are objectified by men and how this can impact on their social behaviours. Objectification can lead to women narrowing their social presence which can hinder performance in mixed sex situations such as the workplace, and objectification can negatively impact on women's mental health. Both of the incidents documented here happened in a cohabitation environment and they highlight that sexual harassment is still apparent between co-workers even if not on site. They show that inappropriate behaviour can manifest when people simultaneously work, socialise, and live together. The construction industry creates this unique environment for its workers due to the nature of the jobs whereby the working environment is temporary until the completion of the projects. Cohabitation is common practice within the industry, and these examples raise concerns about what happens when men and women who work together also live together.

CONCLUSION

This study has highlighted that there are issues on site which need to be addressed before the gender balance of the construction industry can improve. The data analysed highlight the themes of mentoring and visibility, assimilation of traditional roles, and objectification. It has been identified that when women are present on construction sites there is a change in behaviour and treatment, whether this be staring or making inappropriate comments. If these issues are not addressed then the gender imbalance will continue and the industry will suffer due to not being inclusive of 50% of the population. As a non-executive director has said "It's this kind of culture on site that make many people say, 'I wouldn't want my daughter working there'," (Alderson, 2017). To address this, further awareness of the issue is required and implementation of appropriate training for all in the industry to understand what is and is not acceptable.

In her analysis of Kanter's theory, Zimmer (1988) suggests the major failing is that there is no acknowledgement to the degree in which organisational structures are embedded in a broader social construct. Zimmer also concluded that for women, the reality of sexism is a larger issue than that of tokenism and policies which do not address both are bound to fail, and that the consequences for women as a minority group are different than those for men as a minority group. Clearly sexism is a much

larger and broader issue and warrants a much more systematic analysis than provided here. Such an analysis could incorporate an understanding of the distinction between institutional, individual or on-site sexism and whether this is formally or informally sanctioned.

This research has set the foundations for further study into what happens within the industry for women. While this study was restricted to the Scottish construction industry; future work should include a further in-depth investigation on construction sites in different contexts, and with varying levels of female representation. It may be beneficial for future research to use participant observation through the position of a construction worker rather than a member of site management. It is also vital that any research conducted should be done so by a woman as only then can the issues faced be fully understood.

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THE TRANSFORMATION MECHANISM OF WORK-RELATED STRESS INTO UNSAFE BEHAVIOUR IN CONSTRUCTION INDUSTRY: BASED ON DEA METHOD

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During the last decade, increasing attention has been paid to the problem of work-related stress and mental health in the construction industry. Numbers of correlative studies have shown that work-related stress will directly or indirectly affect the performance of individuals and organizations, even may present itself in the form of unsafe behaviour. As one of the most significant causes of safety accident, the unsafe behaviour will bring immeasurable harm and loss to individuals and organizations. However, there is a relative lack of studies that provide clarity on underlying causes and the transformation principle of work-related stress into unsafe behaviour. In order to further study the relationship between work-related stress and unsafe behaviour, this paper carries out two-step research. Firstly, based on Robbins' stress theory model and unique the construction industry's unique working pressure incentives, this paper finds out that there are certain differences in the work-related stress sources of construction industry managers and constructors and collates the mechanism model 'work pressure source-work pressure experience-unsafe behaviour' from the manager's point specific to the construction industry. Secondly, considering the difficulties to quantify the relationship formula between the work-related stress and the unsafe behaviour, Data envelopment analysis (DEA), a multi-index analysis method that does not need to determine the weight and function relationship, is selected. Through interviews and investigations with 15 on-site construction projects' safety managers, this paper quantifies the situation of pressure sources and the frequency of unsafe behaviour in 15 projects and substitutes into the DEA model to verify the current correlation between the indicators and the work-related stress transformation effectiveness of each project. The sensitive of the work-related stress sources is determined by comparing the differences between the effective units and the invalid units, so as to propose the opinions on controlling the sources of work-related stress. The final analysis shows that a lack of social support, short job tenure and conflict demand are the three main stressors that need further attention in the construction of the factory.

Keywords: data envelopment analysis, Robbins' stress model, work-related stress

INTRODUCTION

With the accelerating pace of contemporary social life, workers from all industries began to feel a certain degree of work-related stress. In the construction industry, work-related stress has become an inherent feature of the workplace environment and

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can negatively transcend into family and personal lifestyles if not appropriately managed (CIOB, 2006). Loosemore and Waters (2004) pointed out that the increasing level of stress may present itself in the form of unsafe working practices, lower morale, higher turnover and poorer performance. The construction industry is one of the most risky industry (Li *et al.*, 2015; Wang *et al.*, 2016). In 2017, the Ministry of Housing and Urban-Rural Development of China announced a total of 692 safety accidents and 807 deaths in public housing projects. Construction workers' unsafe behaviour is one of the main causes of safety accidents and still needs continuous attention and research. It has been widely reported that there is a close connection between work-related stress and unsafe work behaviour, though very limited studies about the transformation mechanism between them have been undertaken (Dong-Chul Seo 2005; Choudhry 2008; Fogarty 2010). Currently, studies on workers' unsafe behaviour always mention the negative impact of work-related stress on them (Brandt *et al.*, 2016, Dan Wang *et al.*, 2018). However, the causes of work stress and the key role it played are often overlooked. Golparvar (2011) proposed a "pressure-imbalance-compensation model" through empirical research. The study pointed out that when employees feel work stress, their psychological perception and safety behaviour will appear unbalanced, and employees will do abnormal actions to seek inner balance. Dan Wang (2018) examined the predictive powers of safety-related stress and psychological capital (PsyCap) on safety behaviour, and the moderating role of PsyCap on the safety-related stress-behaviour relationship. Psychology believes that human behaviour will first be driven by psychological activity, and later external behaviour can predict the law of mental activity. Therefore, the inference of unsafe behaviour of employees to prevent the occurrence of safety accidents cannot be judged simply by analysing factors such as the safety atmosphere, the professional skills of workers, and the mastery of safety knowledge. More intuitive consideration, such as the abnormal actions caused by psychological factors, should also be considered as the reason of unsafe behaviour.

Research on work-related stress and unsafe behaviours is still a hot topic. This paper based on the understanding of the theory that work stress will present itself as unsafe behaviours and the work stress, as a subjective psychological factor, is difficult to quantify it and find specific function relationship. In addition, the simple correlation analysis cannot provide more guidance for actual work pressure control. Thus, this paper decided to select DEA method for in-depth study of the model for two reasons: 1) DEA method was used to analysis the relationship between abstract multiple indicators and does not need to determine the characteristics of index weights and function relationships. 2) DEA method was used to analyse the connection about safety atmosphere and employee safety behaviours in construction industry. After the two-step research, this paper can provide a basic work-related stress transformation model framework in construction industry and some advice for actual work-related stress transformation control.

LITERATURE REVIEW

Work-Related Stress

Since the 20th century, scholars have conducted more in-depth research on work-related stress. However, there is no general explanation for the definition of it. In the United Kingdom, for example, in the official documents published by the Health and Safety Executive organization (2004) stated stress is the adverse reaction a person has to excessive pressure or other types of demand placed upon them. In the United

States, the National Institute for Occupational Health and Safety (1999) defined work-related stress as “the harmful physical and emotional responses that occur when the requirements of the job do not match the capabilities, resources, or needs of the worker. Job stress can lead to poor health and even injury.” In China, scholars also have relevant definitions of work-related stress. For example, Xu *et al.*, (2004) believe that work-related stress is a series of reaction processes formed by individuals under the continuous action of stressors.

Although, when compared to other industries, the construction sector has relatively low levels of reported work-related stress, it is still a topic of concern for the industry (HSE, 2007). Different scholars have put forward different views on the study of the causes of work-related stress in construction field. A study of 36 construction site managers in the UK identified ten key stressors for construction managers using a stress audit in one company (Sutherland and Davidson, 1993). Gunning and Cooke (1996) in their Northern Ireland questionnaire study, also identified some specific stressors for two groups of construction professional such as working to impossible deadlines, client demands, hiring/firing staff, working on multiple projects and conflict within the firm. According to the document “An analysis of the prevalence and distribution of the stress in construction industry” (2007) published by the British official HSE organization, workers cannot change the process according to their own wishes and do not receive adequate support and assistance are the two main aspects where workers in construction industry feel more pressure than other industries. In addition, Madine (2000) and other scholars found that construction workers stress mainly come from the following stressors: Shorter deadlines, longer working hours, signing of short-term contracts, increased competition, fines and the industry constantly raise productivity.

Based on telephone interview study of 408 construction labourers, Goldenhar, Williams and Swanson (2003) also identified a number of possible stressors and how they link to negative safety outcomes such as injuries and near-misses. What's more, the main stressors related to injuries and near-misses were: Job demands, Job control, Job certainty, Safety climate and so on. The most significant stressors identified by construction managers have been work overload, role ambiguity and conflict, unpaid overtime restrictive career progression, the diverse range of personalities encountered in their work environment, commuting, changing technology, redundancy, client demands, limited resources, financial pressures, and budget constraints (CIOB, 2006). Paul Bowen and other scholars (2014) build a work-related stress structural equation model and find that age, gender, level of job control, and organizational climate are significant predictors of stress discrimination.

So far, there are three main research theories about the concept of work-related stress: Stimulus theory, reaction theory, and stimulus-response theory. Weiss (1983) is the representative scholar of stimulus theory, he believes that work-related stress is a psychological reaction that a person presents when receiving external environmental stimuli. This theory pays more attention to the influence of the external environment. Quick (1984) and other scholars, who support the reaction theory, emphasizes the need to study people's psychological responses to work stress. A more comprehensive overview of the work-related stress is given in stimulus-response theory. Robbins's “stress source-stress experience-stress result” has been widely used as a classical model in organizational work-related stress management.

Unsafe Behaviour

Unsafe behaviour in the construction industry refers to the behaviour of those who have caused an accident or may cause an accident, including two major connotations: First, it refers to the behaviour that has a high probability of causing an accident; second, it refers to the fact that it is not conducive to reducing disasters during an accident. Apparently, the “human” factor is highlighted in unsafe behaviour, which refers to the construction unit’s operational personnel, such as construction workers and managers. Through investigation and analysis of safety accidents in the construction industry, Researchers have found that construction workers' unsafe behaviours are the direct cause of accidents

The common unsafe behaviours are divided into several categories. Different official organizations will use corresponding methods to classify unsafe behaviours. The ILO divides unsafe behaviours into six categories: 1) neglecting safety operations when supervisors are absent; 2) performing machine operations at inappropriate speeds; 3) illegally using equipment with unacceptable safety performance; 4) using Tools are not safe or methods are not safe; 5) dangerous decoration, cultivation, mixing and connection methods; 6) ignore safety attitude work in a dangerous environment. The categorization standard for casualties of official employees (GB6441-1986) published in China in 1986, divided human unsafe behaviours into 13 categories, 54 sub-categories, such as operational errors, failure of safety equipment, and use of unsafe equipment.

Due to the inherent characteristics of the construction industry, construction workers are inevitably do some unsafe behaviours. For example, Construction workers may not wear safety protection equipment, such as safety helmets and seat belts, while at the construction site. Construction workers did not follow the correct operating procedures for construction (Adnan Enshassi *et al.*, 2015).

The traditional approach to evaluate construction workers’ safety behaviours (CWSB) is through the measurement and statistical analysis of incident-related data (such as number of injuries and ill-health, accident frequency and severity rates, and accident costs), which are often referred to as retrospective or lagging indicators (Sgourou *et al.*, 2010).

Robbins’ Stress Model

The Robbins stress model is a relatively complete conceptual model that embodies job stress generation and has been widely used in organization work stress management. In his book, Robbins introduced the model in detail. He believes that the potential sources of stress can be divided into three categories: Environmental factors, organizational factors and personal factors. When individuals feel pressure, they will experience different pressure feelings due to their personal work experience, social support, and loyalty. Thus, they will eventually manifest the pressures in physical, psychological, and behavioural aspects (Robbins, 2012). The Robbins model is shown in Figure 1. According to this model, work-related stress resources involved in previous literature is shown in Table 1.

THEORETICAL HYPOTHESIS

According to the purpose, this paper further clarifies the research path on the basis of the literature review. That is, starting from the source of work-related stress in the construction industry and considering the entire transformation process from the source of work-related stress to unsafe behaviour. Taking into account the complexity

of work-related stress and unsafe behaviour, this paper needs to further refine the concept of these.

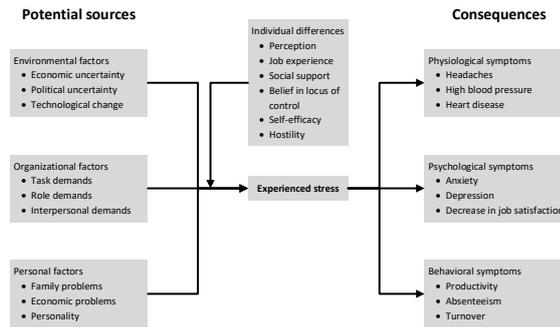


Figure 1: Robbins' Stress Model

Table 1: Relevant Factors on Work-related Stress Resources Involved in Previous Literature

	1993 Sutherland <i>et al.</i> ,	1996 Gunning <i>et al.</i> ,	2000 Madine	2003 Goldenhar <i>et al.</i> ,	2006 CIOB	2007 HSE	2014 Paul Bowen
Environmental factors							
Lack of social support	√	—	—	—	—	√	√
Technological change	—	—	√	—	—	—	—
Job tenure	—	√	√	√	—	—	—
Organizational factors							
Conflict demand	—	√	—	√	√	—	√
Commuting	√	—	—	—	—	√	—
Work long hour	√	—	√	√	—	√	√
Deadline pressures	√	√	√	—	√	—	√
Volume of paperwork	√	—	—	—	—	—	—
Inadequate communication	√	—	—	—	—	—	—
Staff shortage	√	—	—	—	—	—	—
Job over control	√	—	√	√	—	√	√
Increasing competition	—	—	√	—	—	—	—
Organizational climate	—	—	—	√	—	—	√
Work overload	—	√	—	—	√	√	√
Personal factors							
Financial penalty clause	—	—	√	—	—	—	—
Conflict with the firm	—	√	—	—	—	—	—
Work-life balance	√	—	—	—	—	—	√

The research background of this paper is mainly based on Chinese construction projects and focuses more on stress source analysis, so work-related stress is defined as a series of reaction processes formed by individuals under the continuous action of stressors. Also, this article defines unsafe behaviour as the behaviour of those who may cause an accident. Thus, based on previous scholars' research, this paper proposes two theoretical hypotheses and validates them. H1: The severity of work stressors is positively related to the frequency of unsafe behaviour. H2: Different working pressure source structures have different conversion effects to unsafe behaviour. Based on this assumption, this paper compare the three main work stress theory. Considering the aim to analyse the entire transformation process from stressors to behavioural features, the Robbins model has a similar three-layer

structure. Therefore, the Robbins model is selected as the theoretical basis for Work-related stress transformation model in construction.

METHODOLOGY

Based on the above two related assumptions and the theoretical basis of the transformation model, the research method of this paper is divided into three steps, including the determination of transformation model, the collection of relevant data and the selection of data analysis methods.

Work-Related Stress Transformation Model in Construction

Based on Robbins model, this paper focus on the characteristics reflected in the behaviour and puts forward the work stress model for construction industry practitioners. It was found that there was a difference in the sources of pressure between the managers and the workers in construction industry. Among them, volume of paperwork, long way commuting, the shortage of staff and the lack of communication were sources of pressure unique to managers. At the same time, the unsafe behaviours studied in this paper are based on the project level, three common unsafe behaviours are selected, including not wear safety protection equipment, illegal construction, and not active participation in safety technology. Based on the previous analysis, the final model of the work-related stress transformation in the construction is put forward and shown in the following figure 2.

Data Collection Method

15 factory construction cases are selected as the database for project analysis. Through interviews and investigations with 15 on-site construction projects' safety managers, this paper quantifies the severity of pressure sources and the frequency of unsafe behaviour in 15 cases. Since stressors and unsafe behaviour cannot be directly measured, the 5-point scale method Likert was used to evaluate its severity.

Selection of Analysis Model

Data Envelopment Analysis (DEA) is a non-parametric method proposed by Charnes, Cooper, and Rhodes (CCR) in 1978, which aims to measure the relative production efficiency of multiple decision-making units (DMUs).

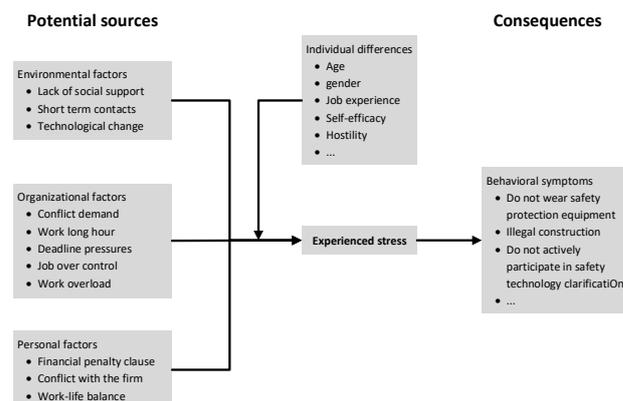


Figure 2: Stress transformation model in construction

Compared to the parametric approach, it can effectively evaluate the relative efficiency of multiple input and multiple output DMUs. The application of DEA has matured, but this maturity has not reached the same level in the field of construction. The first successful case of DEA applied by Charnes and Cooper *et al.*, was to

evaluate the effect of setting up a public school for mentally handicapped children. In the assessment, the output includes intangible indicators such as “self-esteem”. Each indicator has difficulty in setting weights. At the same time, the DEA model does not need to set the functional relationship between indicators in advance. According to the hypothesis, there is a correlation between the severity of work stressors and the frequency of unsafe behaviour. The article chooses a multi-index relationship analysis method and considers that the functional relationship between the two is unknown, and for the purpose of analysing the conversion efficiency, this paper believes that DEA has the ability to analyse the links between intangible indicators and the non-parametric analysis features are suitable for analysing the transformation model.

DATA ANALYSIS AND DISCUSSION

Analysis and Interpretation of Index

The DEA research model includes input variables as well as output variables. The choice of input and output indices is based on the principles of rationality, objectivity and credibility. The previous article sorted out the basic model of the construction industry's work-related stress transformation. The source types are merged and the final model input and output specifications are shown in Table 2. In order to facilitate further analysis, each index is represented by codes I1-I5 and O1-O3.

Table 2: System of Final Indexes

	Second tier indexes	Third tier indexes	Code
Input	Environmental factors	Lack of social support	I1
		Short job tenure	I2
		Conflict demand	I3
	Organizational factors	Deadline pressures	I4
		Job over control	I5
Output	Unsafe behaviour	The severity of illegal construction	O1
		The severity of construction without security facilities	O2
		The severity of negative participation in Safety technology clarification	O3

Analysis Using DEA Method

Data processing

Through interviews and investigations with 15 on-site factory construction cases' safety managers, this paper use the 5-point scale method Likert to quantify the severity of work stressors and the frequency of unsafe behaviour. At the same time, for the confidentiality of information, M1-M15 codes are used to represent the projects, which are located in Wuhan, Shanghai and Beijing. Small, medium and large projects are all involved. For data processing using the DEA method, a positive correlation between input and output variables is required. Before the DEA analysis, the correlation between input and output value is analysed, with the calculation results given in Table 3. The degree of correlation is calibrated using the coefficient γ .

$$-1 \leq \gamma \leq +1 \left\{ \begin{array}{l} \gamma = -1, \text{completely negative correlation;} \\ -1 < \gamma < 0, \text{negatively correlated} \\ \gamma = 0, \text{uncorrelated} \\ -1 < \gamma < 0, \text{negatively correlated} \\ \gamma = 1, \text{completely positive correlation} \end{array} \right.$$

Table 3: Correlation Analysis for the Input and Output Index System

	I1	I2	I3	I4	I5
O1	0.8589	0.6593	0.7023	0.4859	0.5372
O2	0.5430	0.5322	0.6506	0.3174	0.2299
O3	0.2912	0.4846	0.6000	0.2933	0.2275

As can be seen from the Table 3, $0 < \gamma < 1$; this indicates a positive correlation between input and output. Based on the input data, the raw data were tested by correlation analysis for the input and output of the final index (Table 3) and were input into the Maxdea ultra7.0 software with the DEA analysis results of Construction Projects M1-M15 given in Table 4.

Table4: Analysis results of ineffective technical units

DMU	TE	Input improvement					Output improvement		
		I1	I2	I3	I4	I5	O1	O2	O3
M4	0.667	-33.3%	-33.3%	-45.8%	-66.7%	-33.3%	8.3%	8.3%	0.0%
M6	0.8	-20.0%	-20.0%	-33.3%	-60.0%	-60.0%	0.0%	100.0%	60.0%
M8	0.917	-8.33%	-8.33%	-8.33%	-36.7%	-43.3%	0.0%	66.7%	0.0%
M10	0.917	-8.33%	-8.33%	-8.33%	-20.8%	-20.8%	-29.2%	0.0%	0.0%
M11	0.833	-20.0%	-20.0%	-16.7%	-16.7%	-33.3%	0.0%	0.0%	0.0%
M14	0.875	-20.0%	-20.0%	-12.5%	-40.0%	-37.5%	0.0%	0.0%	0.0%
M15	0.889	-28.9%	-11.1%	-11.1%	-11.1%	-22.2%	0.0%	0.0%	0.0%
Mean	0.926	-9.3%	-8.1%	-9.1%	-16.8%	-17.3%	0.6%	11.7%	8.4%

DISCUSSION

According to the results of Correlation Analysis, the severity of work stressors is positively related to the frequency of unsafe behaviour. And based on the DEA analysis, the average efficiency of M1-M15 is 0.926, which means that the overall efficiency is relatively high. So, there is a situation in which the work-related stress actually shifts to unsafe behaviour. Among them, the integrated efficiency values of the eight decision units M1, M2, M3, M5, M7, M9, M12, and M13 are 1, which means the DMU is DEA effective and the work-related stressors structure indeed lead to insecurity behaviour. The efficiency values of M4, M6, M8, M10, M11, M14, and M15 are all less than 1, indicating that the efficiency is invalid, and the input-output structure is unreasonable. Since the model is based on the transformation of work-related stress into unsafe behaviour, it is necessary to analyse the causes of the invalid model and find the key factors that needs to be controlled.

In this paper, through the projection analysis, the radial improved value, the slack improved value and the target value of the non-DEA effective unit can be calculated, and then the input redundancies rate and the output insufficiency rate can be obtained, which can provide reference for how to avoid the conversion efficiency. Target value = original value + radial improvement value + slack improvement value, input/output improvement ratio = (target value - original value) / original value, and the absolute value of the input improvement ratio is the input redundancy rate, as shown in Table 4. From the input point of view, the input improvement ratio of I5 is -17.26%, and the input improvement ratio of I4 is -16.8%, indicating that the current I5 has a degree of redundancy of 17.26%, and I4 has a degree of redundancy of 16.8%. Firstly, from the analysis of cases characteristics, there are seven cases that have not been fully converted in the process from work-related stress sources to unsafe behaviour. The seven projects are all relatively medium-sized or large constructions, which means

that larger projects may have stronger control on work-related stress transformation. Secondly, from the perspective of the structure of the work stressors and the structure of the unsafe behaviour output, there is a large amount of redundancy in the severity of I5 (job over control) and I4 (Deadline pressures), but it does not cause the complete conversion to unsafe behaviour, which means that these two sources of stress may not directly lead to the transformation. We may pay more attention to the other three factors: Lack of social support, Short job tenure and Conflict demand. Some parts of the conclusion and former research in the literature are also in agreement. For example, scholars have begun to pay attention to the relationship between social support, work stress and unsafe behaviour. (Sampson *et al.*, 2014, Chan *et al.*, 2018).

CONCLUSIONS

Based on the Robbins' pressure model, this paper studies typical stressors and unsafe behaviours in the construction industry and proposes a work-related stress transformation model. The corresponding DEA model was constructed and 15 cases were used as the database to analyse the efficiency of the transformation. Through case analysis, common work-related stressors were identified and advices on pressure source control of on-site construction are provided. According to the literature review, Lack of social support, short term contacts, Change, conflict demand, work long hour, deadline pressures, job over control, work overload are eight common sources of on-site work pressure. Because there are only a limited number of cases that can be investigated, this paper only selects the five most frequently studied pressure sources for analysis and it leads to the following conclusions, and these conclusions may only apply to the factory construction: 1. There is indeed a shift from work-related stress to unsafe behaviour, and it is more convenient to control the conversion from the source of work-related stress. 2. The management of the work pressure transformation in the medium and large-scale engineering sites may be better than the smaller ones. 3. The three factors of Lack of social support, Short job tenure and conflict demand all need attention in the process of the work-related stress transformation. On the contrary, Deadline pressure, which we often believe is the most important factor that causes work stress, is not plays the most critical role in the conversion process. Therefore, a more in-depth analysis of the sources of work stress plays a crucial role in the management of work stress.

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HEALTHY, HAPPY WORKERS? THE CONSEQUENCES OF COMMUTING BETWEEN NORTHERN IRELAND AND GREAT BRITAIN

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The recent economic downturn has seen many construction companies in Northern Ireland look to secure work in Great Britain to maintain their operations. A direct consequence of this has been an increase in the number of workers, both professionals and trades, who are now commuting to Great Britain for work; that is, spending at least five consecutive days away from home as part of their regular work schedules. Here, ten exploratory, in-depth semi-structured interviews were held with Northern Ireland construction workers currently travelling to Great Britain for work. Data was transcribed and analysed using cognitive mapping software. Findings revealed that workers struggle with tiredness and fatigue, suffer from depression and loneliness, missing family and friends, which can lead to increased drug and alcohol consumption, and use of prostitutes. The use of hotels also limits workers ability to cook for themselves and so eat healthily, as well as reducing social interaction, encouraging workers into hotel bars and pubs as shared social spaces, again influencing levels of alcohol and type of food consumption. Recommendations are made for the care of those on such schedules, to mitigate such negative impacts on worker health and wellbeing.

Keywords: commuting, health, NI, wellbeing, workers

INTRODUCTION

Despite the fact that there have been considerable improvements in safety on United Kingdom (UK) construction sites in recent years, worker health and wellbeing remains cause for concern. In addition to physical occupational health risks, such as musculoskeletal disorders, lung problems and occupational cancers, the wider health consequences of construction work are becoming more apparent. For example, stress, depression or anxiety has now become a reporting category in its own right for construction worker health, with around 6,000 workers reporting problems each year (Health and Safety Executive 2017); making up 15% of all reported health issues. More worrying is the recently released statistics around male suicide, which found

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that males working in skilled construction trades, had more than double the risk of suicide than the male national average (Office of National Statistics 2017).

Although health and wellbeing is directly affected by work carried out on sites, the way construction work is structured also influences how workers live their lives outside of work: the now familiar concept of 'work-life balance' (Turner and Lingard 2016). Organisational factors such as unsocial work patterns, long travel and abnormal shifts (Miller *et al.*, 2007), remote job locations (Pinto *et al.*, 2011), short term employment and job insecurity (Frone 2013) not only indirectly affect worker wellbeing, they are also closely linked to the 'social determinants of health'; the reasons why people smoke, drink, take drugs or eat to excess (Wilkinson and Marmot 2003), which further contribute to poor health amongst the construction workforce (Sherratt 2017).

One of the more unavoidable aspects of construction work is the need to move its people to the physical places where the projects are being built, which results in an inevitably nomadic workforce (Fellini *et al.*, 2007). Long travel times to work frequently characterise the working day or, when the distance is too great for this to be sustainable, the use of temporary accommodation or 'lodge' for workers close to the work site is utilised. The ongoing negative economic situation in Northern Ireland has resulted in an increase in such commuting for Northern Ireland construction workers, as companies have looked towards Great Britain for work opportunities. In 2015, an average of 43% of Northern Ireland (NI) construction companies' workload was taking place outside of the country, mainly in England and Scotland (Price Waterhouse Coopers 2015). As a consequence, there has been a considerable increase in Northern Ireland workers, both professionals and trades, commuting for the purpose of work (Price Waterhouse Coopers 2015) and regularly living away from home; that is, on a weekly basis. This context provides a good opportunity to empirically explore the experiences of commuting construction workers, and better illuminate the specific ways in which commuting affects their health and wellbeing.

Context

The consequences of long-term commuting and lodge on construction workers have been explored within country contexts other than the UK, where sheer scale and size of the landmasses often dictates such work patterns and shifts. For example, there is a considerable body of work from both Australia and Canada, where construction workers spend an extended period of time at the worksite, followed by a period of time on leave at home. In Australia such arrangements are known as Fly-In-Fly-Out (FIFO) (Blackman *et al.*, 2014), and work is organised using rotational schedules, often associated with longer durations of work and company paid transportation and accommodation. This work structure also enables 24hr/7-day working, and is usually typified by workers undertaking 12hr shifts in a 7-day on/7-day off rotation. Although most frequently adopted in mining and oil and gas industries, the increase in infrastructure projects in remote locations and the need for companies to secure work outside of their local regions or countries, as is now occurring in Northern Ireland, has seen an increase in such approaches within the global construction industry.

It must be recognised that some workers pro-actively opt to take on FIFO working arrangements, not least because they are usually better paid than normal, local work (van Ommeren *et al.*, 2000), where often the further the commute meaning the greater the salary (TUC 2015). The arrangement can also be seen as beneficial, because the extended time off that follows a demanding work period, can be used to spend more

time with families and friends (Houghton 1993), which can also be an attractive option.

Negative Impacts on Worker Health and Wellbeing

However, such work patterns have been found to negatively affect worker health and wellbeing outside of the worksite. Traditional long working hours as found in construction, have already been determined to have a negative effect on workers' work-life experiences (Lingard *et al.*, 2010), and when commuting and living away from home are added to this, the consequences can become magnified (Oswald and Turner 2017).

With regard to work-life balance, research has shown that lodge arrangements can have negative impacts on worker's personal relationships (Yuk King *et al.*, 2012; Lingard and Turner 2017), as their time to spend with family and friends and ability to engage in social activities, such as sports teams or other social clubs, is significantly curtailed (Blackman *et al.*, 2014). When this is coupled with disrupted sleep patterns and other factors, it is perhaps unsurprising that issues around mental health, depression (Driesen *et al.*, 2011), and stress, emerge (Collinson 2008) as workers are subjected to loneliness, segregation from family and friends, and a lack of belonging within their immediate temporary community materialise (Clifford 2009).

Indeed, mental health issues are frequently raised as a concern for such workers, as the risks of such issues have been found to increase in workers undertaking overseas placements (Lockton 2015). Stress and tiredness are commonly reported consequences of such arrangements (Sullivan 2007; Lyons and Chatterjee 2008; Hanoa *et al.*, 2011), with stress a significant consequence of commuting for work, that despite better pay as a result of travel, the increase in stress is so significant that workers still have a lower life satisfaction, than those who do not travel for work (Stutzer and Frey 2008; Fults 2010). Given that the industry is male dominated, and that men are generally less aware of mental health issues (Cotton *et al.*, 2006) and so are more vulnerable to mental health concerns (WHO 2012), this should be cause for considerable concern.

Such work patterns also have negative impacts on workers' physical as well as their mental wellbeing (Hansson *et al.*, 2011; Karlström and Isacsson 2009; Lingard and Turner 2017), with research suggesting specific consequences as increases in the risk of ulcers, cardiovascular diseases, type 2 diabetes (Li *et al.*, 2011), gastrointestinal problems (Hanoa *et al.*, 2011), along with high blood pressure and obesity (Hansson *et al.*, 2011; Hoehner *et al.*, 2012). This could be linked to the fact that such workers have also been found to experience reductions and changes in their fitness routines, relaxation opportunities and social interactions (Hanoa *et al.*, 2011), which may in turn affect their eating and drinking habits, and so over time, lead to the development of physical problems highlighted.

This challenging work environment unfortunately also finds good fit with the social determinants of health (Wilkinson and Marmot 2003), and it is therefore unsurprising that commuting construction workers have been found to be substantially more likely to smoke and drink excessive alcohol and be overweight or obese (Yuk King *et al.*, 2012). Indeed, alcohol and drug use is a significant concern amongst construction workers, as it then has further impacts on family relationships (Storey 2001; Cunradi *et al.*, 2009; Oswald and Turner 2017).

Whilst the above does not paint a particularly pleasant picture of the potential consequences for Northern Ireland workers having to commute to Great Britain on a regular basis, it must be acknowledged that the industry is making efforts to mitigate and improve the mental and physical health of its workforce. For example, initiatives such as *Mates in Mind* (2018), which aims to raise awareness and improve mental health in the UK construction industry, are growing in scale and scope, in attempt to counter these issues within the workforce.

METHOD

In order to begin to empirically explore the consequences for the health and wellbeing of those who commute from Northern Ireland to Great Britain for construction work, a purposive sample of those participating in such a process was secured through a snowball approach. All participants were construction workers based in Northern Ireland, who commute to Great Britain as part of their work for a period of five working days (one working week), or more, at a time, before returning to Northern Ireland for their leave. This sampling strategy resulted in the participation of ten construction workers, eight professionals (two project managers, one quantity surveyor, two health and safety officers, three engineers) and two skilled trades (a crane operator and a machine operator). All but one of the sample were male, and all but one were employed by a main contractor, the other being an agency worker. Although no claim is therefore made to generalisability from this sample, due to the nature of the phenomenon under examination and the exploratory nature of the research, it is considered acceptable and able to make a contextually relevant contribution to the growing body of knowledge in this field.

The exploratory nature of the work supports the use of qualitative data, therefore in-depth semi-structured interviews (Gillham 2005) were carried out with the ten participants, either face-to-face or via Skype, depending on the participants' location and availability. Questions were developed from the literature, taking themes from work carried out in other countries as key starting points, yet enabling the participants to lead the discussions to topics they felt were of significance. The interviews were recorded and data subsequently transcribed. A cognitive mapping software package was used in the analytical process. This software (Decision Explorer V3.3.2) is used to organise and assemble the data into clusters of relationships, producing a systematically organised map of linked concepts, which can then be evaluated using central, domain and cluster analysis, supporting further exploration through the lens of the literature.

FINDINGS AND ANALYSIS

Once the map was developed, three methods of analysis were deployed: Central, Domain, and Cluster analysis. Domain analysis is where the content of the cognitive map is analysed to identify the concepts with the most links deriving from it; thus, indicating their prominence throughout the data as a whole. Central analysis identifies concepts with the highest number of networks evolving from them, these are known as central concepts and are the most influential within the model. Cluster analysis is where groups of concepts (or clusters) are identified which seem to stand alone, forming sub-themes within the data, the higher the number of clusters within a map, the greater its complexity.

Central Analysis

Data from the ten interviews was initially analysed in turn, and developed into one cognitive map per interview, from which central analysis could be carried out; where the higher the 'score' the more influential the concept on the entire model. Central analysis was carried out on each map to generate the top five concepts as emerged from within the data. Following individual analysis, a combined cognitive model was generated from the data as a whole, to reveal the concepts throughout the sample. From this combined model, domain and cluster analysis could then be carried out. For reasons of replicability, the models are not included here, however the key data findings can be found in Table 1 below.

Table 1: Top 5 Concepts from the Combined Cognitive Map

Rank	Score	Concept
1	25 from 62	Accommodation
2	21 from 48	Loneliness
3	17 from 38	Regularly going to the gym provides workers with an alternative to going to the pub
4	17 from 35	Early morning flights to site
5	16 from 36	Activities and exercise help alleviate stress

Domain Analysis

Results of the Doman analysis can be found in Table 2 below.

Table 2: Top 4 Concepts from the Combined Cognitive Map

Rank	No of Links	Concept
1	7	Increase in alcohol consumption and big drinking culture among workers
2	6	Accommodation
	6	Workers benefit from regular communication
3	5	Early morning flights to site
	5	Regularly going to the gym provides workers with an alternative to going to the pub
	5	Loneliness
4	4	Often Working Late
	4	NI companies competing with companies in GB without the additional overheads
	4	Reports of ulcers
	4	Male dominated industry with much bravado
	4	Poor sleep

Cluster Analysis

Cluster analysis was also run on the combined cognitive model, but due to the large number of themes linked together, the Cluster 1 model was not able to reduce or focus the data further when interrogated. Due to the prominence of the concept of 'accommodation' within the two previous analyses, this concept was selected to create Cluster 2 and 3 models, grounded in 'Hotels' and 'Rented Accommodation', found in Figures 1 and 2. The type of accommodation used was frequently discussed by interviewees, and the Cluster analysis was able to demonstrate that this was also an

influential factor in respect of the habitual traits that workers had while working away from home - be they negative or positive to the individuals' routines.

Figure 1: Cluster 2 Analysis from the Combined Cognitive Map: Hotel Accommodation

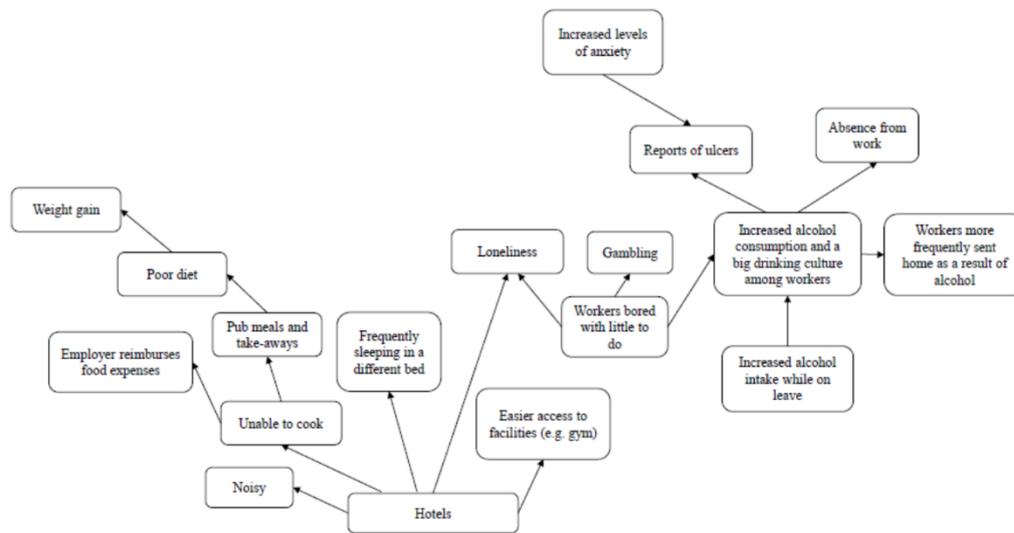
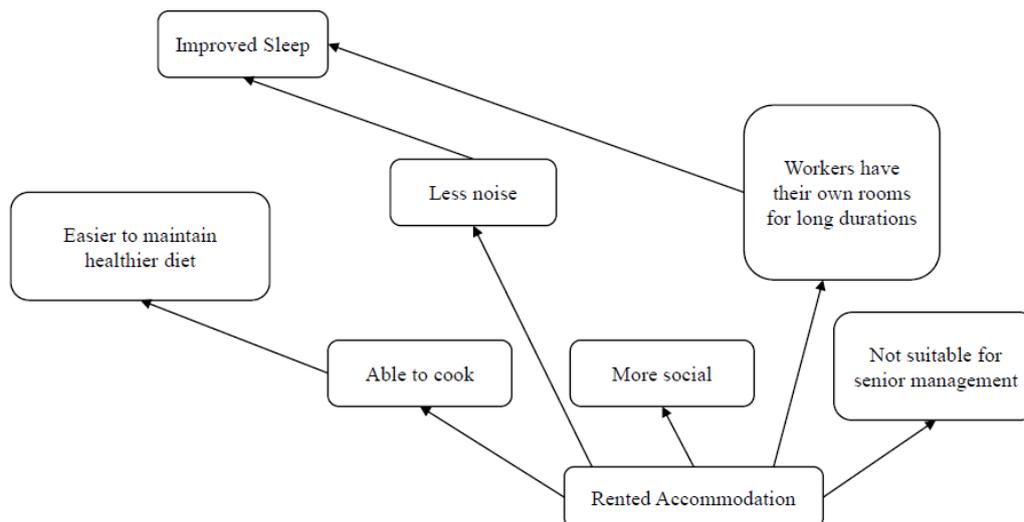


Figure 2: Cluster 3 Analysis from the Combined Cognitive Map: Rented Accommodation



DISCUSSION

The data and subsequent analysis has been able to begin to empirically explore the experiences of construction professionals and trades who regularly commute between Northern Ireland and Great Britain for their work. Despite the fact that much of the existing literature in this area comes from countries other than the UK, the data generated in this study was able to find correlation and fit with concerns that have been generated elsewhere, and are now being felt by workers in this specific context. As the cluster analysis demonstrated, there is a high level of interconnectivity between the themes and concepts, as they emerged from both the literature and data.

Mentally, Northern Ireland workers felt they suffered from several indicators of poor mental health, including stress, fatigue and loneliness. Stress is a known consequence of such commuting patterns (Hanoa *et al.*, 2011), and was associated by these workers with the early morning flights, including the need to manage and resolve frequent cancellations and delays, and the need to be able to fit quickly into the worksite team

on their first day back. Problems of fatigue, again caused by the exertions of travel and from poor sleep when away from home, were commonplace within the data, again as suggested by the literature (Stutzer and Frey 2008; Lyons and Chatterjee 2008). For this sample of workers, problems again arose on the first day of work following early morning flights, and increased as a consequence of poor sleep during the following consecutive days of work. As fatigue can have significant consequences, in terms of slower reaction times and decreased mental performance (Di Milia 2006) for construction workers who face high-hazard, this should arguably be avoided rather than built into workers' schedules.

Loneliness was a more complex concept, again prominent in the data and supported by the literature (Clifford 2009). This factor was developed through workers missing their family and friends, including important events and milestones in family life. Such feelings of isolation and loneliness are also likely to compound other mental health issues, with the potential for stress, fatigue and loneliness, potentially leading to depression (Driesen *et al.*, 2011). Despite the potential for virtual communication to 'keep in touch', issues of poor internet connection and long hours of work, created barriers to this potential mitigating solution.

Two distinct 'responses' to the issue of loneliness could be identified, and both were also associated with the type of accommodation workers were allocated, perhaps explaining its prominence in the data. For many workers, feelings of loneliness were overcome by spending time with workmates; however, hotel accommodation often lack social spaces that are not also a bar serving alcohol. Compounded by issues of boredom, workers felt they had little to do but drink with colleagues, and many felt their drinking had increased significantly since starting this work pattern. They had also experienced changes such as increased gambling and also the use of prostitutes; again, to alleviate both boredom and loneliness in the evenings. Hotel accommodation was also frequently associated with poor sleep and disturbances throughout the night, which in turn also compounded issues of fatigue and stress. The alternative to hotel accommodation was rented accommodation, shared with other workers, and this was seen by many as preferable, enabling workers to interact in a space without drink, often providing a better night's sleep in a quieter environment. Furthermore, in rented accommodation, workers were able to cook their own, healthier, food, rather than rely on hotel or bar meals.

Workers also suffered from a number of physical health complaints, with several noting they had put on weight since starting this pattern of work, because of their diets and lifestyles. Other health issues such as ulcers and gastrointestinal problems were also noted by the respondents. Going to the gym was seen as a positive response to poor health, and a good alternative to drinking in the evenings; however being able to secure short-term memberships was at times problematic, and membership of sports teams was often difficult to maintain and the costs attributable to the workers directly.

CONCLUSIONS

This exploratory study has begun to reveal that many of the potential problems that are associated with FIFO patterns of work are being experienced by Northern Ireland workers as they commute to Great Britain for work. The consequences of such work are myriad, complex and interrelated, but do not help create healthy and happy workers. Issues around mental and physical health are compounded by the management of such working arrangements, and a key finding of this study is the importance of accommodation within this situation. Workers' accommodation can

either help them to manage the situation positively, by providing quiet rooms, shared social spaces and a kitchen for food preparation, or negatively, by encouraging drinking and poor food choices, as well as disturbed sleep.

It is recommended that organisations with a regularly commuting workforce acknowledge the importance of accommodation selection for their workers and make arrangements accordingly. Furthermore, robust provision should be made for mental health support systems, the potential for subsidised gym memberships to encourage healthier lifestyles, and a measure of flexibility in the work patterns themselves, to avoid additional stress over the commute and suitable periods of rest and time with family at home.

Further research is also recommended to better illuminate these issues and provide additional empirical support for such recommendations, to influence practice and ensure the impacts of such patterns of work on worker wellbeing are mitigated as much as possible.

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MASCULINITY AND WORKPLACE WELLBEING IN THE AUSTRALIAN CONSTRUCTION INDUSTRY

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The construction industry is known to be highly masculinised and to have work practices that detrimentally affect employee wellbeing. Drawing on rapid ethnographic research, we explore the wellbeing of female and male construction professionals. This involved interviews with 21 senior female and male business leaders, participant observation of 14 company events, onsite shadowing of 44 male and female construction professionals for 2-5 days and 61 interviews of project staff across 6 major construction sites operated by two multinational contractors in Australia. Our findings reveal significant symptoms of poor mental health such as stress, panic attacks, insomnia, fatigue and anxiety, as well as strains on family life - among men and women. Many employees endure these experiences in silence, adhering to unspoken masculine workplace norms of long hours, total availability, and presenteeism. Employees regularly worked double their contracted hours and discussed the need to 'prove their worth', leaving little time for work-life balance. Despite some efforts to address this by the companies, physical safety appeared a higher priority than psycho-social wellbeing, even in the face of lost productivity. We conclude that the masculinity of the sector is linked to workplace wellbeing for both the men and women that work in the industry.

Keywords: gender, masculinity, workplace wellbeing

INTRODUCTION

“Wellbeing is generally defined as a person’s relative satisfaction with various aspects of their lives, based on the interaction between the resources they have (both material and cultural) and their circumstances” (Reeve *et al.*, 2016: 7). It is not just a sense of general happiness but a dynamic state within which objective and subjective elements interact (Foresight Mental Capital and Wellbeing Project, 2008; Department of Health, 2015). Wellbeing is multidimensional and impacted by a range of factors including individuals’ ability to feel hopeful and cope with life’s stresses (Harrison *et al.*, 2016: 10), feeling in control of their lives, having meaningful connections and purpose (Nussbaum, 2011) and experiencing positive relationships (Huppert, 2008).

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All of these factors make it especially challenging to implement and assess in the workplace.

Workplace wellbeing research has increased in recent years as it has been linked to productivity (Benedict and Arterburn, 2008; Fenton *et al.*, 2014) and evidence that improvements in wellbeing can lead to benefits for individuals (e.g. happiness, confidence, job satisfaction, physical health, work ethic) and organizations (e.g. productivity, staff retention, staff morale and loyalty, a reduction in absenteeism) (Dickson-Swift *et al.*, 2014). Despite some efforts to improve the wellbeing of construction workers, workplace wellbeing interventions have proved difficult to implement, with about 70% of construction workers suffering from mental health issues (e.g. anxiety, depression and stress) as a direct result of working in the industry (Fenton *et al.*, 2014; Doran *et al.*, 2016). Research shows that job demands as well as organisational factors rooted in norms of masculinity are the most frequent causes of work related stress in the industry - and this both amongst men and women (Sunindijo and Kamardeen, 2017). This paper builds on this work and aims to further explore and conceptualise workplace wellbeing of male and female professionals in the construction industry by drawing on research conducted using a rapid ethnographic approach in two construction multinationals in Australia.

Workplace Wellbeing in the Construction Industry

Research shows a multitude of factors that make the construction industry un conducive to workplace wellbeing. For example, a drive for short-term outcomes in project management to maximize productivity (Fenton *et al.*, 2014) contributes to “a fragmented and unstable ‘dog-eat-dog’ environment”, that is often “conflict ridden” and characterized by a culture of blame (Watts, 2009b: 522). The construction industry is also known to “operate in stressful environments” (Du Plessis *et al.*, 2013: 716) with physical stressors such as poor work site conditions (e.g. excessive noise, and unsafe work conditions) and organizational factors having a significant impact on employee’s wellbeing (Sunindijo and Kamardeen, 2017). Job demands such as excessive workload, high job and time pressure, working long hours and nonstandard work schedules, unrealistic deadlines and insufficient time with family appear to be the most frequent causes of work stress and ‘psychological injuries’ (Sunindijo and Kamardeen, 2017; Bowen *et al.*, 2014a). Other factors include: unclear job role and responsibility, inadequate staffing and poor planning, lack of training, lack of feedback and management support, lack of career progression, lack of job security, and poor remuneration compared to excessive job demands (Campbell, 2006; Turner and Lingard, 2016).

In addition to the physical nature of construction work and the organizational factors listed above, the construction industry has an unhealthy work culture, which reinforces and sustains this behaviour (Sunindijo and Kamardeen, 2017). Culturally, construction work is also strongly rooted in traditional masculine values - e.g. control, efficiency and devotion to work (Styhre, 2011); with those displaying different values seen as not ‘fitting in’ (Cartwright and Gale, 1995). Those who manage to negotiate part-time or flexible work arrangements are often seen as “slackers,” not fully committed to their job (Watts, 2009b: 525). This is due to a culture of ‘competitive presenteeism’ (Simpson, 1998), as well as defensive practice and a ‘heroic narrative’, which Watts (2009b: 525; emphasis in original) sees manifesting “as a form of *macho competitiveness*”. Cockburn (1991) found, for example, that working mothers were

unable to gain legitimacy as ‘serious professionals’ in the workplace - due to a ‘masculinist vision’ of professions (Davies, 1996).

Norms of masculinity in the construction industry have been found to impact both men and women who feel the need to adjust their working style so as to ‘fit in’ (Olofsdotter and Randevåg, 2016). While research shows no significant difference between men and women’s wellbeing in the construction industry, women face unique challenges (Bowen *et al.*, 2014b; Sunindijo and Kamardeen, 2017). The masculine workplace culture is characterised by both direct and indirect discrimination toward women, which can stymie career progression leading to reduced job satisfaction and security (Dainty and Lingard, 2006). Many women report daily instances of confrontation, close surveillance, sexual harassment and intimidation and feeling emotionally drained (Watts, 2009b; Gyllensten and Palmer, 2005). Women are also found needing to negotiate multiple roles - job demands (masculine norms) coupled with the expectation of running a home (feminine norms), causing lower job satisfaction, higher work-life conflict, turnover intentions, burnout and other mental health issues (Watts, 2009a; Sang *et al.*, 2007).

While gender has not been isolated as a significant moderator in workplace wellbeing, it has been found to impact workers’ coping strategies (Gyllensten and Palmer, 2005). In male-dominated industries, performing traditional notions of masculinity means that both men and women are likely to believe it is necessary to endure pain and conceal mental health issues so as to display ‘toughness’, reliability and ‘prove’ their worth (Wong *et al.*, 2016). “Doing dangerous work is frequently equated to doing gender” (Stergiou-Kita *et al.*, 2015: 216) leading to ‘hyper masculine’ behaviours in the workplace (Jensen *et al.*, 2014). When performing masculinity, individuals are encouraged to reject characteristics associated with femininity (‘no sissy stuff’), with the expectation that workers accept risks, and endure pain without complaint in the workplace (Stergiou-Kita *et al.*, 2015; Iacuone, 2005). Similarly, O’Brien *et al.*, (2005) found that many men tolerated ‘trivial’ symptoms of poor health and avoided help-seeking behaviour. This included great elasticity in what was considered ‘trivial’ and mental health problems such as ‘depression’ being casually referred to as ‘stress’.

Conformity to masculine norms is also positively related to psychological injuries and negatively associated with help seeking behaviours for both men and women (Wong *et al.*, 2016; Iacuone, 2005; O’Brien *et al.*, 2005). The focus of the construction industry on short-term outcomes and productivity may further interact with norms of masculinity and healthy behaviour in the workplace. Workers are expected to tolerate adverse work conditions without complaints and sacrifice their health to ‘get the job done’ (Phakathi, 2013). As Paap (2006) shows, in competitive male-dominated industries, workers perform masculinity putting productivity above safety so as to achieve a ‘preferred worker’ status (Watts, 2009b). On such ‘competitive battlefields’, help-seeking behaviours are limited (Stergiou-Kita *et al.*, 2015; Desmond, 2011).

METHODOLOGY

In this paper we draw on findings from a larger study that sought to examine the interaction of formal and informal organizational institutions on women professional’s recruitment, retention and progression in the construction industry (Galea *et al.*, 2015). This project adopted a rapid ethnographic approach to reveal the informal rules that are generally undocumented and often, due to their taken-for-granted nature, unrecognised or invisible for those that live them. While rapid ethnography has been

criticised by some classic ethnographers for being a quick and dirty approach to ethnography, it has been found to be an effective solution to the real challenges of fieldwork in time-pressured environments like the construction industry (see for example, Isaacs 2013, Loosemore *et al.*, 2015).

Our rapid ethnography approach included interviews with 21 senior female and male business leaders, participant observation of 14 company events (including diversity training, new employee inductions, graduate assessment centres, leadership training, mentoring initiatives, management ‘road shows’, and diversity-specific events) and onsite shadowing of 44 male and female construction professionals for 2-5 days and 61 interviews with project management personnel across 6 major construction sites operated by two organizations which were multinational contractors. Interviews, observations and shadowing on site focussed on common work practices (e.g. what time people arrived and left the site), roles on site (e.g. who does what roles, whether roles were associated with particular work practices such as total availability or leadership, gendered roles), informal and formal workplace expectations (hours worked, presenteeism), whether there was a demarcation between project site and site office, the composition of work practices during the day (formal and informal meetings and interactions), who had ‘voice’ within these meetings and group dynamics (how do people participate etc.) and narrative (what messages are being reinforced).

Shadowing individual workers involved accompanying and observing them in their normal day-to-day working lives and provided an opportunity for informal conversations with participants and included questions such as ‘Was that a typical site meeting?’ ‘Is it important to arrive on site at this time?’ ‘Was that the normal way that people speak to each other on site’. During the observations of formal company events, researchers made notes and collected artefacts (photographs of room layouts, seating arrangements, who led the events, what was said and by who, corporate messaging posted on walls or issued to employees). After each observation the researchers debriefed and reflected, recording their conversation, to address the challenges of interpretation and analysis in a multi-researcher ethnography, where there are likely to be perceptual differences and various points of agreement and disagreement. In all observations of company events and sites, two researchers were involved to represent the views of both ‘insider’ (extensive experience in the construction sector) and ‘outsider’ (gender experts from sociology and political science) and male and female. This combination allowed us to overcome the problem of construction background researchers missing insights which they may also take for granted as part of the industry and vice versa (Baines and Cunningham 2013). These observations were then used as the basis for the interviews conducted with respondents who nominated themselves during the observation process.

FINDINGS

Job Demands and Mental Health

Work life balance was a significant issue for the majority of employees (men and women) in both companies. The widespread acceptance of working long hours and a culture of presenteeism and total availability within the industry made it difficult to balance work with family and social life. For example, a male construction professional (Company B) stated:

I go home, like, I work a massive day, early mornings. You know, you come home around six o’clock or six-thirty; you have dinner, put your kids to bed and then back on

the computer for another couple of hours working. So, you know, 10 o'clock is probably the norm and then, you know, midnight could be something like the other nights. And doing that has just been taking it's toll.

The challenge of achieving an effective work-life balance was most pronounced for full-time employees with children, with long hours away from home putting a strain on relationships with children and partners, and for young people relocated to work in regional settings.

The data revealed that for men, these practices cut to the core of their health, wellbeing and personal relationships. Stories of divorce were prevalent and often referred to as the 'battle scars' of a construction role by participants.

On the last job when there was a 32-year-old who was given a project management role. In the process of that job, the PM's [Project Manager's] relationship with his wife broke down and they divorced. He was under enormous stress. He's now pulled through and has a new relationship. But the project took its toll. By proving himself on that job he has set himself up now (Site Manager, Male, Company A).

While mental health related issues - stress, panic attacks, insomnia, fatigue and anxiety - were not openly discussed in public, it was prevalent in the data and the high rate of suicide did not feature in the companies' safety narratives (Milner *et al.*, 2017; 2016). During the research, there were three instances of subcontractor suicide reported by participants, all were men. One participant reported that within her Company A project team, three employees were being watched carefully for fears about them taking their own life.

Women participants also reported stress and fatigue in relation to themselves and their personal relationships. Like men, women were expected to endure in silence and without any variation to the existing 'rules-in-use' that implied long hours, total availability and presenteeism. For women with a family, this left them to individually negotiate and execute a balance between the rules in place and attending to their family. Two women participants outlined the issue in interviews encapsulated it this way:

To give you an example of what my typical day looks like, I set my alarm at 4.00 am in the morning. I try and do an hour and a half's worth of work before my kids wake up at 6.00 am. I then do drop off [to childcare and school]. I have two drop-offs. Then I double-back around and come to site. I'm probably one of the last people to walk in at a quarter-past eight, eight-thirty. And, whether it's something that I am sensitive about or whether it actually happens but I feel like the fact that I'm walking half an hour, an hour later than everyone else is, is noted by everyone in the office. So I then work 'til about five, five-thirty. I go home. I bath the kids. Put them to bed. I eat dinner. Do the washing and ironing and then I do some more work... (Commercial Manager, Female, Company A)

I do what the boys do but then I go home and I do what their wives do as well (Estimating Manager, Female, Company A).

The sheer workload - paid and unpaid - that women reported doing, led them to reconsider whether construction is a sustainable career and in some cases, leave or take a more junior or part-time position. While female participants spoke of career 'survival', male participants assumed that they could have both, a construction career and family.

Symptoms of poor mental health emerged as a significant issue for many male and female respondents who reported being stressed, fatigued, having sleeping issues, stress related health issues, turning to alcohol and having anxiety attacks. For men, rigid workplace practices such as long work hours, high workload, and expectations of

presenteeism and total availability had a significant impact on mental health and lead to anxiety and depression. For example, a male construction professional (Company B) stated: “it’s hard work mate. It’s stressful work. Like I said, it’s long hours”.

For women, the exclusionary nature of the industry, the masculine nature of construction environments, and constant questions of female capability can contribute to feelings of isolation, exhaustion and a lack of confidence. For example:

Well I’m pretty social. Like, I’ve lived with people before. I’ve always lived in shared housing for like the last five years and then came up here and I’m living on my own. Friends are like a huge part of my life so having to hang out with these guys all the time has been a challenge I guess for me. I’d say my personal life has taken a dive, definitely, since being here... being the only girl can be a bit shit” (Construction Professional, Female, company B)

Young people reported that they were considering a move out of contracting for better hours.

Organizational Interventions and Their Impact

During fieldwork a new initiative called ‘wellbeing leave’ was introduced in Company A that provided employees with an additional three days paid leave per year to spend on their physical and mental wellbeing. A wellbeing leave brochure was issued to all employees, building the case for work life balance and providing employees examples for how they could spend their new wellbeing leave days, including attending “a yoga retreat, a meditation course, a preventative health check-up or carer’s respite”. The brochure also encouraged employees to take responsibility for their own wellbeing by eating well, keeping active, drinking sensibly, maintaining good relationships and taking lunch breaks.

I was handed the booklet by a male participant. His image was on the front of the booklet. He told me that each day on the way to site he suffered panic attacks but he was not sure if he would take his wellbeing leave” (Participant Observation, Female ‘Insider’ Researcher, Site 1, Company A).

While wellbeing leave was mocked in some circles for its emphasis on “yoga and shit like that” (Participant Observation, Male ‘Outsider’ Researcher, Site 1, Company A) though most participants interviewed were thankful for the additional leave. Nevertheless, they were unsure if their workload would permit it. When asked participants planned to spend their well-being leave with their family or catching up on ‘domestic administration’ such as going to the bank and hairdresser; no participants said they planned to attend yoga or meditation. On two of the three sites we visited in Company A, wellbeing leave was operationalised through a roster system and appeared to be utilised by employees; we were unable to track whether these rosters were maintained throughout the busy closing stages of these project.

On construction sites, work life balance and wellbeing was led from the front. The attitude of project managers and leaders towards formal wellness initiatives such as the flexibility initiative was found to have a significant impact on the success and implementation of such programs. These, however, seemed to evolve within and oppose an organizational culture based on unrealistic work expectations:

One of the things I’ve learned about [Company A] is, at the end of the day, they do, actually give a shit about their people and their attitude towards people who don’t is pretty intolerant. They expect a pound of flesh but to a point. They won’t ask you for more than you wanna give so, if you don’t wanna give, you don’t have to give; just don’t expect the same returns of the people who wanna give (Operations Manager, Male, Company A).

DISCUSSION

As discussed above, construction workers are expected to tolerate adverse work conditions without complaints and sacrifice their health to get the job done. Paap (2006) shows that in competitive male-dominated industries, workers perform masculinity putting productivity above safety to achieve a 'preferred worker' status (Watts, 2009b: 513). On such 'competitive battlefields', help-seeking behaviours are limited (Stergiou-Kita *et al.*, 2015; Desmond, 2011). When performing masculinity, there is an expectation that workers accept risks, and endure pain without complaint in the workplace (Stergiou-Kita *et al.*, 2015; Iacuone, 2005; Pap, 2006; Stergiou-Kita *et al.*, 2015; Desmond, 2011). We found little evidence of this culture being challenged, instead both men and women try to 'fit in' with the masculine norms of the industry at the expense of their wellbeing.

Research shows that mental health in the workplace is positively associated with its culture, itself embedded in the organization's structure (Noblet and LaMontagne, 2006; Makrides *et al.*, 2007). Continuous demanding and stressful conditions closely impact an employee's mental health (e.g. depression, anxiety, self-esteem, burnout) (Sunindijo and Kamardeen, 2017), leading to reduced productivity and quality of work, as well as absenteeism and turnover (Bowen *et al.*, 2014a; Fenton *et al.*, 2014). At the same time, this hyper masculine culture, means that many workers tolerate 'trivial' symptoms of poor health (e.g. dismissing depression as stress) and avoid help-seeking behaviour (O'Brien *et al.*, 2005).

The data also indicate that current occupational health and safety interventions and policies see safety risks as primarily physical rather than psychological. Indeed, workplace wellbeing programs focusing on individuals and individual lifestyle changes (e.g. access to gyms, healthy food, better ergonomics and environments as well as stress audits and recognition of risk factors for poor mental health) were found to merely address short-term risks rather than the underlying causes and drivers of poor wellbeing such as hyper masculine norms and practices (e.g. long work hours, presenteeism and total availability). These types of programs individualize the issue and hold employees responsible to attend these programs and adjust their individual behaviours to improve their health without recognising the whole-of-organization responsibility to create a healthy workplace environment), thus having limited value (Fenton *et al.*, 2014; Knapp *et al.*, 2011).

Commitment throughout the organization (including management at the highest level) to a culture that is not tied to masculinity is therefore a critical factor - it includes management structure, staff communication and interaction as well as flexible work options, and employees' perception of feeling valued (Dickson-Swift *et al.*, 2014). In the construction industry, the prevalence of norms of masculinity means that notions of 'doing gender' need to be closely examined when investigating workplace wellbeing. Future work in this area will consider the extent to which these findings are specific to the construction industry, as well as addressing more explicitly, the role of non-dominant masculinities in challenging or embedding the hyper masculine norms and practices that impact on wellbeing in the sector.

CONCLUSION

The aim of this paper was to explore the wellbeing of male and female construction professionals through the lens of masculinity. Our findings point to both men and women employees in the construction industry enduring significant risks to their

wellbeing in silence as a result of unhealthy workplace practices. Our findings reveal significant symptoms of poor mental health such as stress, panic attacks, insomnia, fatigue and anxiety, as well as strains on family life - among men and women. Employees regularly worked double their contracted hours and discussed the need to 'prove their worth', leaving little time for work-life balance. We argue that, in large part, these practices are driven by unspoken masculine norms that require long hours, total availability, and presenteeism. The focus of the construction industry on short-term outcomes and productivity may further interact with norms of masculinity and health behaviours in the workplace by reinforcing and institutionalizing values of masculinity. The professional employees in our study were expected to tolerate adverse work conditions without complaint and sacrifice their health to get the job done. Despite some efforts to address this by the companies, physical safety appeared a higher priority than psycho-social wellbeing, even in the face of lost productivity. We conclude that the masculinity of the sector is linked to workplace wellbeing for both the men and women that work in the industry.

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FIT FOR WORK? COMPARATIVE MENTAL HEALTH OF BUILT ENVIRONMENT UNDERGRADUATES

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High rates of occupational stress make mental health a critical issue in the built environment (BE) sector. Research has shown that some aspects of mental health, like burnout, continue over from student days into the workplace. Employers and educators should be concerned then that global evidence shows that the mental health of millennial students, born 1980-1999, is deteriorating. Therefore it is important to understand more fully the mental health of future BE professionals before they enter the workforce. Although mental health has been studied in numerous undergraduate disciplines including engineering, science, IT, medicine and law, it is not known whether these results can be generalised to BE students. This study explored the mental health of 410 Millennial undergraduate BE students in a large metropolitan university. The DASS-21 Depression, Anxiety and Stress scales were used to enable a comparison with six previously published studies on undergraduate mental health. Means and standard deviations were calculated and the scores were classified into categories ranging from 'normal' (no disorder) to 'extremely severe' using established population norms for the measurement scale. Generally the sample of BE students showed a greater incidence of normal mental health and a lower percentage of mental health disorders than other university disciplines. However, it is still a matter of concern that one in four in the BE sample experienced either depression or stress, or both. Of even greater concern is that four in ten students experienced an anxiety disorder. These findings have implications for both educators and employers as mental health problems at university can carry over into the workplace. As the construction industry is known for its high number of stressors and poor mental health, it is important that mental health issues, especially high levels of anxiety, are identified early in the talent supply chain and that interventions are undertaken at university to produce more mentally fit graduates.

Keywords: anxiety, built environment students, depression, mental health, stress

INTRODUCTION

Relatively little is known about the mental health of future construction management professionals studying at university. Previous research on construction students has focussed on two main areas: student burnout (Lingard, Yip, Rowlinson, and Kvan, 2007; Moore and Loosemore, 2014); and more recently, student resilience and wellbeing (Turner, Scott-Young and Holdsworth, 2017). Burnout refers to a student's negative disengagement as a result of chronic emotional, interpersonal, study, and/or work demands (Schaufeli, Salanova, González-Romá and Bakker, 2002). Lingard *et al.*, (2007) and Moore and Loosemore (2014) found that burnout was high in

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Australian construction student samples, especially for those who juggled paid work with study. Burnout was also found in a lesser degree in construction students in Hong Kong due to high demands from studying and concern about the local economy (Lingard *et al.*, 2007). More recently, Turner *et al.*, (2017) explored built environment students' resilience capability to adapt to environmental stressors. They found that although resilience was related to better levels of student wellbeing, many built environment students displayed a deficit in maintaining perspective, a cognitive skill necessary for weathering stressful events and recovering from disruptions and set-backs. Despite these studies, very little is known about construction students' mental health in terms of the prevalence and severity of the most common societal types of mental disorders: depression, anxiety and stress (Bitsika, Sharpley and Melhem, 2010). This study fills that gap. Due to the stressful nature of the construction industry (Bowen, Govender and Edwards, 2014; Leung, Chan and Cooper, 2015), it is important for construction educators to better understand the mental health profile of their students in order to build their wellbeing to prepare them for the known challenges they will encounter in their future professional careers (Leung *et al.*, 2015).

Recent reports from across the industrialised world suggest that the mental health of the current university student cohort known as Millennials and born between 1982 and 2000 (Howe and Strauss, 2008) is the worst of any age cohort and is steadily declining. Mental illness has been growing among Millennials in Britain (NHSDigital, 2016), Australia (Mission Australia, 2016), and in the US (American Psychological Society, 2017), particularly among young women (Hawley *et al.*, 2016). Depression increased in the US Millennial cohort between 2005 and 2014 (Mojtabai, Olfson and Han, 2016) and their stress has also increased over recent years, with money and work the major contributors (American Psychological Association, 2017). Although this generation is more likely to engage in stress-relieving activities, 30% believe they do not adequately manage their stress (American Psychological Association, 2017). Moreover, the incidence of self-harm in this age cohort has been growing around the world. Self-harm in male Millennials in the UK doubled between 2007 and 2014 and trebled to almost 20% of females (NHSDigital, 2016). Similar concerning behaviour has been recorded in the US (American Psychological Association, 2017). The rise in mental disorders in the Millennial generation is a disturbing development for both academics and employers as mental health disorders are known to impair the ability to perform the normal routine activities required by study and work (Searle, 2017) and can cause students to dropout (Van Brunt, 2008).

In the past two decades, research has documented declining levels of mental health across all age groups. According to the World Health Organisation (WHO) (2017) "the burden of mental disorders continues to grow with significant impacts on health and major social...and economic consequences in all countries of the world". Approximately 17% (one in six) of English adults reported symptoms of a common mental disorder in 2014 (National Health Group Digital (NHGDigital), 2016). A national study of mental health and wellbeing in the Australian population found a slightly higher incidence, with one in five Australians aged 16-85 having experienced some form of mental disorder in the previous twelve months (Australian Bureau of Statistics (ABS), 2008). Although the prevalence of mental health disorders in all age groups has been increasing globally (WHO, 2017), the incidence of disorders is greatest in the Millennial generation (NHGDigital, 2016; Mission Australia, 2017; American Psychological Association, 2017). In Australia,

Millennials experienced more mental health disorders than older age groups, with approximately one in four 16-24 year olds (26%) and 25-34 year olds (25%) experiencing some form of disorder (Australian Bureau of Statistics (ABS, 2008).

Depression is now the most common health disorder, whose incidence has risen by more than 18 percent since 2005. There are now an estimated 300 million sufferers world-wide (WHO, 2017). Depression is an emotional disorder which involves a negative disturbance in mood (ABS, 2008). “Depression is characterized by sadness, loss of interest or pleasure, feelings of guilt or low self-worth, disturbed sleep or appetite, tiredness, and poor concentration. Sufferers may also have multiple physical complaints with no apparent physical cause. Depression can be long-lasting or recurrent, substantially impairing people’s ability to function at work or school and to cope with daily life. At it’s most severe, depression can lead to suicide” (WHO, 2017).

In contrast to the world trend, anxiety disorders are the most common mental illness in Australia, experienced by 14.4% of Australians, while only 6.2% Australians suffer from depression (ABS, 2008). Anxiety disorders involve feelings of tension, nervousness or distress, which can prompt individuals to fear or avoid stressful situations that evoke these negative emotions (ABS, 2008). In Australia, people with anxiety disorders report taking an average of 4.4 days sick leave per month (ABS, 2008) and anxiety disrupts sufferers’ social lives and close personal relationships (Searle, 2017).

Stress disorders also affect a substantial proportion of the world’s population. Surveys in the US report that the rising incidence of stress is negatively impacting adult health and wellbeing (American Psychological Association, 2017). Stress is defined as “a state of persistent arousal and tension with a low threshold for becoming upset or frustrated” (Lovibond and Lovibond, 1995). In one longitudinal UK survey, Millennials reported higher average stress levels than any other generation, and more Millennials reported that their stress has increased from the previous year (Edwards, 2017).

Females generally experience a greater prevalence of psychological distress than males. The Australian Bureau of Statistics’ (2008) national survey found that in a twelve-month period, women (22%) reported experiencing higher rates of mental disorders than men (18%). More women experienced anxiety disorders (18%) compared to 11% of males. More women (7.1%) experienced depression compared to 5.3% of men. Younger women aged 16-24 were approximately twice as likely to experience affective disorders (8.4%) compared to 4.3% of same-aged males. In the slightly older group aged 25-34 years, women were nearly twice as likely to experience anxiety disorders (12%) than males the same age (ABS, 2008). Similar gender-related trends were found in England, with more adult women aged 16 and over (19%) experiencing common mental disorders than men (12%) and with more severe symptomology (10% compared to 6%) (NHGDigital, 2016). In the US also, women’s stress levels are higher than men’s (American Psychological Association, 2017).

AIM

Although scant attention has been paid to the mental health of built environment students, research in other disciplines like medicine, law (Larcombe *et al.*, 2016), and nursing (Storrie, Ahern and Tuckett, 2010) has found that university students

experience higher incidences of depression, anxiety and stress than their peers in the general population (Larcombe *et al.*, 2016). However, it is not known whether these results can be generalised to students studying built environment degrees. In fact, Larcombe *et al.*, (2016) argue that the impact of field of study on mental health been under-researched. Therefore, this study aims to explore the prevalence and severity of depression, anxiety and stress in undergraduate students studying construction-related degrees. The three specific research questions are:

What is the mental health profile of students studying undergraduate degrees in the built environment?

How are demographic characteristics such as gender and international student status related to student mental health?

How does the prevalence and level of mental disorders compare with other disciplines of university study?

METHODS

Sampling Strategy

A purposive sampling strategy was employed. Millennial students studying an undergraduate degree in a Built Environment school in a large metropolitan university in Australia were invited to participate in the study. The survey was administered in two waves, in Semester 2 of 2014 and Semester 1 of 2015. To maintain environmental consistency, students were surveyed in Week 7 of their twelve week semester. A 15 minute pen and paper survey was administered as part of a course-related activity. On completion of the survey, students were invited to voluntarily place their anonymous survey in a box by the door as they left the room. This resulted in a 90% return rate from those surveyed. Independent sample *t*-tests were conducted to check if the demographic variables for the Wave 1 and Wave 2 samples were similar. The means of the demographics for both semesters of the first and final year samples did not statistically vary, indicating that the two semester waves of each year level could be combined to form a single sample.

Data Instrument and Analysis

The DASS21 survey, a 21 item shortened form of the original DASS-42 scale (Lovibond and Lovibond, 1995) was used to measure participants' incidence and level of depression, anxiety and stress. As the DASS instrument has been widely used around the globe, its use in the current study allows for the comparison of the mental health of BE undergraduate students with the population norms for same age group and with the findings from studies of other disciplines at other universities across the world. The Depression, Anxiety and Stress subscales consist of seven items each and each subscale exhibits high reliability (Henry and Crawford, 2005). The response format is a 4-point Likert scale, with higher scores reflecting a higher level of depression, anxiety and stress. Each subscale is made up of seven items that are summed to compute a score. The Depression subscale contains items like "I found it difficult to work up the initiative to do things", "I felt down-hearted and blue", and "I felt I wasn't worth much as a person". Items in the Anxiety subscale include "I was aware of dryness of my mouth", "I experienced trembling (e.g., in the hands)", and "I was worried about situations in which I might panic and make a fool of myself". The Stress subscale contains items like "I found it difficult to relax", and "I tended to over-react to situations". Cronbach's Alpha scores showed that all three subscales

demonstrated satisfactory reliability and internal consistency in the current sample (Depression = 0.83, Anxiety = 0.79, and Stress = 0.83).

Participants

Of the 410 respondents, 179 (43.8%) were first year students, 5 (1.2%) were in their second year, 24 (5.9%) were in their third year, while 183 (44.7%) were fourth/final year students. Almost one quarter (101; 24.7%) of the sample were female. Most of the sample (309; 76.1%) were aged 24 or younger and 17.8% (72) were international students. The majority of the sample (308; 68.3%) worked part time, with 133 (43.1%) students employed in the construction industry.

Mental Health Profile of Students

As recommended by Lovibond and Lovibond (1995), the results of this study's shortened DASS-21 measure were multiplied by two to make them comparable to the 42-item version of the scale (DASS-42) to enable a direct comparison of the current findings with extant university studies (e.g. Larcombe *et al.*, 2016). The sample size for each of the subscales differs as some surveys had missing data and those subscales were subsequently removed. Using the clinical cut-off points provided by the scale developers (Lovibond and Lovibond, 2011), the scores for each subscale were classified as 'normal', 'mild', 'moderate', 'severe', or 'extremely severe' and the frequencies and percentages of each level of disorder were calculated (see Table 1). As explained in Crawford *et al.*, (2011), the ranges for each level of the three DASS subscales varies.

Almost three quarters of the current sample (74%) scored in the normal range for depression (0-9) and for stress (0-14) (75.3%), indicating that students' overall level of perceived depression and stress fell within the normal ranges for the general population. That is, the majority of BE students were not depressed or stressed. However, a substantial number of built environment students did experience some form of psychological distress. One quarter of the students experienced depression or stress (ranging from mild to extremely severe). For anxiety, fewer students (61.3%) recorded scores in normal range (0-7), even though as previously noted, the sample mean still fell within the normal range ($M=6.81$, $SD=7.08$). Almost 40% of students did experience some level of anxiety disorder (ranging from mild through to extremely severe). Ten percent of the sample experienced mild depression, 16.7% reported symptoms of mild anxiety and 9.6% experienced mild stress. A further 9.6% of the sample experienced moderate levels depression, anxiety or stress. Approximately 5.8% of the sample experienced severe-extremely severe depression, while 6.3% experienced severe-extremely severe stress. Almost 12% experienced severe-extremely severe anxiety.

Table 1: Prevalence and severity levels of student mental health

Category	Depression		Anxiety		Stress	
	N	%	N	%	N	%
Normal	282	74.0	242	61.3	300	75.3
Mild	40	10.4	66	16.7	37	9.6
Moderate	37	9.6	41	10.4	35	9.0
Severe	12	3.2	17	4.4	19	5.4
Extremely Severe	10	2.6	29	7.5	3	0.9

Demographic differences in mental health

The results were then analysed to examine the prevalence of mental health disorders in relation to the demographic categories of gender and international student status. Independent samples *t*-tests were performed to test the significance of the DASS-42-equivalent mean differences in each of the three mental health disorders (depression, anxiety, and stress) according to these two characteristics. There was no significant difference between male (M=6.43, SD=7.14) and female (M=6.28, SD=6.27) means for depression, with both means falling within the normal range (0-8). However, gender differences were noted for both anxiety and stress. Female students experienced significantly more anxiety (Mean=7.98, SD=6.86, $t(363) = -2.34$, $p=0.02$) and more stress (Mean=11.51, SD=8.89, $t(363) = -2.30$, $p=0.02$) than males (Mean=6.05, SD=6.60; Mean=9.23, SD=7.69 respectively). The scale means for stress fell within the normal range (0-14) for both genders. While both genders' means fell within the normal range for anxiety (0-7.99), the female mean (7.98) was at the upper end of the cut-off.

Students from other countries experienced significantly higher levels of depression (Mean=8.32, SD=7.81; $t(364) = 2.44$, $p=0.01$) than local students (M=5.99, SD=6.69). They also experienced higher levels of anxiety (Mean=9.59, SD=7.86; $t(364) = 4.11$, $p=.0001$). Although the mean for stress for international students (Mean=11.37, SD=8.56) was higher than that for local students (Mean=9.42, SD=7.89), this difference ($t(364) = 1.7$, $p=0.08$) was only significant at the 10 per cent level. The means of all three disorders fell within the normal range for both international and local students, but the mean of anxiety for international students (7.86) fell on the high end of the normal range (8-10).

BE students' mental health compared with other disciplines

As previously noted, the results of each DASS-21 subscale (depression, anxiety, and stress) were multiplied by two to make this study comparable to the DASS-42 scores for six existing studies of mental health in different academic disciplines in Australia, USA, Hong Kong and Turkey. A comparison of the mean scores for each study and their classification ranging from 'normal' (no disorder) to 'extremely severe' are shown in Table 2. The current sample of BE students showed a greater incidence of normal mental health and a lower incidence of mental health disorders than any other discipline.

Table 2: Comparison of mental health means with extant studies

Study	Country	N	Depression	Anxiety	Stress
Current study	Australia	451	6.5 (normal)	6.9 (normal)	9.9 (normal)
Wong <i>et al.</i> , (2006)	Hong Kong	7915	8.7 (normal)	9.4 (mild)	14.0 (normal)
Bayram and Bilgel (2008)	Turkey	1617	10.0 (mild)	9.8 (mild)	14.9 (mild)
Townes <i>et al.</i> , (2011)	Australia	295	10.1 (mild)	7.5 (mild)	13.0 (normal)
Osman <i>et al.</i> , (2012)	USA	410	7.7 (normal)	6.4 (normal)	11.1 (normal)
Larcombe and Fethers (2013)	Australia	316	9.2 (mild)	7.4 (mild)	14.4 (mild)
Larcombe <i>et al.</i> , (2016)	Australia	5061	10.2 (mild)	8.2 (mild)	13.7 (normal)

DASS-21 means were multiplied by 2 to make them comparable to DASS-42 means (Lovibond and Lovibond, 1995)

DISCUSSION

Although university student mental health has been studied in numerous undergraduate disciplines, until now, it has not been known whether these results can

be generalised to students undertaking an undergraduate degree in the built environment discipline. This study was designed to fill the gap in knowledge about the prevalence and severity of depression, anxiety and stress in built environment students. The findings confirm that as in other fields of university study, mental health issues are of serious concern in the built environment student population. The first question focused on identifying the mental health profile of built environment students. One in four students had experienced depression and stress ranging from mild through to extremely severe over the previous two weeks, a finding that is consistent with the level of disorders reported in their peers not attending university (ABS, 2008). More students (one in three) had experienced disordered levels of anxiety over that same time period. The finding of a greater prevalence of anxiety in comparison to the other two disorders is consistent with Australian general population findings (ABS, 2008) and with previous studies of university students (e.g. Bitsika *et al.*, 2010; Bewick *et al.*, 2010). The present study confirms that for some students, studying at university is marked by the experience of psychological distress, and more particularly of anxiety.

The second research question explored whether the demographic characteristics of gender and international status were associated with the incidence of mental health in BE students. For depression, there were no statistically significant differences between male and female students in terms of the prevalence or severity of depressive symptoms, with the majority of students reporting normal levels of functioning. This result differs from other studies which have found that a higher proportion of females experience depression (ABS, 2008). However, the gendered findings of female BE students experiencing significantly higher levels of anxiety and stress than males were consistent with other research in Australia (ABS, 2008) and the US (American Psychological Association, 2017).

International students experienced significantly worse levels of mental health than local students, reporting higher depression, anxiety and distress. As the number of international students studying in overseas universities is increasing, this finding alerts educators to pay special attention to fostering the wellbeing of such students who are far away from their normal social support systems. Taken together, these results indicate that similar to the extant research on other university disciplines, a substantial proportion of Millennial built environment students were suffering from some form of emotional distress, with female and international students the most vulnerable of all.

The third research question explored how the mental health of built environment students compared with students in other disciplines of university study. When compared with six other studies, built environment students experienced a lower incidence of mental health issues. This study was not able to determine why the built environment sample displayed a better mental health profile than students in the comparison disciplines, but the finding indicates the need for further research.

Although the built environment students in this sample generally experienced better mental health than students in other fields, it is still a matter of concern that one in four in this sample experienced either depression or stress, and two in five students experienced an anxiety disorder. Female built environment students are particularly at risk of developing anxiety and stress disorders, while international students have a greater risk of developing all three emotional disorders of depression, anxiety and stress. These findings should be of concern to academics as mental disorders are

known to impair students' daily functioning and subsequent academic performance, and these students are more likely to drop out of university study (Van Brunt, 2008).

CONCLUSIONS

This research contributes to the understanding of the mental health of students undertaking studies in the built environment. The results confirmed that studying at university can be a psychologically distressing time for many students. The findings suggest the need for further research to better understand the causes of student distress, especially for female and international students. Future research could employ student interviews to gain a more in-depth understanding of the factors which impact upon students' mental health. Further research can also explore whether built environment students are receiving sufficient support and attention to their emotional needs. Research is also needed to identify which resources can be important for fostering good mental health and for alleviating students' anxiety and stress.

The sample of this study was limited to built environment students in one Australian university and hence the results are not able to be generalised to students in other universities or countries. Further research in other contexts is therefore recommended. Despite these limitations, this study adds new knowledge to the under-researched topic of the mental health of students undertaking higher education studies of the built environment. This research offers new insights into the prevalence and nature of the mental disorders that these students experience and identifies targeted areas for the improvement of student mental health.

The findings of this study have implications for educators in the built environment disciplines. Early detection and support can benefit students who experience psychological disorders. Educators can be trained to identify students with mental health issues so that students can be referred to university counselling services for support. In addition, targeted programs for addressing anxiety and stress through raising emotional awareness and developing coping strategies would better equip built environment students with skills for adapting to stress.

The results also suggest that built environment departments should consider developing a coherent strategy that provides mental health interventions for females and international students identified as demographic groups at greater risk of developing mental disorders. As the construction industry is known for its high number of stressors and poor mental health, it is imperative that mental health issues, especially high levels of anxiety, are identified early in the talent supply chain and that interventions are undertaken at university to produce more mentally fit graduates.

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ANALYSIS OF HEALTH AND WELL-BEING PRACTICES AMONG OLDER CONSTRUCTION SITE-BASED WORKERS IN SOUTH AUSTRALIA

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There are limited studies undertaken on the prevailing health and wellbeing practices of older construction workers, and how these practices influence the employee satisfaction and performance. To narrow this gap, the study aims to explore how the health and wellbeing practices influence the performance of older construction based workers. A questionnaire based survey was performed among the 85 South Australian older (50 plus years) construction workers involved in site based project work to identify the prevailing health and wellbeing practices and their impact on work ability. The survey data was subjected to descriptive and inferential statistics with regression analysis to predict the impact of the practices on work ability. Eighteen health and wellbeing practices were identified to be significant in influencing the work ability and productivity of older construction site-based workers. The results indicated that the highly ranked five practices were from the 'leadership and organisational support' category as follows: (i) my employer cares about my health; (ii) employers should play an active role in improving the health of their employees; (iii) my company's leader are committed to worker health, safety and well-being; (iv) preventative screening; and (v) my employer provides me with resources necessary to maintain good health. The least ranked practices were drawn from the following 'workplace health promotion (WHP)' programs category: (i) corporate sponsored challenges; (ii) healthy food options on site cafeteria or healthy snack option; (iii) case managers to track disease management; (iv) medication adherence programs; and (vi) monitoring of health goals / biometrics, BMI and weight loss, cholesterol levels and blood pressure. The overall sum of working ability reported by most respondents was found to be good and moderate. The identified practices could be used for the promotion and development of interventional strategies aimed at improving the general and mental wellbeing of older construction workers.

Keywords: health and wellbeing, workability, older workers, South Australia

INTRODUCTION

Construction organisation devote huge amounts of resources for enhancing the well-being of the employees in several ways, from employee recognition and professional development practices to facilitating with health care and benefits (Goetzel *et al.*, 2014). More so, the better the general health and wellbeing of the employees, the better will be the productivity levels. This suggests the need for the construction

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industry to implement and practice health and wellbeing programs to improve employee efficiency, attendance and on the job performance. In Australia, and globally, the construction industry drives the economic activity significantly. Its significance is further evidenced by being the third largest industry of Australia after services and contributes 8.1 per cent to the Gross Domestic Product. In 2015-16, it grew by 2.8 per cent in output terms, producing \$134.2 billion of output and employing nearly 1.1 million workers directly from all over the globe (Department of Industry, Innovation and Science, 2017). Despite the noted importance of the construction industry, the population of Australia is ageing. This means Australia will have fewer working age people to support the older Australians. More so, the ageing population will cause many issues for Australia in years to come such as, health, size of the working-age population, housing and demand for skilled labor (Australian Bureau of Statistics, 2016), and overall, the construction workers' mental health was poorer than that of the general Australian population (Lingard and Turner, 2015). In addition, older workers have the highest rate of mortality, psychological and cardiovascular diseases (Kunze *et al.*, 2013). The construction industry is also beset by a number of issues that affect the workers. For example, several large-scale epidemiological studies of illness among construction workers, such as the work of Stocks *et al.*, (2010), reported a high incidence of occupational ill health and a high burden of cancer attributable to occupational factors in the UK construction industry among various trade occupations. Consequently, the work ability of employees may depend upon other factors, such their eating habits, amount of exercise and stress level in their personal lives. Likewise, construction workers have been identified in several studies as a group at high risk of poor health (Lingard and Turner, 2015), with linkages of lifestyle factors such as smoking and drinking alcohol, and lack of normal vigorous activity during leisure time to poor work ability (Alavinia *et al.*, 2007). This research particularly targets the blue collared older construction workers in South Australia. The ageing workforce is mainly targeted for this study as they are more subjected to health-related issues (Arndt *et al.*, 2006), and are more prone to physical and psychological deprivation (Sivam *et al.*, 2018). The construction workers are also susceptible to smoking and alcohol consumption. Numerous studies in the Australian context and other countries have been conducted to investigate the impact of health and well-being practices on the employee satisfaction and productivity of workers, as the development of health promotion programs in organisations. (De Silva *et al.*, 2017; Loudoun and Townsend, 2017; Lingard and Turner, 2015; Dickson-Swift *et al.*, 2014; Lingard *et al.*, 2012). However, majority of these Australian studies have been regional or State specific, and have focussed on the younger workers. Conversely, older construction workers have different challenges in the workplace (Sivam *et al.*, 2018). To narrow this knowledge gap, the study aims to explore how the health and wellbeing practices influence the performance of older construction based workers in South Australia.

LITERATURE REVIEW

Goetzel *et al.*, (2012) defines employee wellbeing as “including the combination of different mental factors such as frustration, stress and anxiety and physical indicators like heart condition, blood pressure and general physical health”. According to a number of studies such as Goetzel *et al.*, (2014), most construction firms devote huge amount of resources for enhancing the well-being of the employees in several ways, from employee recognition and professional development practices to facilitating with health care benefits. For instance, many organizations adopt one of the two ways for

influencing health of the employees, with the first by ensuring that a workplace that promotes or is at least not unfavorable to health. The second involves encouraging the employees to practice a healthier lifestyle in general by facilitating with incentives or opportunities such as arranging a healthy eating seminar or giving subsidy for joining a fitness center. The number of benefits of implementing these health and well-being practices by organisations is well documented in literature (Schwatka *et al.*, 2012; McDaid and Park, 2011). For example, such health and well-being practices, and strategies have been found to contribute a lot towards the economic benefits for employers and a positive health effects for employees (McDaid and Park, 2011). The other notable benefit is through the ability of employees facing health problems to receive the payments from the public transfer system like the welfare schemes, disability insurance or unemployment insurance as they are at the higher risk of becoming unemployed either temporarily or permanently (Wright and Huang, 2012). While many studies have identified the challenges facing the younger workers, in contrast older employees specifically must face different challenges in the workplace. It is also well established that they may be treated as less valuable in comparison with the young employees particularly when working in non-managerial position. For example, studies by Jokela *et al.*, (2010) indicated the psychosocial environment in which older workers work encourage them to retire at a specific age. In addition, a number of longitudinal studies indicates that health is influenced by psychological and physical demands of job such as the psychological job stress includes mortality, early exit from work, coronary heart disease whereas the physical job demands comprise of awkward posture, repetitive movements, disability retirement (Jones *et al.*, 2013). In summary, the literature review highlighted the limited empirical South Australian construction specific health and well-being studies. Hence, to fill that knowledge gap, this present study investigates the health and well-being practices amongst the older construction workers and how this influences their employee satisfaction, performance and workability

RESEARCH METHODS

To explore how the health and wellbeing practices influence the performance of older construction based workers, the following research methods were employed in the study.

Measurement Instrument

The questionnaire comprised the following three distinct sections: Section 1 encompassed the general demographics of the study (i.e. age, and trades background); Section 2 was aimed at capturing the respondent's perceptions on the importance of the health and well-being practices prevailing on their sites. In total, 21 items were included as identified from literature and mostly based on McCleary *et al.*, (2017) and was composed of 2 sub instruments. The first comprised 8 '*Leadership and Organisational Support*' items, and the second, thirteen '*Workplace health promotion (WHP) programs*' type of items. For both sub instruments, respondents were asked to rate their opinions on these 'health and well-being practices' using a five point Likert-scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). Section 3 comprised the modified version of the workability index (WAI) as proposed by Ilmarinen (2007) and is designed as a good predictor of a person's employability now and in the future. The 7 WAI questions ranged from current work ability demand (0-10); work ability in relation to the demands of the job (2-10) current diseases as diagnosed (1-7); estimated work impairment due to diseases (1-6); sick

leave during the past year (1-5); own (personal) prognosis of work ability 2 years from now (1-7); and mental resources (1-4). The number in parentheses against each item indicates the scoring range. This study reports only on the overall WAI as computed, as it is beyond the scope of this study to discuss the individual sub-questions or items. The classification of the WAI as captured in section 3 resulted in the following 4 categories and associated total score (in parentheses): Poor (7-27); Moderate (28-36); Good (37-43); and Ideal (44-49). In summation, these ratings provide a final result that ranged between 7-49 points which is called work ability rating (WAR). The work ability rating enables us to understand the ability of worker to do his work. The total score is the sum of score obtained for each question.

Justification for adopting the WAI and measurement instrument

The study employed the WAI as primarily proposed by Ilmarinen (2007) and the health and wellness program questionnaire as used in the study of McCleary *et al.*, (2017) were used for this research. It is the most popular measure for determining the ability of workers to continue with their job and responsibility. Secondly, the WAI instrument has numerous usages in conducting research into different industries. For example, this instrument has been adopted among railway construction workers (Capanni *et al.*, 2005); aging (de Zwart *et al.*, 2002); and construction industry (Welch *et al.*, 2010).

Data Analysis

Data as collected was analysed using the IBM SPSS software (*version 25*). Four methods were employed: (i) *Parametric tests* were undertaken to measure the significance of the ‘health and well-being practices’, (ii) *descriptive statistics tests such as measures of central tendencies and frequency analysis* enabled further ranking analyses to obtain the relative importance of the health and well-being practices; (iii) *regression analysis* was used to predict the impact of the practices on work ability; and (iv) the *coefficient of variation (CV)* is used as a general measure of the standardised skewness or variability of the responses. This was computed using the standard deviation as a percentage of the mean score.

Population and Sampling

The questionnaire was distributed to older site-based construction workers in South Australia. The survey method is the most suitable for conducting this type of study as it helps in measuring knowledge, behavior and opinions, and has remained popular in the construction industry (De Silva *et al.*, 2017). To maintain the privacy of the participants due to the complex and sensitive nature of information, the survey was administered face to face. The survey instrument that was already designed and validated was used for this study as it ensures that accurate data is being gathered (Metwally, 2012). The snowball sampling technique was used for this study which entailed participants recruiting other participants for survey questionnaire. This technique has been used in construction studies (De Silva *et al.*, 2017).

Participant selection

The participants particularly those who were 50 years and over as this age group are classified as ‘older workers’ (Eaves *et al.*, 2016), and work on the site were contacted through paper and electronic medium. The rationale for the selection of this age group is nested within the assertion that older workers have the highest rate of mortality, psychological and cardiovascular diseases (Kunze *et al.*, 2013). The unit of analysis for the study was the ‘construction worker’. As asserted by McCleary *et al.*, (2017, pg. 257), in studying WHP (Wellness) programs, an important population to

research is the employees themselves. Black *et al.*, (2017) participation criterion for survey respondents was applied: 1) those who had a history of metabolic or cardiovascular disease were not included in the survey. 2) Rather, only the individuals not taking any type of prescribed medication and are free from illness or infection and do not had any previous medical conditions were invited to the survey.

Characteristics of the Sample

From a total of 180 questionnaires distributed, a total of 85 usable responses were obtained equating to an overall response rate of 47 %. Based on the respondents to questionnaire, (54.1 %) of them were aged between 50 and 54, followed by 35 (41.2 per cent) in the 55 to 64 years category. The minority 4 (4.7 %) fell into the 65 to 74 years. The inclusion of these three categories was to take into consideration the definitions and possible indicators of functional age. From the trade's perspective; the majority (42.3 %) of respondents were either plasterers (23.50 %) or plumbers (18.80 %). This was followed by 10 (11.80 %) of painters. There was also a fair distribution of trades such as carpenters (6); roofers (8); bricklayers (9); electricians (7); and general labourers (9). Of these, the inclusion of roofers, bricklayers and general labourers is of importance as these trades are defined as outdoor trades due to their work being outside in the early construction phases, and therefore prone difficult conditions such as heat (Eaves *et al.*, 2016).

SURVEY RESULTS AND DISCUSSIONS

Ranking of Health and Well-Being Practices

Table 1 presents the descriptive results of analysis for the 21 health and well-being practices. As illustrated, the mean agreement scores ranged from 4.01 to 2.04. The COV of the health and well-being practices ranged between 16.9 and 53.7 with the least ranked practices unsurprisingly demonstrating lower levels of agreement between the respondents. It is beyond the scope of this study to discuss all the 21 practices. Therefore, only the top four scoring above 3.5 and the least ranked due to the relevance of the practice have been singled out.

My employer cares about my health and wellbeing

The practice "my employer cares about my health and wellbeing" (mean = 4.4) is the most important health and well-being practice influencing the older construction workers. This practice was also statistically significantly different from the population mean score of 3.5 ($t = 8.139, p = 0.000 < 0.05$). More so, this finding is also consistent with the well-being literature regarding senior management support or workplace health promotion programs (WHPPs), the impact of the employee's general well-being on the overall productivity of the firms (organisations), as well as associated benefits of health programs (Loudoun and Townsend, 2017; Goetzel *et al.*, 2014; Lingard *et al.*, 2012; Goetzel *et al.*, 2012; McDaid and Park, 2011). For example, McDaid and Park, (2011) found that the organization's implementing such health and well-being promotion strategies are contributing a lot towards the economic benefits for employers and a positive health effects for employees.

Employers should play an active role in improving the health of the employees

"Employers should play an active role in improving the health of the employees" (mean = 4.07) was ranked as the second most important health and wellbeing practice necessary for improving the workability and performance of older construction workers.

Table 1: Ranking of health and well-being practices amongst older construction workers in South Australia

Health and well-being practices	MS	Std. dev	COV (%)	OR ¹	R ²
<i>Leadership and organisational support practices</i>					
WB1 = Lower health insurance premiums should be offered for participation in health promotion programs	3.51	1.211	34.5	6	5
WB2 = Employers should play an active role in improving the health of their employees	4.07	0.737	18.1	2	2
WB3 = My company's leader are committed to worker health, safety and wellbeing	4.01	0.681	16.9	3	3
WB4 = My employer cares about my health and wellbeing	4.14	0.726	17.5	1	1
WB5 = My work environment allows me to maintain good health	2.98	0.816	27.4	12	7
WB6 = My employer provides me with resources necessary to maintain good health	3.65	0.841	23.0	5	4
WB7 = Our CEO and senior leaders are committed to improving the health of their employees	3.29	0.651	19.8	8	6
WB8 = Our CEO and senior leaders feel it is their responsibility to take care of their employees' health insurance needs	2.78	0.822	29.6	15	8
<i>Workplace health promotion (WHP) programs</i>					
WB9 = Preventative screening and vaccinations	3.67	0.746	20.3	4	1
WB10 = Exercise programs-either on site or discounts for local gyms	3.35	1.066	31.8	7	2
WB11 = Monitoring of health goals/biometrics-BMI/weight loss, cholesterol levels, blood pressure etc.	2.04	1.096	53.7	20	12
WB12 = Smoking cessation programs	2.00	1.035	51.8	21	13
WB13 = Completing a health risk appraisal	2.99	1.286	43.0	11	5
WB14 = Managed programs for substance abuse or mental health	2.91	1.087	37.4	14	7
WB15 = Healthy food options on site cafeteria or healthy snack option	2.69	1.215	45.2	17	9
WB16 = Corporate sponsored challenges	2.71	0.843	31.1	16	8
WB17 = Ergonomic workstations (e.g. standing desks, adjustable workspace furniture)	3.04	1.229	40.4	9	3
WB18 = Lunchtime lectures/ education on healthy behavior	3.00	0.951	31.7	10	4
WB19 = On site health clinic for routine visits at my job	2.98	1.154	38.7	13	6
WB20 = Case managers to track disease management	2.09	0.610	29.2	18	10
WB21 = Medication adherence programs	2.07	0.686	33.1	19	11

Notes: N = 85,¹OR = Overall ranking of the 21 well-being practices based on the mean score (MS) where 1 = Strong disagree, 2 = disagree, 3 = Neutral, 4 = Agree, and 5 = strongly agree; ²R=Ranking based on the individual categories

The higher ranking of this practice is further evidenced by being statistically significantly different from the population mean score of 3.5 ($t = 7.142, p = 0.000 < 0.05$). This finding is also consistent with health and wellbeing literature regarding the measures and investment undertaken by construction firms and other sectors in enhancing their employee's wellbeing (Choi, 2015; Goetzl *et al.*, 2014; Ross, 2010). Similarly, the organization needs also to promote health and safety practices to improve loyalty, satisfaction and motivation of older employees (Ross, 2010).

My company's leaders are committed to worker health, safety and wellbeing

The third most important health and well-being practice is “my company’s leaders are committed to worker health, safety and wellbeing” (mean = 4.01). This practice was also statistically significantly different from the population mean score of 3.5 ($t = 6.926, p = 0.000 < 0.05$). The literature is replete of studies which highlights employers or organizational support to employees through the proactive implementation of a number of programs such as health promotion programs, wellness programs, stress management programs, fitness programs and health management programs (Choi, 2015; Dickson-Swift *et al.*, 2014). For example, Dickson-Swift *et al.*, (2014) identified organizational culture which includes organisation support among the contributing feature to making a positive impact upon the health of both employees and employers. Similarly, within the US construction industry context, the study by Choi (2015) recommended specific proactive preventative intervention ergonomics programs aimed at the older construction workers such as lifting training programs.

Preventative screening and vaccinations

The fourth most important health and well-being practice is “Preventative screening and vaccinations” (mean = 3.67). This was also the most highly ranked from the ‘WHP programs’ practices. As with the preceding three practices, the higher ranking of this practice is also further evidenced by being statistically significantly different from the population mean score of 3.5 ($t = 2.108, p = 0.038 < 0.05$). Support of this finding is also consistent with construction specific literature (Loudoun and Townsend, 2017) and other fields and disciplines (Zwetsloot *et al.*, 2010; McCleary *et al.*, 2017). For example, according to Frick and Zwetsloot (2009 cited in Zwetsloot *et al.*, 2010), health screening at recruitment can be used as a mechanism for managing the impact of health on production. Likewise, “workplace screening, ideally linked to medical care to ensure follow-up treatment as necessary” is acknowledged as one key element crucial to WHPPs (McCleary *et al.*, 2017, p. 256).

Smoking cessation programs

Despite the importance attached to WHP programmes and numerous studies that have highlighted the impact of smoking among the construction workers (Alavinia *et al.*, 2007; Lingard *et al.*, 2015; Dickson-Swift *et al.*, 2014; Australian Government Department of Health, 2016), this study revealed some contradictory findings with the practice of “smoking cessation programs” being ranked the least important health and wellbeing practice (mean = 2.00). For instance, according to the statistics by the Australian Government Department of Health (2012), 31% of the construction workers smoked when compared to the entire working population with a National average of 21%. This is despite the significance of the Lingard and Turner (2015) study which prioritized smoking cessation and physical exercise as priority areas for intervention amongst the male, blue collared construction workers. Similarly, earlier Australian studies such Dickson-Swift *et al.*, (2014) also identified that conducting health information session (such as quitting smoking) amongst the promoting features in organisations that had a positive impact upon the health of both employees and employers. Likewise, Alavinia *et al.*, (2007) found some association between lung obstructions arising from smoking with scores on the Work Ability Index (WAI).

Overall Workability and Regression Analysis

Based on the classification of the WAI as discussed in the research methodology section, the results the construction workers WAI were computed. Most of the

participants had a good (51.8%) and moderate (41.1%) work ability respectively. Subsequently, a multiple linear regression was calculated predicting the older construction workers workability scores based on their health and well-being practices (Table 1). The results of the model summary are presented in Table 2.

Table 2: Model summary stepwise regression predicting workability

Model	R	R ²	Adjusted R ²	Standard error of the estimate
1	.179 ^a	.032	-.070	0.655
2	.518 ^b	.269	.025	0.625

Notes: ^a Predictors: (Constant), WB8, WB2, WB3, WB6, WB5, WB7, WB4, WB1; ^b Predictors: (Constant): WB8, WB2, WB3, WB6, WB5, WB7, WB4, WB1; WB17, WB12, WB19, WB21, WB15, WB10, WB20, WB18, WB13, WB11, WB14, WB9, WB16

The ANOVA results (not included here) showed that for both models, the regression equations were not significant ($F(8, 76) = .313, p = .959 > 0.05$ with an R^2 of .032 and ($F(21, 63) = 1.102, p = .959 > 0.05$ with an R^2 of .269 for models 1 and 2 respectively. However, the results indicate that the aggregated 21 health and well-being practices (model 1) account for 26.9% of population variance of the overall workability success. This finding suggests modest degree of contribution of the health and well-being practices to overall workability.

CONCLUSIONS

Through a questionnaire survey, this study sought the perception of the older construction site-based workers on how the health and wellbeing practices influence their performance in South Australia. Based on the work of McCleary *et al.*, (2017), 21 health and well-being practices categorised into 8 “Leadership and organisational support practices” and 13 “WHP programs” were revised and adopted. The findings conclude that the following 3 “leadership and organisational support practices” as highly ranked and significant: “my employer cares about my health”, “employers should play an active role in improving the health of their employees” and “my company’s leader are committed to worker health, safety and well-being”. In contrast, the 3 highly ranked WHP programs” practices were “preventative screening and vaccinations”, “exercise programs-either on site or discount for local gyms” and “ergonomic workstations”. Surprisingly, contrary to the literature, the overall 2 least ranked practices were drawn from the following WHP programs category’ as follows: “monitoring of health goals / biometrics, BMI and weight loss, cholesterol levels and blood pressure” and “smoking cessation programs”. The overall sum of working ability reported by most respondents was found to be good and moderate. The findings of the present study is not only one of the few empirical academic works investigating the health and well-being practices, and the workability index of older workers within the South Australian construction sector, but could also be used for the promotion and development of interventional strategies aimed at improving the general and mental well-being of older construction workers. Most importantly, the workplace well-being as investigated not only deals with all the working life aspects of employees, but encompasses the safety and quality of the physical environment to whether the employees feel positive or negative about their work. This study has some limitations. First, the population sample was restricted South Australia only, and one industry namely construction, consequently, the findings may not generalize to other states and countries or older construction workers on site. Second, there could be a possibility of biased answers due to self-reporting nature of the questionnaire and this might not provide reliable estimates of the health and wellbeing practices.

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**INSTITUTIONALISING
CONSTRUCTION
MANAGEMENT
RESEARCH?**

ENGAGING THE CONSTRUCTION SUPPLY CHAIN: A PLURALISTIC PERSPECTIVE

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Construction Supply Chain Management (CSCM) has recently gained momentum as a means of improving the construction industry's productivity. However, it has been difficult to create a dominant paradigm that translates CSCM into effective and value-added practices. Drawing on a critical literature review combining insights from Neo-Institutional Theory and Engaged Scholarship principles, the paper presents an alternative practice oriented framework for advancing CSCM. The contribution is a supplement to the macro-oriented agenda typically associated with industrial change, which often neglects to consider the relationship between micro-practices and institutional logics in the effort of progress. In particular, the proposed framework acknowledges pluralism and contextual sensitivity as a prerequisite for providing greater insight into the problematic and messy nature of industry change. In conclusion, the role of micro-level agency is argued to be instrumental for the further progress of CSCM. Thus, the paper attempts to re-orientate CSCM by presenting a framework based on participatory analysis and critical discussions combining field and individual-level perspectives. The research limitations are affected by the CSCM research conducted in non-positivistic paradigms, which involves a certain amount of subjectivity as some of the arguments depends on the authors' perceptions.

Keywords: CSCM, engaged scholarship, pluralism, research methods, sensitivity

INTRODUCTION

In Denmark, the construction sector is one of the largest industries with approximately DKK 200 billion turnover per year. Danish authorities have pointed out that there is a need to increase productivity in construction to maintain economic development and competitiveness. One way to reach the goal of increased productivity is to address the potentials of Construction Supply Chain Management (CSCM) since as much as 90 percent of the turnover can be related to external costs (Karim *et al.*, 2006). Previous efforts have focused on implementing Supply Chain Management (SCM) principles from other industries without tangible results. A contributing explanation might be that other industries are typified by integrated structures, standardized processes and long-term relationships, whereas the construction industry is identified by structural features like temporary locations, fragmentation and adversarial relationships that hinder the adoption of SCM practices (Burgess *et al.*, 2006). Thus, considering the potentials in addressing these costs, one of Denmark's major contractors has initiated a CSCM research project to increase productivity in the Danish construction industry.

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Linking into the debate on 'rigour and relevance', the aim is to unfold a practical development agenda while also contributing to the burgeoning interest in contributing to theory-building in construction management research (CMR). We develop our argument around a discussion of the need for contextual sensitivity in the progress of CSCM, which is related to new philosophical understandings involving academia and practitioners in the process. Accordingly, we differ from the dominant positivistic paradigm normally used within operations management and the macro-oriented agenda that is often associated with institutional change in the construction industry.

First, we review some of the main discussions and reflections of the CSCM literature to reveal the unresolved tensions it creates. Then, Neo-Institutional Theory (NIT) is discussed as an opportunity to explore the role of micro-practices in the development of CSCM. With this in mind, we present Engaged Scholarship (ES) as an approach for advancing CSCM that is sensitive to the plurality of institutional factors of the construction industry. Finally, operationalisations and implications for further CSCM research are presented by proposing a novel analytical framework.

A Review of Discussions and Reflections on CSCM

To justify a new thinking of the CSCM enquiry, we will review some of the overall implications in the generic SCM research. To begin with, we critically illuminate learnings from other industries and point to macro-contextual sensitivity as a remedy to unlock inexpedient path-dependencies of CSCM research. Next, we focus on the micro-level and ask what can be learned from the implementation process of other managerial logics in construction to avoid repeated failures. Finally, we present a pluralistic micro-to-macro approach to progress the rigour and relevance of CSCM.

Macro Contextual Conditions of CSCM

Reading the terrain of the construction industry, strategies for maturing CSCM have often been pragmatically legitimised by the promise of better performance enabling cost reductions and innovations (Schiele, 2007). In particular, focus has been on developing integrated approaches to the implementation of CSCM by mirroring the development of other industries (Lith *et al.*, 2015). However, supply chain models established for other industrial contexts are problematic to use in construction, as they are often characterized by the integration of sequential interdependencies and activities. In contrast, the pattern of interdependence in construction is fragmented and non-sequential (Bankvall *et al.*, 2010). For this reason, novel reflections of how problems are linked in construction supply-chains have often been debated in CMR when discussing how to mature and advance CSCM principles (Schiele, 2007).

In general, high maturity is associated with organisational harmony where purchasing professionals work together across tactical and strategic levels. Moreover, maturity is often linked to an organisation's capacity to translate the price based ordering role to shared understandings across the entire chain creating trust and long-term relations. In contrast, a low degree of maturity is associated with purchasing professionals remaining on the operational level (Voordijk *et al.*, 2015). According to Meng *et al.*, (2011), the maturity level of supply chain relationships in construction is highly related to the ability of managing aspects as risk-sharing, transparency, trust, common objectives and strong communication across the entire supply chain. Thus, CSCM maturity is ideally progressed by interactions stimulating compliant behaviour beyond solitary levels of organizational reality.

In this macro-perspective, the construction industry is often theorized as the least integrated of all industries, typified by adversarial supply relations and lack of trust between parties as some of the main barriers to maturing CSCM. Notwithstanding, some suggestions to maturing CSCM have assumed that solutions from other industries can be followed, instead of recognizing the complexity and uncertainty of project-based organisations (Fearne and Fowler, 2006). The key difference between adaptations of managerial logics across industries is, however, that construction cannot be compared to an integrated organisational environment. Integration therefore represents no easy answer to the complications of the construction industry, and it may be the case that the fragmented landscapes of construction may never grasp the full potential of supply chain integration, as we know it from other industries (Briscoe and Dainty, 2005). Moreover, we argue that a continuous mirroring of construction in the experiences of others might entail an uncritical reproduction and theorization of the idea that change should be based on the policies of other industries instead of developing solutions that are sensitive to local needs and practices of the construction industry. This inexpedient path-dependency can be challenged through a criticism of what we can learn from others, and previous experiences with managerial logics in construction might be a remedy to this.

Micro Contextual Conditions of CSCM

Sensitivity towards the local conditions of construction, also embraces the experiences gained from other managerial efforts in the construction industry to understand the potentials and pitfalls of developing CSCM. As such, we gesture that the lack of generalizations across different problem-domains is indicative of an inability to learn from experiences that describe practical development efforts in the industry.

As such, we claim that some managerial logics in the construction industry have resulted in noncompliance and sub-efficiency due to insensitivity to the industry's considerable levels of complexity and uncertainty. For example, as stated by Fearne and Fowler (2006), previous attempts to extend partnering logics throughout the supply network of construction has been unsuccessful due to absence of long-term interest, conflicting cultures and lack of trust among chain partners. Comparatively, lean logics concerned with supply chains have often been legitimized in other industries by their ability to optimize and produce continuous improvements in the supply network. Thus, where others have made significant progress towards more efficient and integrated supply chains through the systemic adoption of lean logics, the adaption in construction has resulted in the sub-optimizing of individual resource-domains, which has negatively affected the overall efficiency of the building project.

According to Meng *et al.*, (2011), construction supply chain relations are fragmented and deviate from organisation to organisation and from project to project. These local circumstances are possibly the main reason as to why successful managerial logics from integrated industries are ill-performing in the context of construction. Thus, construction has tried to adopt the potentials of CSCM since the 1980s, however, the adaption has been incomplete and novel approaches have to be developed to solve the puzzle of CSCM (Vrijhoef and Koskela, 2000). As research indicates (Frödell, 2010; Thunberg *et al.*, 2015), supply chain decisions are affecting the overall efficiency of the entire building process, which stresses the relevance of engaging with stakeholders across the supply chain. This is, however, an often-overlooked aspect in CMR. Correspondingly, as claimed by Papadopoulos *et al.*, (2016), there is a lack of enquiry

into how companies can launch frameworks for advancing CSCM by orchestrating these in ensemble with practitioners to advance operationalization.

Subsequently, failing to understand the relationship between new change recipes at the specific contextual macro-level influences the desired development process at the micro-level of practice. If we are to avoid repeated failures or hegemonic change recipes, we suggest that an alternative roadmap for progressing CSCM must at least acknowledge the past experiences of managerial efforts in the construction industry, and engage locally with practitioners to create novelty through contextual sensitivity.

The Micro-to-Macro Approach of CSCM Research

Reviewing some of the SCM enquiries across industries reveals that the main research paradigm is positivist and related to manufacturing and transaction cost economics (Burgess *et al.*, 2006), and that questions of how to conduct empirical research are rarely addressed (Kotzab *et al.*, 2005). In other words, there is a lacuna of research conducted in an interpretivist paradigm, which is otherwise relevant when exploring the complex and unpredictable nature of the construction industry. Consequently, positivist accounts could fruitfully be supplemented with more pluralistic approaches using multiple method paradigms to evolve and progress the research area of CSCM.

A critical review across industries by Soni and Kodali (2011) highlighted that a practice-oriented research design may well result in cross-method synergies and improved approaches for future studies of SCM. Moreover, the review stated that 'action research' principles and triangulation of stakeholder knowledge would advance SCM research. Thus, the development of CSCM may progress faster if there is greater plurality of research, which in turn would require a wider engagement with non-positivist methods. Overall, the justification for challenging the dominant positivist paradigm is that methodological uniformity only does little to enable us to "understand the complex network of relationships, which shape industry practice" (Dainty, 2007, p. 9), and ultimately leave construction in status quo.

Consequently, interpretivist approaches might provide us with richer understandings of the conditions that govern the progress of CSCM and how these shape local practices. Justifying a practice-oriented research approach is, however, a challenge that will include convincing others that it is a valid method of creating scientific truth. This will depend on the ability to create legitimacy for a variety of performance improvements that might not be rationalised, in a positivistic sense, as benefits across the entire supply chain, but nevertheless are perceived as meaningful in a localised or situated practice. As such, we argue that to release the potential of CSCM more sensitivity should be paid to understanding the nature of construction through a micro-to-macro approach, and thus the limits of what we can learn and apply from the generic SCM literature and other industries.

Methodological Concerns in the Study of CSCM

Regardless of a growing interest in CSCM, it has been difficult for both practitioners and academics to educate themselves based on current literature and the idiosyncratic nature of the industry. This calls for new philosophical positions that challenge the paradigmatic inflexibility and path-dependencies, which are so prevalent within the built environment (Dainty, 2007). To the extent of our knowledge, is there no single definition of CSCM, nor is there a dominant paradigm that has successfully translated SCM practices into the construction industry.

Thus, the CSCM puzzle, in all its simplicity, is how to shape a shared endeavour moving from a price-based negotiation regime to a collaborative trust regime based on long-term relations, transparency, shared risks and common objectives (Kotzab *et al.*, 2005). Such a shared endeavour is often associated with industry convergence across field-embedded organisations to create supply chain integration, which is a recipe that has proven successful in other industries. The project-based construction industry can be seen as a divergent and fragmented system (Bankvall *et al.*, 2010) and the assumption is that alternative theoretical and methodological conceptualizations are needed to develop an effective framework as suggested by Papadopoulos *et al.*, (2016), which can advance both academia and practice of CSCM. Building on the arguments set out in the review section, we next present Neo-Institutional Theory (NIT) and Engaged Scholarship (ES) as elements in an analytical and pluralistic framework for conducting ‘action by research’.

Institutional Theory and Institutional Pluralism

In general, researchers have tended to study the outcomes of institutional influences on organizations (Suddaby, 2010), but recently there has been a reorientation focusing on the micro-level to explain how actors can mobilise others to gain legitimacy for an alternative logic in a highly structured context, industry or field at the macro-level. A ‘field’ can be seen as an arena of actors sharing sociocultural productions and the dynamic relationship among them (Scott, 2014).

Fields are identified by the process of isomorphism, which forces one part in a settlement to mirror other parts that confront the same set of environmental conditions (DiMaggio, 1983). Isomorphism arises from regulations, professionalization or uncertainty in the institutional environment and affects structures as companies are seeking to adopt legitimate solutions or legitimize their practices towards others (Dainty *et al.*, 2013). Isomorphism can lead to both path-dependency and lock-in if organizations are trying to mimic each other regardless of efficiency. Additionally, path-dependency is typified by past field experiences, and radical change can only emerge if a new path is construed a strategic moment in time. Nevertheless, fields are not entirely stable and change never fully path-dependent or deterministic.

A contemporary perspective in NIT deals with the notion of pluralism (Lounsbury *et al.*, 2012; Greenwood *et al.*, 2016). Here the argument is that any institutional field is identified by the coexistence of multiple demands, pressures or institutional logics from the environment that prescribe what constitutes legitimate behaviour, what goals are suitable, and what instrumentality is legitimate to accomplish these goals (Santos and Pache, 2013). Viewing the construction industry as a field it can be argued that it is populated by several competing logics that each nurtures a form of isomorphic pressure. Following Jensen *et al.*, (2011) there is a tendency to treat such logics as unambiguous and complementary when discussed as reform strategies at the field level. However, as demonstrated by Koch and Urup, (2017), constellations of multiple institutions and logics at the local level are often practised as contradictory leading to internal fragmentation in companies, which affects the performance and potentially constitutes a barrier towards achieving a more coherent and desired result.

Empirical studies at the micro-level have stressed the challenge of competing logics within or across institutional fields, which calls for new hybrid perceptions to create contextual sensitivity by the desired outcome of higher productivity (Höllerer *et al.*, 2017). As such, pluralistic researchers and practitioners must focus on the mediating capacity of the co-existence of competing logics while also exploiting the benefits of

their interdependence (Reay and Hinings, 2009). Returning to the rigour and relevance debate, our argument is that we must study how managerial logics occur in practical interactions in the process of changing the rules of organizing time and space in social reality (Thornton and Ocasio, 1999). Thus, the combination of NIT and ES, which is discussed below, is proposed as analytical ingredients for conducting a framework of progressing the rigour and relevance of CSCM research.

Engaged Scholarship as Approach

ES is an approach for confronting real tangible problems by undertaking a process that engages with both stakeholders and academia to an associated problem-domain, which is too complex for any parties to solve alone. ES grasps the interpretivist paradigm using principles of inductive research methods like 'action research' to collaboratively construct a meaningful reality of the studied environment where the scholar becomes a participant in the change process of others (Voordijk and Adriaanse, 2016).

In the competition of methodological primacy in CMR, we present the combination of NIT and ES as an analytical framework and a contribution to the inquiry of CSCM. The approach dissociates from social engineering and aims at a reflective analysis of how managerial mechanism affects different focus groups and cultures that coexist in project-based organizations typically and unfairly studied as others or sub-culture (Terjesen *et al.*, 2012). Theorizing practice, the engaged research is problem-driven in relation to specific focus groups making sense of their social interaction. The inquiry differs from distinctive macro-explanations and explicates the micro foundations of institutional logics to explain micro-to-macro mechanisms involved in the progress of CSCM. Thus, scholars can engage in organizations by building case studies and using multi-methodology to identify practices, competing logics, cognitive and structural aspects. As such, it is an exploration of the micro-agency that arises in the friction between logics that otherwise appears incompatible (Johansen and Waldorff, 2017). Hence, ES is stressed as a concept that can help integrate relevant industry representatives and scholars to explore how actors are linked in supply networks and thereby understand the institutional mechanisms of these networks.

The criticism of ES is the challenges of merging different mind-sets generated by the triangulation of stakeholder knowledge. This process can be unpredictable and the trial is to balance the level of dimensions needed to reveal key features of a problem (Van de Ven, 2007). Another criticism is the risk of decisions made by organisational power by settling for the lowest common sum of stakeholder knowledge. Thus, the research becomes average by resolutions, which disconnect the process of creating substantial scientific truth (Bresnen, 2017; Mckelvey, 2006). ES has been criticised for lack of scientific rigour and CMR has been criticised for lack of more practitioner influenced problem definitions set aside by concerns of scientific rigour. Thus, the argument to emphasize ES is to act on and avoid the danger of academic isomorphism that follows with dominant ways of exploring organizational phenomena (Bresnen, 2017). In other words, CSCM have strong requirements for 'action by research' when handling practical problems across the supply chain (Kotzab *et al.*, 2005). This contrasts with the majority of SCM research, which have followed the positivistic paradigm, which is possibly the reason why ES is not institutionalized.

We argue that an interpretivist paradigm, acknowledging the idiosyncratic nature of construction, can provide new insights into the causal relationship of science, actions, and consequences across the supply chain. ES can play the proactive role of helping one of Denmark's largest contractor groups solve a productivity issue by challenging

the quest for scientific rigour in managerial studies, which has disoriented from the initial balance of favouring practical relevance (Bresnen, 2017). Hence, the contractor becomes an ‘idea factory’ where practitioners and researchers can co-produce valid knowledge together (Van de Ven, 2007).

Research Operationalisation and Development of CSCM

As an empirical contribution, we now present a series of analytical questions and related research approaches that form an operational basis for a conceptual research framework of progressing CSCM. The framework is limited by the scale of research done in the non-positivistic paradigm and must be acknowledged as a primary roadmap for a new thinking in CMR. As such, the framework draws on pluralism by combining different epistemological views to the advancement of CSCM (Mingers and Brocklesby, 1997). Thus, the criticism of combining views is often based on a polarity between research paradigms instead of seeing the potential of overcoming the weaknesses of a single research paradigm. Nevertheless, it will be hard to develop any research area if all researchers belong to the same paradigm and culture conducting the same type of research (Dainty, 2007; Näslund, 2002; Pearce, 2015).

For this reason, the framework is trying to explore the potential of reorienting NIT in ensemble with ES methodologies. Hence, analytical questions and approaches to operationalize the development of the CSCM inquiry are emphasized in Table 1. In addition, main themes from the literature review are related to the framework, which we find essential for framing the future roadmap of CSCM. In particular, we focus on understanding the recursive relationship between macro-structuring forces and the micro-practices of CSCM to advance a framework capable of bridging the micro-to-macro divide in studies and practices of change. As such, the framework is assumed rigorously enough to embrace academic requisites and relevant enough to explore existing project-activities significant to the construction industry.

Table 1: Analytical Questions and Approaches to the Operationalisation of CSCM

Main Review Themes	Analytical Questions (NIT)	Analytical Approach (ES)
Understand the role of industry context as a prerequisite for maturing and progressing CSCM	What institutional mechanisms are required to mature CSCM in project-based organizations?	Coproduction of stakeholder knowledge to define maturing implications of CSCM
Advance micro-practices and organisational strategies to mobilize agency in the ‘messy’ implementation game of CSCM	How can CSCM logics be implemented within project-based organisations and be legitimated as a field-practice?	Orchestrating an interventionist learning strategy for creating actionable knowledge for the implementation of CSCM
Create legitimacy for local improvements that do not necessarily apply for the entire supply chain	To what extent can CSCM be integrated and legitimized within projects and what is its impact on performance?	Conducting practical research designs and strategies relevant to evaluate and measure the impact of CSCM logics

We claim that a theoretical appeal of multi-methodology focusing on the above question and approaches can provide a deeper sensitivity to the understanding of complex supply networks. The analytical considerations are based on how CSCM logics can interact with and give rise to new organizational forms by identifying existing conflicting logics across the chain. Furthermore, the theoretical argument behind this is that NIT needs to ‘get dirty’ and revitalize its relations to organizations and individuals ‘in-situ’ to reboot its theoretical development and its relevance to practice (Dover and Lawrence, 2010; Johansen and Waldorff, 2017).

The framework proposal is, in other words, a response to ‘the tyranny of best practice’ (Fernie and Thorpe, 2007) that endorses one dominant way to typify buyer and seller relationships across industries. Instead, we suggest that construction practitioners

must challenge past development efforts often established on instrumental rationality and unreflective experiences from other industries, and reflect upon to the fact that no one explicit relational form is suitable for all. Consequently, the advancing of CSCM requires that scholars, policy makers, clients and industry bodies reflect upon and engage with the knowledgeable practitioners of the construction industry (Fernie and Thorpe, 2007). As such, we claim, that the further proliferation of CSCM depend on research that engages with and rethinks social issues theoretically to change both the way actors think and how they act in the world (Dover and Lawrence, 2010).

CONCLUSIONS

We have discussed and reflected on the potentials and challenges of addressing the rigour and relevance gap in CSCM research. Accordingly, we have not chased ideal models or dualistic oppositions between related issues of CSCM. In contrast, we have tried to unfold selected considerations in the current CSCM literature to build up our main argument about the important role of contextual sensitivity. As such, we have stressed industry insensitivity as the main barrier to the proliferation of CSCM by illuminating unsuitable lessons of other industries, leading to sub-efficiency and inexpedient path dependencies in the construction industry.

At the same time, we argue that the fragmented nature of the industry for too long has been an excuse to justify a passive prohibitive barrier to build trust, long-term relations and process adaptations beyond individual projects. Consequently, this leaves actors of construction in a status quo or worse, and calls for new practical and academic understandings to orchestrate institutional change in construction. Thus, we have analysed alternative mechanisms and dynamics in the process of contributing with a novel framework for the further proliferation of CSCM that focuses on both micro and macro-level aspects. Above all, we stressed that change is not entirely programmable or foreseeable, but a messy and iterative process where actors must engage themselves in practical settings and have the capacity to manipulate organisational strategies to advance CSCM.

Finally, we conclude, that the nature and challenges of the industry has been theorized beyond recognition and what (and how) to do about it, should be the next research outlook of CSCM releasing the capacity of action. With this in mind, the limitations of the research presented is affected by the partial research conducted in non-positivistic paradigms, which involves a certain amount of subjectivity as the arguments to a higher extent depends on the authors' perceptions. Thus, to consolidate the statements put forward in this research, future attempts must be directed to validate the proposed framework and the new thinking of CSCM research. As such, rethinking pluralism could provide an important foundation for future research frameworks that advances a richer conceptualisation of CSCM.

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**INFRASTRUCTURE
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THE PROBLEM OF EVALUATING 'VALUE FOR MONEY' OF SCHOOL BUILDING PROGRAMMES

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The programmes of school development in the UK have been driven by high profile strategic initiatives from Buildings Schools for the Future, to Priority School Building Programme; each with a major focus on education but with an objective around better value. The subsequent programme evaluation used quantitative evidence of Value for Money (VfM) to support the strategic rhetoric and delivery policy. In other fields, principally medicine, there is a growing critique of this evidence based public sector provision and this research undertake this with the school building programmes. In this, it deconstructs the data itself, its analysis and its use through the themes of quantification, rationality and politicisation. Using sample secondary cost and design data, obtained using the Freedom of Information Act 2000 from The National Audit Office, the Education and Skills Funding Agency and Local Education Authorities, it explores this basis of this evidence and its use. The sample data confirmed that the Priority School Building Programme was producing cheaper schools; however, the reductions were not as great as claimed with some doubts about comparability. Although, this shows that the Education Funding Agency control of costs was successful, the nature of the end buildings was obscured. Thus, political clients chose their definition of VfM through setting the rationality and quantification to emphasise what to them is good. However, the politicisation of the evidence does not convince other or future stakeholders. Thus, the important task of delivering better schools is constrained by the quantification methodology for cost and quality data as it is a political activity.

Keywords: evidence-based, procurement, quantification, rationality, politicisation

INTRODUCTION

Education is a major issue for the UK government. Spending on education in 2016 accounted for approximately 11% of public spending being £84 billion pounds (ukpublicspending.co.uk 2017) with a capital spend of £4.8 billion (Long and Bolton, 2016) allowing for an overall increase in the number of places (NAO 2017). Education policy is also a big issue with the voting public (IPSOS MORI, 2016), making it often the centre of election rhetoric. Thus, education capital programmes are promoted to the public, either to demonstrate action or as a source of criticism.

The focus of the current UK government is to cut the national deficit by reducing spending wherever possible through cuts and increased efficiency (Kraftl 2011). The 2010 Conservative/Liberal coalition government cancelled the previous Labour

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administration's school capital projects, the 'Building Schools for the Future' programme [BSF], and provided a new programme, 'Priority School Building Programme' [PSBP] which focused on lower costs and more streamlined delivery. It is claimed that significant savings have been achieved, despite overspending of almost 10% on the original budget. (NAO 2017). Thus, politics is promoting cost savings as a desirable outcome as well as criticising the previous administration for poor value for money in their capital investment.

In a similar political world of medical provision, there is a growing critique of 'naive rationalist' approaches to evidence-based policy (Klein 2000, Greenhalgh and Russell, 2009). These works both look at the limits of evidence and on the use of it in decision making. Thus, Greenhalgh et Russell, (2009) critique the positivistic complete belief in numbers because chosen metrics deny complexity and context. This simplification to metrics is convenient for the rhetoric of politics but completely denies the conflicting values in the system of service delivery. Drawing from these ideas, this paper critiques 'value for money' in schools' projects through three themes: rationalisation, quantification and politicisation; arguing that they are the necessary lens to understand the constitution of the VfM data collected, the interpretation of this and its use. Sample data has been collected from numerous projects through freedom of information requests and then used to explore the meaning of metrics and data (rationalisation and quantification), trying to determine what the numbers say but also how they are used selectively for the purpose set by the initiator (politicisation). The conclusion shows how a political exercise is created from costing, giving a problem for the construction industry but more importantly a problem for the future development of schools.

THE CONSTITUTION OF VALUE FOR MONEY

Value for Money (VfM) has long been considered as an issue in the construction industry (Olatunji *et al.*, 2017). Baker *et al.*, (2013) provide a definition that VfM is 'the optimal use of resources to achieve the intended outcomes'. However, a richer lens is required to deconstruct the use of 'value for money' in practice and this is provided by considering its rationalisation and politicisation as well as its quantification. Rationalisation sets the metrics uses as these embody how we understand what is involved and what causes this. Rationalisation is a prerequisite for quantification but quantification adds a certainty and factualness to the presentation. Politicisation encompasses the power over meaning and the differences seen by different stakeholders.

Rationalisation of Value for Money

The idea that it is possible to determine value and set this against the cost of a building has long been established in the construction industry (Best and de Valence, 2016). In the last 30 years, UK governments, through Latham (1994) and Egan (1998), prioritised VfM taking it as a simple, achievable outcome. Even, the Construction 2025 report (HM Government, 2013)) does this, seeking a universal cost reduction of 33%, although equivocating that life cycle costs and environment are also important.

The key rationalisations are the metrics chosen to represent VfM. These need to be abstract and simplified for calculation but to carry meaning to support arguments. In the UK public sector, VfM is audited on behalf of parliament by the National Audit Office (NAO). They define VfM, as achieving Economy, Efficiency and Effectiveness i.e. minimise the resources used; maximise the productiveness of those

resources; and ensure that they achieve their objectives. Figure 1 shows the rationalisations that builds up this VfM. The NAO offers metrics for these values (Table 1) which have been further developed by the Education Funding Agency (EFA) for assessing VfM in academies and free schools (Table 2).

It is apparent that NAO approach is not universally agreed and this conflict of rationalisations is similar to that discussed about construction improvement metrics (Green 2011). VfM is a complex concept which can only be simplified to cost in certain circumstances. Boyd and Chinyio (2007) suggest that client satisfaction is an intrinsic part of VfM but emphasise its changeable and ambiguous nature. The complexity of VfM increases if it also considers users who Wandahl (2004) describes as 'Value Carriers' as each holds an individual viewpoint. Thus, Heald, (2003) suggests that the true measure of VfM is impossible to ascertain.

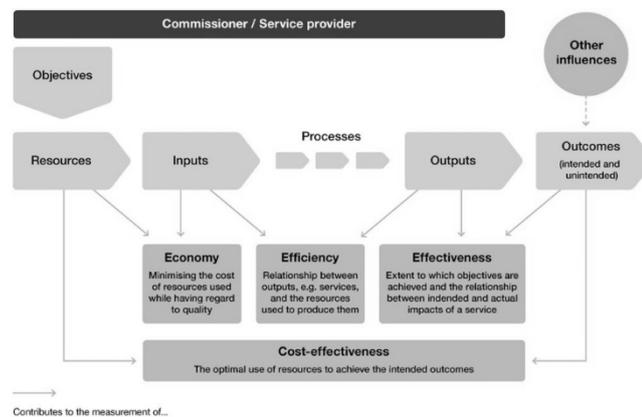


Figure 1: NAO value for money guidance (NAO 2011)

Value Driver and Short Description	Suggested Metrics	Value Driver and Short Description	Suggested Metrics
1. Maximise business effectiveness Describes how facility deliver the benefits required by the business case. This includes issues relating to staff productivity, unit costs of production and ease of working. It also includes creating environments that employees and users enjoy and that encourage business processes.	*Staff satisfaction *Operating costs per head *Post occupancy analysis *Staff turnover *Churn costs *Sickness turnover	4. Impact positively on the locality Describes issues that relate to the building's aesthetics, the way it conveys the organisation's corporate image, and the building's relationship to its context.	*Post occupancy evaluation *Design awards *Design Quality Indicator *Response of planning authority
2. Ensure effective project management and delivery Relates to the management processes used, and the selection of an integrated team working throughout the supply chain.	*Compliance with achieving excellence targets *Construction industry standards KPIs *OGC Best Practice Project Management Guidelines *OGC Gateway Review *Net present value *Internal Rate of return *Whole Life Cost	5. Minimise building operation and maintenance costs, and environmental impact Issues to do with maintaining, operating and cleaning the facility once it is in use. This also includes minimising impact on the environment and environmental sustainability.	*Whole life cost *Facilities management estimates *BREEAM assessment or equivalent *Sustainability index *Construction Excellence Sustainability KPIs (Environment) *Public survey *Planning approval *Industry KPIs *Accident rates *Health & Safety statistics
3. Achieve the required financial performance Defined by the business case for the project. It includes achieving the optimum balance between capital costs, a building's operating and maintenance costs and residual whole-life value.		6. Comply with third party requirements Describes statutory and other requirements including planning consent. Covers all aspects of Health and Safety both during and after construction, and addresses adherence to Central Government guidance	

Table 1: Suggested VFM metrics (redrawn from NAO 2004).

Quantification of VfM

Quantification is a tool that establishes a numerical basis for describing the world (van Basten, 2014). In this, it not only accounts for quantity but tries to lock down value and even intangible entities (van Basten, 2014). This move to objectivity gives an authority to numbers and presents them as a truth (Powers 1994). Quantification of construction costs is an extremely well-established discipline which in the UK is delivered by quantity surveying (e.g. Kirkham 2007). This long history of establishing building costs has delivered a consensus around costing practices which make them appear uncontroversial; however, the fact that there are endless disputes about what money is to be paid and how this relates to work done, shows that this is superficial.

Value for money framework for the academies and free schools programmes

This framework indicates the various factors that we will look to consider in making an overall VfM assessment

Inputs <i>Additional resources invested</i>	Outputs <i>Impact on education</i>	Outcomes <i>Impact on attainment and wider outcomes</i>
<p>Administrative costs:</p> <ul style="list-style-type: none"> • Total DfE administrative costs • Average cost per school • How efficiencies are being achieved <p>Start-up costs:</p> <ul style="list-style-type: none"> • Total start-up costs • Average cost per school • Progress made in minimising costs <p>Capital costs (where relevant):</p> <ul style="list-style-type: none"> • Total capital costs • Average cost per place <p>Operating costs:</p> <ul style="list-style-type: none"> • Additional recurrent operating costs • Progress in minimising additional costs <p>Overall total costs:</p> <ul style="list-style-type: none"> • Total additional costs of the programme • Total additional cost per school 	<p>Use of autonomy:</p> <ul style="list-style-type: none"> • What academies and free schools are doing differently • Extent to which freedoms are being used • Evidence on benefits of using these freedoms <p>Impact on education quality:</p> <ul style="list-style-type: none"> • Impact on Ofsted inspection ratings • Areas being improved over time • Prevalence and benefits of multi-academy trusts <p>Attractiveness of academies:</p> <ul style="list-style-type: none"> • Extent to which academies and free schools are filling their places • Evidence of impact on parents getting first choice of school <p>Behaviour and attendance:</p> <ul style="list-style-type: none"> • Impact on improving absenteeism and exclusion rates 	<p>Impact on attainment:</p> <ul style="list-style-type: none"> • Attainment over time, compared to similar schools and by length of time open <p>Narrowing attainment gaps:</p> <ul style="list-style-type: none"> • Pupil intake characteristics • Impact on reducing attainment gaps for disadvantaged groups <p>Impact on wider schools system:</p> <ul style="list-style-type: none"> • Impact on attainment in other local schools through competition effects <p>Impact on longer term outcomes:</p> <ul style="list-style-type: none"> • Impact on post-16 attainment and labour market outcomes • Estimated impact on improving longer term economic and social outcomes <p>Overall value for money:</p> <ul style="list-style-type: none"> • Costs per unit increase in attainment • Net Present Value of the programme • NPV per additional £ pound spent

Table 2: EFA Value for Money Guidance (DfE 2013)

In government terms VfM is purely judged on simplified calculation of increased output per pound spent. This is shown in reports from various agencies. The NAO (2017) presents high level figures based on square metre unit rate, costs per pupil and total sums. Hampshire CC, (2017) also use high level data with single point averages for floor areas, average floor areas per pupil, contract periods, gross and nett metre squared costs and average costs per pupil place. It provides further detail on the breakdown of average metre squared gross and net costs in total area bands, as well as breaking the costs into categories for New Build, Re-build and Extension and Refurbishment. GCS (2015) reports annually on the progress of selected government departments towards their cost reduction goals. The data is presented in more detail in this report with elemental costs, benchmark cost data broken down into area bands as well as average cost for the 20th and 80th percentile. An elemental breakdown of the baseline BSF costs is also provided to measure any savings achieved, by the EFA led capital projects. NAO, (2013) reports high level cost data for total programme spend and per place unit costs across programme waves. It reported that free schools have lower build costs than previous programmes by up to 45%, but this was not expanded upon. James and Brown, (2013) reports that schools built under the contemporary EFA programmes are projected to save 40% when compared to BSF schools, with caveats about small sample size and the use of projected costs.

Political Stakeholders

Education capital spending is political. Thus, both the delivery of schools and the reporting of the success of this delivery are coloured by the political tension being played out, namely the Labour and Conservative parties fighting for power.

When Labour came to power in 1997, education spending was at its lowest in real terms since the 1950s (Lupton and Obolenskaya 2013). Education was a prominent part of its manifesto and spending on capital projects doubled from 5.5% of the education budget in 1998 to 11.6 % in 2009 (Lupton and Obolenskaya 2013). Labour also changed the way new schools were funded, building upon the Conservatives’ PFI initiatives. This peaked in 2008, with the global ‘credit crunch’ and criticism of the VfM of PFI deals (Shaol *et al.*, 2013).

The Conservative and Liberal Democrat Coalition entered power in 2010. Their main concern was cutting deficits by implementing austerity measures (Kraftl, 2011). The focus of school capital investment was shifted from achieving world class education to

individual schools in poor condition (Lupton and Thomson 2015). Privatization continued through PFI. The James review (James 2011) made recommendations on how to proceed with education capital procurement with a view to improving VfM. This changed the priority to dilapidated schools, rather than social deprivation. The review called for clarity and consistency in the criteria used to select capital allocation, and that this should be based on condition (Lupton and Thomson 2015). It also centralised procurement strategies with standard contract arrangements and standardized designs and specifications, managed by the EFA rather than the LA.

METHODOLOGY

This research explores the challenge of evaluating value for money in construction projects. VfM is substantively a subjective concept; however this is driven by the quantitative representation of value and cost. Taking a critical realist stance (Archer *et al.*, 1998), the factual nature of costs and facilities can only be interpreted through the social construction of meaning of the quality of the facilities and the successful delivery of these as well as the calculation of VfM. The research used an analytical framework, with themes of rationalisation, quantification and politicisation, derived from the work of Greenhalgh and Russell (2009). The study involved collecting quantitative data to understand their problematic nature and how they could be used. This was not an attempt at engaging in a competing statistical analysis with the NAO but one of developing an understanding through the practice of collecting and using numbers about the difficulty of creating and using costs and specifications of schools. In line with critical realism, this helped answer the question what sort of reality has to exist (Archer *et al.*, 1998) for the use of VfM to be viable.

The study used design and cost information held by agencies such as the EFA and Local Councils collected using the Freedom of Information Act (FOI) 2000. This included background data on the NAO (2017) report specifically where the claim that schools built under the PSBP were one third cheaper than under BSF. Details were requested for the square metre costs in each case and the basis for the calculation, as well as the source data. Data was also requested from all local councils in England and Wales, asking for cost data on their 3 most recent secondary school capital projects; set to ensure returns would not exceed the cost limit of £450 set by the FOI 2000. Finally, data was requested from the Education Funding Agency (EFA) about details of their 10 most recently completed capital projects. The EFA returned drawings and data from 12 schools completed under the PSBP programme. This enabled an exploration of specification and quality.

Sixty seven local authorities returned results giving 113 projects. The level of detail varied due to the interpretation of commercially sensitive material and material which could facilitate security breaches. The main exclusions using these exemptions from the FOI 2000 were for elemental breakdown, with some authorities exempting all cost information. Thus, only 44 schools were reported with sufficient information: 15 academies, 21 BSF schools and 8 locally procured schools. Only 23 had elemental cost data. To maintain consistency, projects involving refurbishments or extensions or primary schools or special schools were rejected. The data was then rebased to 2017 costs and calculations performed to provide £/m², £/place, m²/pupil. The projects that provided high quality drawings were examined to establish sanitary provision for comparison with the PSBP and baseline designs.

DISCUSSION ON ACHIEVING VALUE FOR MONEY

The discussion considers what could be learned from this quantitative study of school construction costs. In some ways this is exactly the exercise undertaken by governments and agencies but they report it uncritically as if they are uncovering facts. This discussion seeks to deconstruct the VfM debate. It first considers the quantification data exposing differences in data use. Then, it enquires into the rational system of thinking which allows this to take place. Finally, it reveals the different meaning that different stakeholders place on this and shows who has the power to have authority over this meaning.

Quantification

Comparing costs per square metre and costs per pupil

The simple metrics of price per square metre and price per pupil for the PSBP, returned by the National Audit Office, were examined alongside the result from the Local Authority Survey to give a basic cost comparison between PSBP schools and schools procured under other routes (Table 3 and 4).

Table 3: Results summary for square metre unit costs £/m²

Sample	size n	mean	Minimum (£)	Maximum (£)
PSBP (NAO)	35	2060	1822	2625
LA Survey	44	2473	1797	3324
Academies	15	2480	1971	3324
BSF	21	2585	2035	3177
Locally Procured	8	2167	1797	3050

The results for cost/m² and cost per pupil follow the same pattern. The sample results agreed that the PSBP schools were the lowest cost group at around 20% below the Local Authorities sample. The NAO revealed in an explanatory note that the average sizes of the PSBP schools were smaller than those for other schools. A comparison of the size of sample schools from the EFA PSBP sample and the Local Authorities sample suggested that the PSBP schools were on average smaller than the Academies, BSF schools and the Locally Procured schools. The idea that scale has a non-linear effect on costs is important. The £/pupil is a main determinant of funding and so it may be a hidden encouragement to build a particular scale of school.

Table 4: Summary of results for £ per pupil unit costs

Sample	size n	mean m (£)	Minimum (£)	Maximum (£)
PSBP (NAO)	10	16433	13029	23810
LA Survey	44	21677	13650	31170
Academies	15	21362	13650	26550
BSF	21	22927	15548	31898
Local	8	18987	15668	22137

Comparing pupil per toilet

This abstract metric has the intention of investigating provision and space quality as a response to criticism of the PSBP programme by Mark (2015). Drawings were examined to count the facilities available in each school available for 4 PSBP schools, 6 BSF schools, 1 Academy and 1 Locally Procured school. The numbers of pupils per toilet (Table 5) shows a greater number of pupils per toilet as schools increase in capacity. The designs were compared for the space related to the sanitary facilities. This found that the PSBP schools had the lowest mean ratio of area per toilet at 3.08 m² against the Local Authority schools of 3.96m²; again a changed base.

Table 5: Summary of results for number of toilets per pupil

Programme	n	Average Capacity	Av. No. Toilets	Ratio per pupil (2d.p.)	Minimum Ratio	Maximum Ratio
PSBP	4	1001	60	17.18	13.15	23
Combined	8	1242	68	18.22	15.91	21.65
Academies	1	1440	80	18	18	18
BSF	6	1145	65	17.68	15.91	18.49
Local	1	1624	75	21.65	21.65	21.65

The investigation of the data from the reduced sample found that, while the Priority School Building Programme was producing cheaper schools, the reductions were not as great as claimed. The difference between the average costs, with BSF schools being around 25% more than PSBP, is not as substantial as the claim made in the NAO (2017) report. The average size per pupil was slightly smaller for PSBP schools, with the average for the combined Local Authority survey around 3.9% higher; however, the difference was not statistically significant. The results also revealed that the scale of school influenced the cost and that this was not accounted in the figures presented. In addition, the recommended classroom size for 30 students was reduced from 60m² to 55m² from Building Bulletin 98 to 103 (DfE 2014; DfES 2004). This impacts on the overall area per pupil without any adjustments to out of class or social spaces. In all these cases the simplified metrics confuse the meaning of the quantification.

It is clear that quantitative reports were produced for a reason. For example, the National Audit Office has a remit to audit or report on the appropriate agencies, whilst the House of Commons Library's remit is to provide impartial briefing material to MPs and ministers. The benchmarking studies by Hampshire County Council, are produced by local authority property professionals in partnership with the Local Government Agency and EFA, to support delivery. All the reports give limited background data in a heavily summarized format. Assessment of building quality or of performance are absent in any meaningful form. The reports also use the same or derivative data, which are taken to be factual records of transactions.

Rationalisation

The driving rationalisation for VfM is that lower costs are a good thing. The NAO sophisticated VfM assessment is not actually used in practice with simple cost/m² calculations being used in the NAO (2017) claim that the DfE is building schools at lower cost than the BSF programme. It even concedes that it does not follow its own rationalisation by stating that no quality assessments or post-occupancy evaluations have been made. As a proxy, the NAO undertook a survey of 53 school leaders, of whom 45 (85%) were satisfied with their new buildings; thus, there is little real indication of the VfM only a view of costs. The NAO report also does acknowledge criticism from RIBA (2015) who see problems in value because of: standardisation; short timescales; changes to sanitary facilities; the reduction in social space and lack of expansion potential. However, there is no assessment of these risks in completed schools.

Certainly, using cost/m² or cost per pupil encourages the narrow focus on costs. The rhetoric of VfM may be about value but the quantification involves being selective of measures, resulting in simplification of the situation to make it tractable. In such circumstances, evaluations only work when there are 'like for like' situations which are difficult to find. Even to approach consistency, data requires to be normalised both against differences and against time thus distorting fact with assumption. This debate

has long been played out with cost benefit analysis (Ackerman 2008) and for VfM within the evaluation of foreign aid (Barr and Christie, 2015). These refer to the problem of: pricing, incommensurability of data, uncertainties being removed, and futures being solidified. It is also the point made by Greenhalgh and Russell (2009) about the avoidance of complexity and context in evaluating health provision. Even the accuracy of construction cost data is easily challenged. For example, Robson *et al.*, (2016) show how cost data from BoQs is produced for the sake of tendering and payment but then used for extended purposes such as estimation of improvement. They show that construction cost data is problematic and limited to set purposes.

Power (1994) refers to such numerical rationalisations within her work on the audit explosion. This involves both promoting the correctness of evidence and how important it is for transparency to be made important to the public. This rationality is paramount within the NAO and drives what is thought important; not the delivery of good schools but creating greater m² for a lower cost. Ultimately, Power (1994) sees this as a form of administrative control of meaning which is a political agenda.

Politicisation

Value for Money is an important concept in the political context surrounding the Priority School Building Programme. The current administration has focused on austerity and efficient use of its available resources. Based on this, the PSBP aspires to maximise the creation of modern functional school buildings. Fundamentally this is not the same aim as BSF, which was to produce world class facilities to engender an educational transformation. Such differences in aims become subsumed into criticism of the previous governments' excesses and wastefulness.

The EFA, who act as the client for the construction of school capital projects, has an interpretation of VfM that is focused on minimising costs for a given output. It must be recognized that the outturn costs of schools are only part of the picture. Criticisms have been made about quality of schools built both under the new regime (Mark, 2015) and of the BSF (James 2011). Quality of school buildings is part of the educational environment, and several studies have shown correlation between school premises factors and educational achievement of pupils (Duran-Narucki 2008), (Uline and Tschannen-Moran 2007), (Barrett *et al.*, 2015). Students are more likely to be concerned about feeling safe in an environment that helps to prevent theft, vandalism and bullying (Sorrel, 2008). Teachers, who will be judged on the students' results, may be more focussed on the design of their classroom - the single most important factor in affecting achievement (Barrett *et al.*, 2015). Thus, whilst the EFA are the construction client, they are not the end user and they collect little data on the quality of the schools and experience of end users. The current design of secondary school buildings is heavily regulated (DfE 2014) and funding is based on the pre-designed solutions. This method of funding allows little room for attempts to improve quality. The RIBA (2015) suggest that funding needs to be raised by 20%, if real VfM is to be achieved. It needs to be recognised that relationship between good buildings and student attainment is framed by the politicised rhetorical environment making it difficult to really improve VfM.

CONCLUSIONS

The analytical framework determined that quantitative representations of VfM are set by the rationality of the evaluation and the meaning making of the political system. Thus, the VfM methods employed by the EFA to control cost are successful within the

system set up by them to audit activity. This audit is a political task for which its rhetorical argument, driven by rationalisation and quantification, proves better decisions or blames previous decisions. Indeed, quantitative analysis is presented as neutral which is used to reinforce arguments as to whether something is good or bad. In this complex rhetorical environment, quality can suffer as a result of the promotion of such cost rationalisation measures, and the different stakeholders who want to reduce costs have their own agenda in this activity. Thus, VfM exercises are products of the political domain of powerful stakeholders who control the rationalisations and quantifications, which makes agreement across stakeholders unlikely and complicates the development of schools for better operational performance.

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HOW TO EMBRACE THE STAKEHOLDER IN PUBLIC PRIVATE PARTNERSHIP DECISION-MAKING? A THEORETICAL DISCOURSE

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Stakeholder is the seed of unpredictability and subjectivity in decision-making over the long-lasting, relationship driven, life cycle of PPP projects. However, their conflicting interests, roles and responsibilities alter their level of involvement and importance leading to conflicts which may escalate into litigation, renegotiation or, even worse, project failure. This makes the PPP decision-making highly fragmented, contextual and dynamic. Motivated by a limited relevant research, the current study focuses on integrating the stakeholder into PPP decision-making. For this purpose, PPP specific stakeholders are identified through a content analysis. Further, a conceptual framework for stakeholder integration is devised based on the identified research concentrations obtained through a thematic analysis. The framework consists of three interacting components; issues, process and solutions supported by important considerations identified through an extensive literature review. Additionally, a conceptual mechanism providing rationalization for conflict emergence has been presented, formalising the types of conflict based on the stakeholder relation, and their interaction with the project. The study provides a foundation for proactive conflict and relationship management by treating PPP as a complex arena with multiple stakeholders, drawing upon their theoretical knowledge base.

Keywords: conflict emergence, PPP, stakeholder identification, complex systems

INTRODUCTION

The situation for stakeholders in public-private partnership (PPP) structuring for large infrastructure projects is more sensitive and complex than in a typical construction project (Jayasuriya *et al.*, 2016). It requires proactive efforts in stakeholder identification and categorization to effectively figure out their roles and responsibilities in the project (El-Gohary 2006). This is not only important for addressing the ineffective risk allocation issue in PPP contracts but is also desirable for prevention of opposition and conflict (Burke and Demirag 2017). Different

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pressure groups in the external boundary of the project need to be considered in the decision-making process for greater public acceptance (Badasyan and Alfen 2017).

These issues raise serious concerns for the policy and decision makers, demanding greater flexibility in contracts for social inclusion and innovation. To manage the numericity of stakeholders over the project life span and achieve total project success (Aladpoosh *et al.*, 2012), integration of stakeholder management concepts in PPP scholarship appears to be a logical first step which has not been addressed substantially till now in the relevant research domain with limited crossover studies of the two areas available in this context (De Schepper *et al.*, 2014).

It demands a philosophical and epistemologically pluralistic rationalization for effective decision-making. This can be done by expanding the linear and inflexible contractual decision-making framework of PPP (Demirel 2017) with information sharing between two main liable parties into a multi-actor decision space allowing for exploring the entire environment for developing real term partnerships based on trust (Domingues and Zlatkovic 2015). To map and formalize this decision space, the current study has chosen to interpret the PPP contract as a complex system using concepts highlighted in complexity theory (Anderson 1999) and analyse the stakeholder management issues in the PPP system using stakeholder theory (Freeman and Reed 1983; Parmar *et al.*, 2010). The advantage that the stakeholder theory offers to decision makers is its normative approach towards stakeholder inclusion focusing on their behavioural patterns and relationship management for value creation (Aladpoosh *et al.*, 2012).

Many authors have acknowledged PPP as a complex system in general but little effort has been put to seek the implications of complexity theory in interpreting this relationship. The underlying basics of complexity theory (Anderson 1999) and its various concepts relevant to management (Cicmil *et al.*, 2009) have been applied in this study to provide basis for integrating knowledge of stakeholder management in PPP decision-making. Considering complexity theory, PPP can be viewed as an open system, with interacting components exchanging feedback with its external environment. This implies that both the internal and external stakeholders should be considered during the decision-making processes.

On the other hand, the knowledge base of stakeholder theory (Parmar *et al.*, 2010; Freeman and Reed 1983) has been briefly analysed to provide inspiration in rationalization of stakeholder related-issues in PPP projects. Whether or not someone is a stakeholder in the project, can be decided on the basis of drawing on normative considerations of stakeholder theory. In the multi-actor system of PPP, stakeholder behaviour can be considered dynamic due to their varying power and interest across the life cycle phases. Because of this, their attitude towards any decision will also shift on basis of time and changes in the surrounding environment of their interaction with other stakeholders and the processes. This makes the stakeholder behaviour contextual. Considering stakeholder behaviour dynamics, a power balance needs to be sought in their conflicting interests to achieve value creation and social equity for legitimate stakeholders in any decision scenario.

Considering the above arguments and propositions, exploratory questions are raised as follows:

Over the last eighteen years, how much traction has this topic generated among researchers in the construction engineering and management (CEM) discipline?

What are the key issues and decision-making aspects explored in the relevant literature and how can the current research contribution be better rationalized for stakeholder inclusion in PPP decision-making?

How can the dynamic nature of stakeholder relationships be rationalized for deepening the underlying stakeholder-induced dynamism in a PPP decision-making system?

These questions have guided the development of methodology of this study which also highlights the different meta-analysis conducted in the research to seek substantial answers.

RESEARCH METHODOLOGY

Formation of Dataset

The primary method employed in this research is content analysis of published studies. PPP literature published during 2000-2018 was extracted via different databases, Web of Science, Scopus, Taylor and Francis, ASCE, Elsevier and Google Scholar, using keywords ‘public private partnerships’, ‘P3’, ‘BOT’, ‘DBFM’, ‘TOT’, ‘BOO’ and ‘PPP’. The flow diagram showing the detailed method employed for reaching the dataset used for the in-depth content analysis is shown in Figure 1.

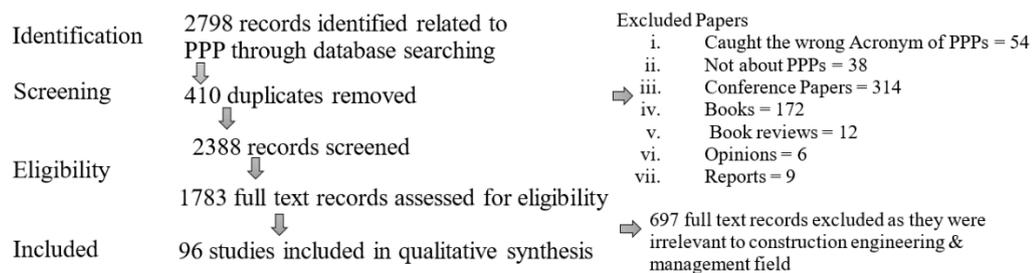


Figure 1 PRISMA flow diagram for literature dataset generation

After finalizing a dataset of 1783 articles relevant to PPP research in the field of CEM, articles relevant to stakeholder management and relevant themes were shortlisted based on the title, abstract and keywords. After manual assessment, a total of 96 articles were found relevant to the scope and problem statement of this research.

Analyses

Different analyses were conducted to achieve the three objectives of the study as shown in Figure 2. Since there is a limited cross over research available on the two areas, a focused content analysis of 21 studies was done on papers relevant to stakeholder theory, complexity theory and their application to management to develop a suitable recipe of integrated concepts for the areas of stakeholder management and PPP projects from CEM perspective. Four implications have been proposed based on their mutually complimenting observations which have been used as an inspiration in the thematic analysis and rationalization of stakeholder relationship dynamics. The underlying relationship dynamics between stakeholders in the context of PPP decision-making process have been rationalized considering issues identified from the content analysis of 96 relevant papers beforehand. For stakeholder identification and categorization for PPP projects, a frequency-based content analysis was performed. During the process, individual identified stakeholders belonging to a common group were merged using common terminology. Furthermore, four stakeholder groups were identified based on literature; public sector, private sector, general public and 3rd party (Yuan *et al.*, 2010).

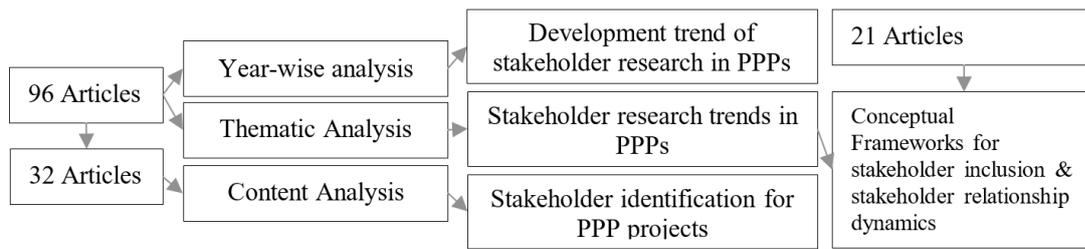


Figure 2 Meta-analysis framework of the study

These broader groups effectively reflect the key players in a PPP system as shown in Figure 3. Following this section, a thematic analysis of the stakeholder problem in PPP system is discussed. In doing so, the full-text of 96 relevant articles was analysed to study the research trends of stakeholder management related research in PPP. In focus were the key problems and issues related to stakeholder problem in PPP projects in construction based on which a conceptual framework for stakeholder inclusion in PPP decision-making has been proposed.

L1: Stakeholder Category	Internal		External	
L2: Stakeholder Family/Group	Private	Public	General Public	3 rd party
L3: Stakeholder Role	Private Authority	Project Manager	■ ■ ■ ■ ■	Press/Media
Identified Stakeholders				

Figure 3 Methodological framework for stakeholder identification and classification

RESULTS AND DISCUSSION

Development Trend of Stakeholder Management Research in PPP

Stakeholder management was introduced as 10th knowledge area in PMBoK in 2013 (Rose 2013), due to which research in the field has gained momentum in its application to construction projects. However, fewer studies have been reported in relevance to PPP infrastructure projects (De Schepper 2014).

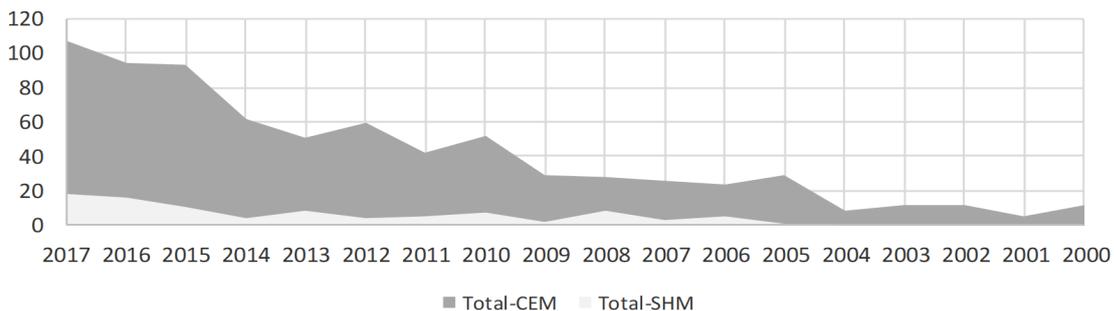


Figure 4 Year-wise PPP research development trend

As shown in Figure 4, though the number of papers/year are increasing signifying the enhancing interest and need (Neto *et al.*, 2016), the area still remains largely unexplored. Additionally, in the period 2000-2018, stakeholder management (SHM) relevant papers from the entire dataset of PPP research in CEM field constitute only 12%. Out of which, only 4% of the papers cover stakeholder management as a major research focus.

Stakeholder Identification and Classification

Stakeholder identification is the most crucial part of stakeholder management. Drawing on the implications from the complexity theory and stakeholder theory, two considerations need special attention during this process. One is to identify the maximum number of stakeholders and categorize them on basis of internal and external project environments. This will have a deep-rooted impact on the overall stakeholder analysis during which the stakeholder impacts can be assessed over the PPP life cycle. Two, legitimacy of stakeholder groups in the decision-making process can be more efficiently established in the contextual and dynamic PPP environment. A focused content analysis was carried out aiming at stakeholder identification and categorization to provide PPP decision makers a ground for conducting a thorough stakeholder analysis for infrastructure projects.

A comprehensive stakeholder taxonomy was developed, as shown in Table 1, identifying the three hierarchical levels given in Figure 3. It is pertinent to note that the public and private party having maximum frequency (f) in the internal stakeholder category, have a key role in driving the decision-making process. However, the stakes of other parties need to be taken into consideration while planning. For example, a project's location may be harming a cultural heritage site that may create tension on the internal-external project boundary, bringing local interest groups, in a key position to sabotage project success. In the content analysis, interest groups have the maximum frequency in 3rd party stakeholder role and it is categorized as an external stakeholder.

Table 1 Frequency based ranking of PPP stakeholders within their corresponding families of stakeholder roles

Group	Stakeholder Role	f	Group	Stakeholder Role	f	
Private sector	Private Authority	12	Public Sector (Internal)	Public Authority	15	
	Project Manager	6		Government establishment	10	
	Subcontractors	5		Project Manager	6	
	Investors/ Financier/ Banks /Businessmen	5		Consultants	4	
	Consultants	4		Quantity Surveyor	1	
	Contractor	4		Financial Manager	1	
	Engineers/ Architect/ Designer	4		Contract Manager	1	
	Property developers	2		Project Sponsor	1	
	Labor/ Union	2		Public Sector (External)	Line ministries and departments	3
	Supplier/ Vendor/ Service provider	2			Legal Authorities	2
Employees	1	Auditors	2			
General Public	General Public	10	3rd Party	Technical Advisors	1	
	Customer/ End user	4		NGOs/ Interest Groups	5	
	Politicians/ Community representatives	3		Civic Institutions / Municipality	2	
	Landowners	1		Press/ Media	1	

Conceptual Framework for Stakeholder Inclusion in PPP Decision-Making

The research concentration in SHM for PPP projects reveal that of the 96 relevant articles, only 32 address SHM or one of its core concepts as a major focus of research. However, stakeholder-relevant issues and their relevance to other areas of PPP decision-making have been addressed in the rest of the articles helping to understand the plaguing problems relevant to stakeholder in PPP projects and their possible solutions. Various research concentrations relevant to stakeholder were identified based on a detailed content analysis coupled with a frequency-based thematic analysis in which different topics were assigned a main and subtheme, as given in Table 2.

Table 2 Thematic analysis results

	Main theme	Total no. of papers	Sub-theme (with frequency greater than 1)	No. of Papers
1	stakeholder management process considerations	19	stakeholder satisfaction	6
			stakeholder perception	4
			stakeholder identification	2
			stakeholder expectations	2
			stakeholder attitude	2
2	stakeholder-related issues in decision-making	33	principal-agent problem	7
			conflicting stakeholder interests	7
			government opportunism issues	6
			information asymmetry	5
			trust and collaboration issues	4
3	stakeholder-related considerations in decision-making	40	role of stakeholders	9
			flexibility in contracts	7
			relationship considerations	7
			bargaining behaviour of stakeholders	6
			conflict management	3

The themes and sub-themes are interlinked and take feedback from one another. Collectively, the three inter-related main themes and sub-themes can be rationalized to form a working solution for stakeholder management inclusion in PPP knowledge expanse which be conceptualized as shown in Figure 5.

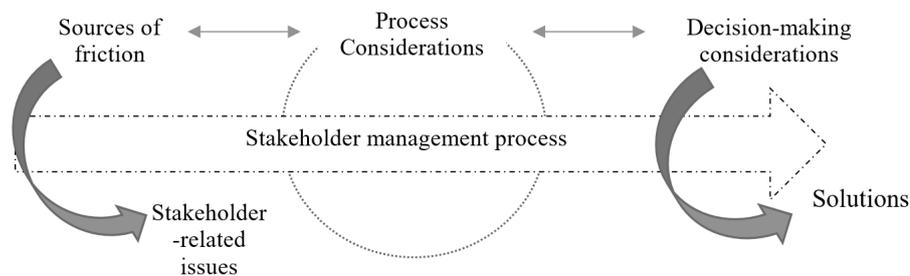


Figure 5 Generic conceptual framework for stakeholder-related PPP research

For example, in case of principal-agent problem (issue), the most important of stakeholder-related issues, conflicting interests between the principal and agent (source of friction), may lead to opportunistic behaviour in either agent or principal (issue) causing a variation in stakeholder attitude towards a decision (process consideration) as either supporting or opposing (Xie and Ng 2013). The private party may indulge in profit maximization (Pusok 2016); the government may extend limited or whole support to the project for gratification of their political agenda; while forsaking the wider social value creation (Zhu 2015) through the project (decision consideration), an important yet less addressed aspect of decision making. Principal-agent problem can further decrease stakeholder satisfaction levels (process consideration) for both internal and external stakeholders at different project stages orienting their risk behaviour (decision-making consideration), creating friction in stakeholder relationships (decision-making consideration). Introducing flexibility in PPP contracts (solution) has been abundantly discussed in literature as a possible solution for greater stakeholder inclusion (Cruz and Marques 2013) which resonates with the idea of expanding the contractual boundary, rationalizing a decision space across the internal and external environment of the project.

7. Conceptual mechanism of stakeholder relationships

Building upon the argumentation of the thematic analysis and the conceptual framework for stakeholder management inclusion in PPP decision-making system, it is to be noted that the relationship between stakeholders becomes the governing factor in any decision scenario. The dynamics of stakeholder relationships in the project

environment are rationalized in the form of a conceptual framework given in Figure 6 and Figure 7.

Figure 6 shows a unique graphical representation of decision-making in PPP life cycle. For any phase of the project, decision-making is a process expanded over a flexible decision space with external and internal actors interacting with each other and the project itself on a process and sub-process level reaching a decision point marked on the boundary of each phase. The decision point reflects the project milestone achieved to advance to the next stage of the project.

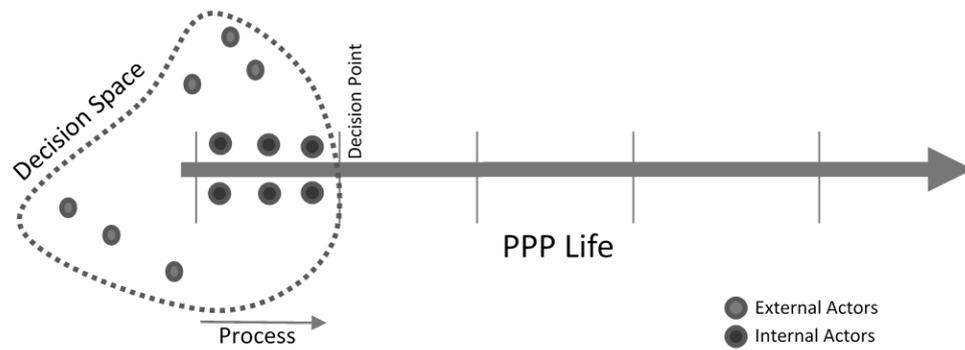


Figure 6 Decision space of the PPP life cycle phases

Furthermore, Figure 7 expands the decision space to uncover the dynamics to reach a decision point. Two basic types of stakeholder attitudes exist for every decision; opposing and supportive. The range of either opposition or support, however, can vary from high to low. Both types of attitudes are governed by constraints related to both stakeholders and the project itself which reflect in the quality of relationship. These constraints govern the level of friction in the relationship and in turn affect the probability of conflict occurrence, and the impact of the conflict on the system.

This phenomenon can be rationalized in terms of zones of conflict in the decision space shown in Figure 7.

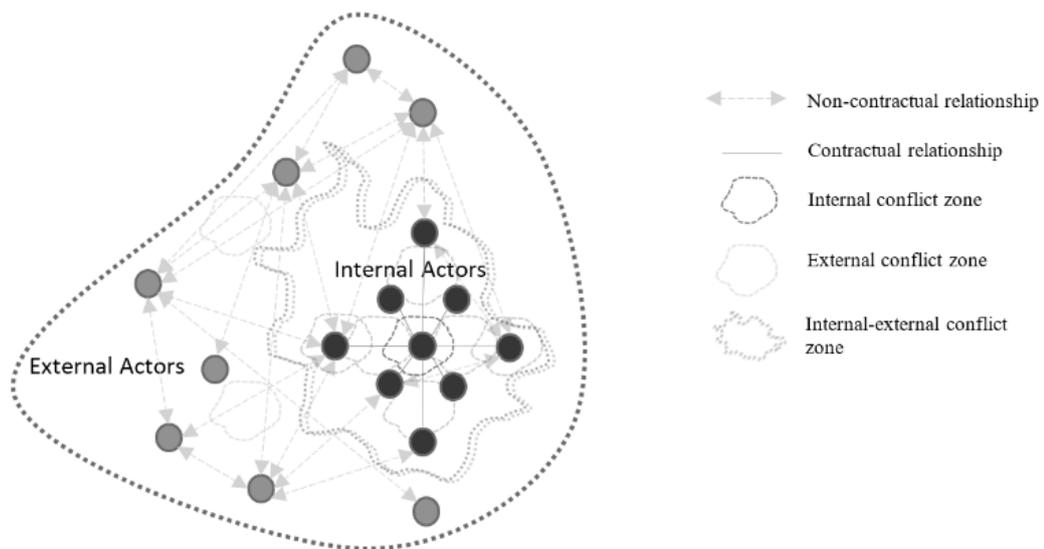


Figure 7 Dynamics of stakeholder relationships and classification of conflict zones

In case of PPP, conflicts can be inter-actor or intra-actor as given by the three types of conflict zones: between internal actors, between internal and external actors, and

between external actors. The reasons for conflict may vary according to the said types. Information asymmetry and principal-agent problem are the main kinds of issues where one of the contracting party's self-interest or greater level of information drives the decisions that may affect other internal actors and create a dilemma in effective risk allocation (Li and Cai 2017; Shi *et al.*, 2016). Additionally, private party's goal of profit maximization or the government's political interests may compromise public interest leading to public opposition (Lousberg 2016).

This may drive a chain reaction, where different interest groups may also clash with each other depending upon their own vested interests. Moreover, the boundary between the external and internal actors, as shown by the internal-external conflict zone, is particularly sensitive. This is because general public and several 3rd parties do not have proper understanding of the project impacts early on in the project life cycle. Their level of support or opposition to the project will, thus, increase or decrease as the project impacts start to materialize (Chen *et al.*, 2017). For example, climate change related hazards resulting from the project will affect multiple unidentified stakeholders who may not be in project's geographic proximity (Martimort and Straub 2016).

CONCLUSIONS AND RECOMMENDATIONS

The study has conceptually rationalized the stakeholder-relevant decision-making contributions as a first step in the integration of stakeholder management knowledge area in PPP research along with providing a deeper look into the relationship dynamics and mechanism of conflict emergence. To deal with the interrelated issues, different conflict zones have been earmarked. For different phases of project life cycle, and for different stakeholders, these conflict zones can be used to perform a more efficient stakeholder analysis and design suitable conflict prevention mechanisms for proactive stakeholder management practice integrated with contract management. This can prevent the cost and time overruns that are caused if a project goes into litigation. It must be noted that the proposed conceptualization is a generic baseline rationalization which can be sophisticated to act as a framework for conflict prevention and stakeholder integration in PPP decision-making. Expert opinion and case study demonstrations can be used to develop a PPP stakeholder analysis framework which can be directly used while making decisions at different stages of project life cycle. Sectoral variation in legitimacy of stakeholders, types of conflict and their impact can also be compared in future. The current study has employed concepts of complexity theory and stakeholder theory. To further develop this work, refined analytical tools of system dynamics, fuzzy logic, and agent-based modelling can be used to assess the robustness of the subjective rationalization as well as its further sophistication.

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INSTITUTIONAL LOGICS AND HYBRID ORGANIZING IN PUBLIC-PRIVATE PARTNERSHIPS

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Cross-sectoral collaboration has been touted as a solution to a range of problems in various sectors. In the construction context, public-private partnerships have recently given promises of increased productivity and innovative solutions through business models combining logics and governance structures from both the public and private sectors. Little is, however, known about how partnerships are established to combine different logics in response to competing institutional demands. Drawing on a study of a municipality's efforts to create cost efficient services, we analyse the formation of two partnerships as emerging hybrid organizations in the intersection between four institutional logics. We show how different logics are mobilized in the process of shaping the partnerships in response to the institutional pluralism and complexity they face. On this background, we discuss how the contours of two different forms of hybrid organization emerged, even though the partnerships initially operated and responded similarly to the institutional demands. We conclude that partnerships can be seen as 'trading zones' that follow different trajectories in coping with institutional demands, and hence the development of hybrid organizational forms.

Keywords: hybrid organizations, institutional logics, PPP, trading zones, complexity

INTRODUCTION

Partnerships are perceived as potential solutions to solve problems emerging in contemporary societies (Andrews and Entwistle, 2010). In particular, there is growing demand and pressure for the public sector to become more innovative, and policies aiming at achieving this are high on the agenda. Strategies for enhancing public innovation have been developed, ranging from New Public Management, emphasizing market competition, to so-called collaborative governance, which “emphasizes multiactor engagement across organizations in the private, public, and nonprofit sectors” (Hartley *et al.*, 2013: 821). Collaborative governance approaches are diverse and vary from governance networks to public-private partnerships that “exploit resource complementarities between public authorities and private firms” (Hartley *et al.*, 2013: 826). Common among these are, however, that they are arrangements that

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include stakeholders from various sectors, and that they in contrast to traditional forms of governance combine a variety of organizing models and governance mechanisms in a reflexive effort (Minkoff, 2002) to achieve the fulfilment of a societal need. On paper, a public-private partnership represents a hybrid organization with mutual understandings and institutional logics (Jay, 2013). The consequence hereof is that the traditional areas of responsibilities between the public and the private party shift. Moreover, an internal restructuring of organizational structures and governance processes of the respective parties also takes place, as they are exposed to conflicting demands from different institutional environments (Pache and Santos, 2013). Despite their importance, our knowledge is limited on how partnerships are established in response to such competing demands. On this basis, our aim is twofold. First, we have an empirical interest in understanding how partnerships are established as hybrid organizations as a means for a municipality to create cost efficient services. Drawing on institutional theory, we focus on which problems occur between the different organizations involved, and investigate how different institutional logics are combined and what logic is dominant in the problem solving process. Second, we contribute to the literature on hybridity by addressing the question of how stable hybrid forms of social organization are, and whether they entail a blending of logics or a segregation of logics. In doing so, we draw on the STS understanding of 'trading zones' (Collins *et al.*, 2007) as a metaphor for a place where problems of coordination are resolved.

THEORETICAL FRAMEWORK

In the paper, we combine several theoretical perspectives in order to establish an understanding of partnerships that is open towards the empirical findings.

Hybrid Organizations

Borys and Jemison (1989: 235) define hybrids as "organizational arrangements that use resources and/or governance structures from more than one existing organization". Doherty *et al.*, (2014: 418) argue that hybrid organizational forms are "structures and practices that allow the coexistence of values and artefacts from two or more categories". A hybrid organization does not have a canonized size, but can take different forms, mixing market and social logics from different areas of society (Jay, 2013). A hybrid organization can thus be seen as a company, firm, association, etc. that combines institutional logics in various ways (Battilana and Dorado, 2010). Regardless of form, hybrid organizations can be seen as responses to an increasing societal complexity in which organizations are exposed to multiple institutional logics "that prescribe what constitutes legitimate behaviour and provide taken-for-granted conceptions of what goals are appropriate and what means are legitimate to achieve these goals" (Pache and Santos, 2013: 973). The upsurge of hybrid organizations can be linked to the plurality of institutional influences that contemporary organizations face (cf. Thornton *et al.*, 2012; Vermeulen *et al.*, 2016). Hybrid organizations are able to pursue objectives that are not possible for an individual firm (Haigh and Hoffmann, 2012). Hybridity can thus be seen as both organizational responses to competing institutional demands and a result of the cross sectoral collaboration where state, market and/or social actors combine resources and blend logics from each their field to complete a task. In both cases, hybridity is a response to external pressure or purposeful strategic agency oriented towards finding responses to handle potentially incompatible or even paradoxical concerns (Ocasio and Radoynovska, 2016).

Institutional Pluralism and Complexity

Institutional pluralism arises from the presence of divergent interest groups each with the power to ensure that their interests remain legitimate (Jarzabkowski, 2009). In pluralistic fields, divergent interests co-exist and give rise to organizational challenges and variations in strategic choices as they provide “viable alternatives that account for practice variation in firms within the same industry” (Jarzabkowski, 2009: 285). Ocasio and Radoynovska (2016) discuss organizational heterogeneity and strategic choices and make a distinction between institutional pluralism and institutional complexity. Pluralism describes a situation when an organization faces multiple, not necessarily incompatible, prescriptions because it operates in multiple institutional spheres. Conversely, institutional complexity refers to the experience of incompatible prescription from multiple logics that might co-exist within the same sphere. The distinction is crucial, as organizations under conditions of institutional pluralism “make commitments to particular combinations of logics based on relatively stable (logic) hierarchies at the field level” (Ibid. 2016: 290). Consequently, institutional contradictions remain dormant due to the organizations’ ability to differentiate among the competing demands. On the other hand, under conditions of institutional complexity, typically associated with periods of institutional innovation and conflicts where established structures are challenged, organizations tend to adopt a particular interpretation of the contradictions of logics to which they otherwise made a commitment. Organizations thus exist in a field where they can interpret the tensions of multiple logics as being either incompatible or paradoxical. In the first situation, the strategic response of the organizations is suggested to be based on a choice to differentiate, choosing one logic over another, whereas organizations facing perceived paradoxical demands have the capacity to integrate or blend competing logics into their business model (Ocasio and Radoynovska, 2016; Vermeulen *et al.*, 2016).

Institutional Work in Trading Zones

Due to the dynamic interaction between institutional logics and organizational responses, it is necessary to part with purely structural explanations in the study of the shaping of hybrid organization. We therefore align with Powell and Colyvas (2008) and Smets *et al.*, (2015) who argue that more attention should be paid to the practices individuals use to construct the relationality between logics. Institutional work provides one such opportunity. Lawrence and Suddaby (2006: 215) propose a focus on institutional work as “the purposive action of individuals and organizations aimed at creating, maintaining and disrupting institutions.” Thus, in contrast to literature focusing on institutional change at the field-level, institutional work explores the micro level processes. The central concern is to redeposit agency into institutional and organizational analysis (cf. Rasmussen *et al.*, 2017). In particular, we follow a Giddens inspired understanding of the relation between structure and agency, where social structure is both the medium and the outcome of social action. In this perspective, the actions, interactions and negotiations between actors are the core level of analysis (Jarzabkowski, 2009), as it is through interaction that institutionalized practices are crafted, reproduced or modified, even as unintended consequences. Institutional work is well-suited for analysing how hybrid organizations are shaped in response to experiences of institutional complexity (Greenwood *et al.*, 2011), and how responses potentially lead to the establishment of new institutions. This is relevant for understanding how organizations respond to complexity by developing ordered prescriptions that constitute legitimate behaviour, or by altering field structures to accommodate competing institutional demands. Such prescriptions can however

entail different measures in terms of how efforts to create, maintain or disrupt institution are accomplished. We therefore draw on the concept of 'trading zone' that denotes "any kind of interdisciplinary partnership in which two or more perspectives are combined and a new, shared language develops" (Collins *et al.*, 2007: 657). Trading zones are dynamic entities that exist in different states over time depending on whether collaboration is cooperative or coerced and whether the 'end-state' is a heterogeneous or homogenous culture. The concept helps us to understand different states of collaboration, modes of handling incommensurability between partners and logics, and the way that the "twin dimensions of homogeneity-heterogeneity and collaboration-coercion" (Collins *et al.*, 2007: 663) change as trading zones develop be it in a more integrated manner, in a coexisting disjunct manner or other forms. In particular, it contributes to the literature on hybrid organizations and institutional work by stressing the dynamic and processual nature of these concepts.

RESEARCH DESIGN AND METHODS

The paper draws on the findings from an ongoing five-year research project (2016-2021) on the effect of public-private partnerships for productivity improvements in the Municipality of 'Hafnia'. The focus is to theorize the impact of the partnership model in order to understand its role as a particular project delivery method. In the study, we focus on two partnerships, 'Fiducia' and 'Eruditio' and the client organization 'Aedificare' that is responsible for handling the majority of building projects for the Municipality in the coming years. The larger of the two partnerships, Fiducia, consists of six architecture, engineering and construction (AEC) companies led by a large contractor. They conduct new-built and renovation projects for a single municipal administration worth a €310 mill. The second, smaller, partnership, Eruditio, consists of five AEC companies led by a medium-sized contractor. Their work mostly involves renovation projects for the remaining six administrations in the Municipality worth a €80 mill. The primary data for the paper consists of twenty-one interviews that conducted during the spring and fall of 2017 with representatives from the client and the two partnerships. The interviews focussed on explicating institutional logics and organizational responses in trying to understand the practices leading to the establishment and initial shaping of the partnerships. In addition, we draw on observations from two strategy workshops held by both partnerships, and formal project documents comprising tender specifications, bids, internal memos, etc. detailing the formal, especially legal and economic, setup of the partnerships.

We have structured the following analysis according to three phases or 'temporal brackets' (Langley *et al.*, 2013) in the life of the partnerships. Temporal bracketing, or decomposition, emanates from process research and involves the identification of comparative units of analysis within a stream of longitudinal data. The three phases presented in the findings are accordingly not well-defined or formalized phases in the partnerships. Rather they are constructed as "progressions of events and activities separated by identifiable discontinuities in the temporal flow" (Langley *et al.*, 2013: 7). Central moments where established orders were questioned mark the transition from one phase to the other. This enables us to replicate theoretical ideas in successive periods and analyse specific mechanisms that recur over time.

FINDINGS

Here we present the findings focussing on the interaction and blending of logics due to the partnerships' responses to moments of institutional complexity.

Phase 1: Complexity and Conformity in the Framing of the Partnerships

Early 2016, the Municipality received a commissioned report revealing that the price of new buildings were up to 60 % higher in Hafnia compared to other municipalities. The report disrupted the existing regulatory logic in the industry and Hafnia where individual tenders for individual projects otherwise were seen as a way to ensure a competitive market, and ensure the prompt delivery of a project at a fixed price and under well-established conditions of risks and distribution of responsibilities. In response to the report and Hafnia's requirements for more cost-efficient buildings, Aedificare announced two public-private partnership tenders in June 2016, involving construction projects for a €400 million. The ambition, according to Aedificare's Head of Construction, was to reduce uncertainties, costs associated with control and enforcement of contractual obligations and create an island of stability in an otherwise fragmented, and short-term focused industry.

Eighteen teams applied to be prequalified, and eventually Fiducia and Eruditio were selected. In their efforts to meet the contract award criteria, which had a strong focus on qualitative organizational issues, both teams drew strongly on a community logic employing notions of culture, trust, collaboration and empowerment, in their outline of the operationalization of the partnerships. We would argue that this was not a coincidence. The community logic is thus endowed with much legitimacy in the local industry due to major reform initiatives the past 20-25 years, where the lead actors in the two partnerships had been engaged. Our argument is, that the community logic made it possible for both partnerships to address, and suggest a solution to the institutional complexity they were facing that was recognizable for Aedificare, and moreover presented itself as a promising (and highly legitimate) way of integrating competing concerns that otherwise characterize public-private construction projects.

Phase 2: Culture Work and Emerging Incompatibility between Logics

Following the award of the contracts, work commenced in the two partnerships, both in relation to the Municipality's projects, and the efforts to build the partnership organizations. Although it was the intention that the each partnership should operate as a collective entity, void of subcultures and clashes between competing company interests, regulatory conditions surrounding the tendering and contract award process influenced the partnerships' responses. Thus, in the tender, Aedificare had stipulated the use of the general conditions for turnkey contracts making the contractor the legal subject in the framework agreement. This constituted the contractor as the legally responsible party in each of the partnerships, and gave them the formal leading role. This was a role that was supported by a market logic as well, as the success of the partnerships depended on the parties' ability to arrange the production according to the needs of the contractor. The formal setup of the partnerships, however, attempted to mitigate the potential negative consequences of this privileged position of the contractors. The establishment of steering groups comprising several parties should assure this, but so should also the common offices established by both partnerships.

Thus, during the spring of 2017, Fiducia's management invested substantial resources in building up a shared culture in the partnership to mitigate potential conflicts due to differences between the involved companies. Installing the community logic on all levels of the organization was crucial in creating the shared culture necessary to avoid conflicts caused by different company cultures and business structures. Fiducia accordingly established common office facilities at a 'neutral' site where an estimated 40-45 employees from the six companies and the client organization would work on a

daily basis. The motivation for establishing the common office at a neutral location was rooted in the efforts to signal internally that employees work for and in the partnership, thus cutting all ties to the individual organizations. The ambition was accordingly to build the partnership around a shared culture that should maintain the strong community logic by breaking down potential company conflicts internally in the partnership. Eruditio also used the spring of 2017 to strengthen the collaboration by bridging individual cultures and business structures by agreeing on common work procedures and practices. Drawing on the community logic, Eruditio also chose to establish a common office. The community logic was, however, challenged by the market logic. Due to the relatively small size of Eruditio's project portfolio, offices were established at one of the involved companies' existing premises, and because of the limited portfolio employees could not be dedicated full-time to partnership projects, but also had to work on projects tendered and completed for other clients than Hafnia. Eruditio thus decided on a solution, where the common office would house twenty employees from the partnership, working one to three days a week depending on the required workload. This use of the project office conflicted with the community logic where the common project office was a way to ensure the successful partnership.

This phase also saw the emergence of incompatibilities between the community logic and the administrative logic of managing procedures and ensuring accountability. While the administrative logic had been dormant in the first phase, it was mobilised as work on specific projects began in the partnerships. A discordancy thus emerged between the municipality's politically conditioned decision processes, and the partnerships' operational setups that were geared towards continuous production. In particular, the administrative logic implied a gateway process for Aedificare, where decisions on e.g. financing and construction permits were taken progressively in accordance with the municipality's appropriation system. Moreover, Aedificare attempted to enforce a maximum profit margin for both partnerships, arguing that the partnerships exceeded the centrally established profit margin. Fiducia, on their terms, argued that their profit margin indeed matched the requirements, and that the reason for any discrepancies was that instead of calculating the profit margin item-for-item and project-for-project, they calculated it on portfolio level. In essence, this meant that Fiducia's accounting figures did not comply with standard reporting procedures in the municipality. These mundane symbolic and material practices effectively disrupted the community logic by disassociating an accounting practice developed for the purposes of the partnership within the context of the administrative logic.

Phase 3: Reorientation and Divergence in Organizational Responses

While some of the organizational responses were envisioned to insulate employees from complexity arising from competing institutional logics, other organizational features made the partnerships more sensitive to competing demands. Due to the size and nature of the framework agreements, both partnerships received a lot of media coverage - positive as well as negative - as different stakeholders engaged in the debate advancing other particular logics in their criticism. In particular, a regulatory logic was mobilized by a number of smaller contractors arguing that the framework agreement skewed the competitive market and had instigated a duopolistic situation, where the partnerships exploited their dominant position. This was arguably harmful to the smaller enterprises, which under normal regulated market conditions would get their share of the market for building and refurbishment in the municipality. In an attempt to address some of these concerns, Fiducia in particular chose to engage in corporate branding activities, advertising their partnership on various media platforms.

At meetings and seminars representatives from the industry were invited to hear about the partnership, and Fiducia representatives branded the partnership and disseminated the experiences. Fiducia thereby attempted to address the industry's critical voices.

Concurrently, Aedificare reoriented its efforts, and began to maintain the community logic in relation to the administrative logic by accepting different processes and reporting methods in the partnerships as long as these could be translated into their standard reporting paradigms. This hybridization or blending of logics within the client organizations was particularly important for Aedificare's Head of Construction, as employees were required to work both in accordance with administrative practices and procedures, and in the spirit of the partnership ideal. This flexibility was seen to be necessary on an operational level, as constantly changing political objectives meant that what was a rational decision on one project might be considered irrational on the next. Aedificare's employees therefore had to be able to work in accordance with the administrative logic and the community logic to meet the needs of both worlds.

In order to facilitate this flexibility, Aedificare developed guidelines anchoring experiences at organizational level rather than a purely individual level. The two partnerships, however, had different motives for engaging in this initiative and delivering data according to the new standard paradigms. Accordingly, Fiducia's project portfolio consisted exclusively of projects funded by a single administrative department in the municipality. Due to its large size, this administrative department had a professional setup, and was in a position to provide the partnership with the necessary data and resources to conduct benchmarks to monitor progress and ensure that work was on track and within specifications. On the other hand, six independent administrative departments, each with their own systems and procedures, and each with only limited resources, funded Eruditio's portfolio leading to an unresolved need in the partnership. Consequently, in response to the tension between Aedificare's requirements and the administrations' inability to provide the necessary data, Eruditio drew on the regulatory logic by developing existing accounting tools and methods to reduce operational risk, and ensure a higher degree of contractual compliance.

DISCUSSION

In this section, we combine insights from the analysis in order to address the question: How do activities in the partnerships interact with institutional structures at the field level, and how does the hybrid organizational responses develop? In the analysis, we have identified four distinct institutional logics that condition the institutional pluralism under which the partnerships operate: The market logic, regulatory logic, community logic, and administrative logic. The market logic is to ensure profit and the best possible delivery of client demands without the limitations often caused by the regulatory logic, which in turn is concerned with matters related to contractual compliance, risk allocation, and distribution of responsibilities. The administrative logic is to ensure transparent governance principles and manage accountability and procedures, including ensuring that budget *allocation* and project progress conform to the political requirements. Finally, the community logic is to ensure the commitment of individuals to the partnerships by means of culture, identity and values. On this basis, we now illustrate how the different logics were mobilized in the process of shaping the partnerships in response to institutional pluralism and complexity.

In the first phase of the partnership, the organizations engaged in practices that can be characterized mainly as institutional creation of the community logic. An explanatory factor for this is related to the characteristics of the industry, where the mythologizing

(Lawrence and Suddaby, 2006) of collaboration and trust historically has been a central element in the industry's development rhetoric and agenda. We argue that the community logic presented itself as a highly legitimate solution to coping with the institutional pluralism of the partnership ideal, as it neither 'spoke in the language' (Derrida, 1985) of the administrative logic nor the market logic. Instead, it provided a third way that simultaneously spoke in the language of the private and the public part and appealed to both. All organizations engaged in this type of work, which was carried by a variety of practices that also implicitly disrupted the regulatory logic. This e.g. entailed selecting team partners based on prior working relations instead of lowest price, and developing a governance framework that focused on value creation in the entire supply-chain, instead of sub-optimization of individual work contracts.

The second phase was characterized by two major events. First, the establishment and materialization of the more symbolic contents of the tenders, Second, the emerging incompatibilities between institutional logics that had to be handled. Here, Fiducia actively continued to create and maintain the community logic by building a common office for all employees irrespective of organizational affiliation. They also engaged in activities, infusing the normative foundations of the community logic into the daily routines (Lawrence and Suddaby, 2006) of the partnership, forming cross-functional project teams and encouraging interdisciplinary teamwork. In Eruditio, the community logic-based idea of a common office as a means of establishing a unitary partnership organization was disrupted by the market logic. In an effort to mitigate the negative consequences hereof, Eruditio engaged in institutional maintaining of the community logic in relation to the regulatory logic. Thus, instead of using frequent and reciprocal, physically mediated, interaction between the different companies and professions to ensure correspondence, they legitimized their approach by means of a 'musketeer oath' based on the regulatory logics where each part agreed to take full responsibility for their own work, and any interfaces this might entail to other trades.

In the third phase, Fiducia and Aedificare primarily engaged in maintaining the community logic in relation to the regulatory and administrative logic. Fiducia thus engaged in creation work of the community logic by advocating the partnership and their results to the public in a direct response to the potential threatening work of critical stakeholders in the industry. Furthermore, Fiducia continued to create and maintain the community logic in order to blend or integrate practices belonging to different logics into the partnership organization, Thus, in responses to the 'moment of crisis' in the second phase, Fiducia continued to maintain the community logic. In contrast, Eruditio responded to the institutional complexity by hedging and improving risk assessment methodologies to counteract the negative financial consequences of the partnership model, which was characterized by uneven financing cycles and resource distribution, and a lack of structured data for benchmarking their operations.

In summary, we would argue that although the two partnerships initially responded similarly in the first phase, mobilizing the community logic, the contours of two different forms of hybrid organization emerged in the second and third phase of the project. This happened as the partnership organizations negotiated the different demands in relation to each other, and engaged in different forms of institutional work. Most notably, in relation to the concept of trading zones, we argue that the partnerships from the outset were envisioned as highly collaborative and homogenous entities functioning as 'inter-language' trading zones (Collins *et al.*, 2007) where the development of an in-between vocabulary, held in place by common offices, work practices and incentive systems, was to ensure collaboration. We, however also see

that complexity arising from conflicting logics in the daily lives of the partnerships shaped different courses. In particular, conflicts between the administrative and the community logics accentuated the heterogeneity of cultures and logics involved. While Aedificare initially attempted to coerce own administrative routines as templates in both partnerships, thus giving primacy to one logic instead of opting for a strategy of blending, the two partnerships evolved differently. Fiducia thus managed to maintain a cooperative collaboration, evolving into a 'fractionated' trading zone (Collins, 2007) where different logics remained segregated but mediated by common guidelines functioning as a boundary object between the partnership and Aedificare. Eruditio, on the other hand, evolved into a 'subversive' trading zone by accepting the demands of the client organization and changing their practices accordingly.

CONCLUSIONS

This paper has reviewed the literature on hybridity to develop an understanding of partnerships, focusing on the role of institutional logics. Based on a study of two partnerships established under uniform conditions, we analysed the interplay of institutional logics in the process of shaping of hybrid forms of organizing. We showed how different logics were mobilized in the process of developing responses for handling potentially incompatible institutional demands. On this basis, we argued that two different forms of hybrid organization emerged upon the partnerships' initial same response to the institutional demands. We therefore conclude that the partnerships can be seen as 'trading zones' that follow different trajectories in coping with institutional demands. It is, however, a question whether logics will blend and/or merge or whether the partnerships will emerge into a continued trading zone, where logics continue to be heterogeneous. It is also a question whether the partnerships will initiate a change of the field structure of the construction industry towards new, stabilized hybrid organization forms capable of delivering the promises articulated in the partnerships. This is for future parts of our longitudinal study to answer.

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MODELLING THE DRIVERS FOR PUBLIC-PRIVATE PARTNERSHIPS (PPP) PROVISION OF UNITED KINGDOM (UK) SOCIAL INFRASTRUCTURE

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As the devolved governments of the United Kingdom (UK) continue to develop innovations of Public-Private Partnerships (PPP) for social infrastructure provision, this research models the PPP drivers which support partnership-based procurement in the UK. Despite having provided much of the best-practice policy foundations globally, in the UK there has been extensive criticism of PPP for delivering poor Value for Money (VfM) to the tax-payer. Notwithstanding these criticisms, the regional UK governments have declared their committed to cross-sector partnering. This has transpired in a policy reformation encompassing an overhaul of the previous Private Finance Initiative (PFI), followed by the introduction of several nuanced models designed to function across the UK jurisdictional markets. Accordingly, the purpose of this research is to investigate the drivers of PPP which support these frameworks as a credible mechanism for future social infrastructure provision. Following an extensive interrogation of existing scholastic literature, this research identified three themes which were comprised of 20 key drivers for further scrutiny and empirical investigation. Building on previous research by McErlane *et al.*, (2016), this research employed survey questionnaires to sample key PPP stakeholder organisations. From a sample of 73 organisations, this research utilised Confirmatory Factor Analysis (CFA) to assess the hypothesis derived from literature and therein distil the key constructs in an effort to develop the PPP drivers' model. In doing so, the findings confirmed that PPP drivers fundamentally are encapsulated in three key components, specifically: 'improved productivity and efficiencies', 'financial mechanism and the associated benefits of private finance' and 'wider efficiencies offered to governments'. Given the status of the UK in terms of global practice, these findings make a valuable contribution both domestically and internationally. Furthermore, as private-sector participation in infrastructure provision continues to gather momentum in the current socio-economic climate, this research offers much-needed clarity around the strategic merits of PPP for improved collaborative partnering.

Keywords: PPP, social infrastructure provision, Confirmatory Factor Analysis (CFA)

INTRODUCTION

Across the globe, Public-Private Partnerships (PPP) are being extolled as a vehicle to provide more and better infrastructure. Notwithstanding international traction, in the United Kingdom (UK), despite being a pioneer of PPP, mobilisation of these

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frameworks for the provision of social infrastructure has markedly declined in the wake of Value for Money (VfM) Concerns to the taxpayer. Even so, in spite of its tarnished reputation, the UK government has declared its commitment to cross-sectoral partnering arrangements and has subsequently stated that PPP will continue to be a credible mechanism for social infrastructure investment in the future where offering best VfM (HM Treasury, 2016). Against this backdrop, the devolved governments of the UK have developed nuanced PPP frameworks to replace the previous Private Finance Initiative (PFI) Which was discredited and subsequently abandoned in 2012. Hence, the purpose of this investigation is:

- To provide a contemporary overview of PPP frameworks across UK jurisdictional markets;
- To consider the drivers of PPP which espouse these frameworks as a viable mechanism for social infrastructure procurement; and
- To empirically evaluate the PPP drivers for social infrastructure provision in the UK.

LITERATURE REVIEW

Contemporary Overview of UK PPP Social Infrastructure Frameworks

8. *England*

In England, in light of the austere policies implemented in response to the Global Financial Crisis (GFC), to lessen public-sector debt; George Osborne announced Private Finance 2 (PF2) to replace PFI in December 2012. One of the principal differences between PF2 and PFI has been the policy introduction of the public-sector as an equity co-investor. By directly investing into the project, it is anticipated this will cultivate greater stakeholder collaboration reflected through an improved partnership between contractual stakeholders. Better objective alignment; greater transparency and information sharing; improved risk allocation and management; and joint decision-making, all potentially will enable the government to obtain a share of investment returns, reduce project costs and ultimately deliver better VfM. This investment will be managed by a central unit positioned within the Treasury and agreed on equal terms to the private-sector (HM Treasury, 2012). As well as co-investing, the previous PFI framework has been nuanced to reduce procurement timescales, circa 18 months. Soft services have also been removed from the contract to facilitate greater long-term flexibility, efficiency and transparency. This will equally remove the risk premium which had been previously attached to investments, thus ring-fencing excessive profits (HM Treasury, 2012).

In today's economic climate, HM Treasury (2012) Regards banks no longer as a sustainable source of debt provision. Rather, going forward, suggested divergence from the conventional funders has been expressed through greater weight attached to institutional investor involvement. Traditionally, PFI projects have been circa 90:10 debt/equity ratios. However, by reducing the gearing ratio to 75:25, it is anticipated this recalibration will stimulate greater earlier activity in the markets, increasing competition and serving to reduce returns to levels which are more reasonable and politically defensible. Furthermore, and arguably more pertinent, this new leveraging arrangement will insulate traditionally risk averse institutional investors from construction risk exposure. By doing so, there will be less dependence on banks to provide lending capital, as well as freer, earlier and greater filtration of newer alternative financial sources, resultantly lowering prices on less restrictive terms (HM Treasury, 2012).

While PF2 has seemingly addressed many inherent issues of PFI, its arrival should be concomitant with several caveats. Lower gearing will likely increase transaction costs. Likewise, there are no guarantees institutional investors will necessarily want to be involved any earlier (Read, 2013). Moreover, despite having been introduced in 2012, the National Audit Office (2018) Identified that out of the six deals signed under PF2, institutional investors still have not invested into debt. Additionally, Solvency II; introduced to reconcile and codify solvency requirements against risk profiles, will possibly limit long-term investments (Mittnik, 2011). Banks, having historically undertaken the syndicated arranging responsibilities, has meant institutional investors do not possess the requisite due diligence skillsets; at least not on this scale (Read, 2013). It is therefore no surprise that since its introduction, PF2 activity has been muted and has subsequently been used for only a small number of projects. Poignantly, a pipeline of PF2 projects which was due to be announced in June of 2017 has been abandoned with the future of PF2 still uncertain (ConstructionNews.co.uk, 2017). A report published by the findings of the National Audit Office in March of 2018 (NAO, 2018) Highlighted outstanding concerns regarding PF2 as part of their investigation into UK P Fundamentally, these concerns relate to transparency and performance measurement, flexibility and the underlying motivations behind the utilisation of PF2.

9. Northern Ireland

Northern Ireland (NI) Has also developed its own Third-Party Development (3PD) Model which utilises a design, build, finance and maintenance contract; though, the 2015 proposed pathfinders are yet to achieve financial close (Education Authority, 2015) And it remains unclear if they are still in discussions. Notwithstanding the launch of 3PD, PPP in NI has been subjected to notable criticism and indeed the Executive has expressed little appetite for P A 2009 report disseminated by the then Northern Ireland Public Service Alliance (Hellowell, 2009) heavily criticised PFI in NI. This report, together with numerous other publishing's have culminated in PPP being a contentious topic amongst strategic decision-makers which has been reflected through sedate market activity.

10. Scotland

To replace PFI, Scotland has introduced the Non-Profit Distribution (NPD) Model. NDP was launched to be a more practical and viable alternative to PFI, and in 2015, the NPD framework delivered £0.46billion (bn) of capital projects. While NPD is effectively grounded in the foundations of PFI, it additionally includes measures to address many of the criticisms of its predecessor. NPD caps excessive private-sector gains; instead, profits are reinvested into the public domain. Moreover, the Special Purpose Vehicle (SPV) Board is steered by subordinated debt-holders, as well as a public Authority, charity or community representative. In this regard, NPD has been extolled for its capacity to collaboratively facilitate stakeholder engagement in the decision-making process (Asenova and Beck, 2015).

Scotland has also developed the Scottish-Futures-Trust (SFT) Hub initiative. The SFT Hub resembles other 'PFI-lite' schemes such as the Building Schools for the Future (BSF) And Local Improvement Finance Trust (LIFT) Programmes, so much so, according to Asenova and Beck (2015), hub guidance documentation specifically acknowledges the parallels between itself and other existing arrangements in the UK. The first hub project was undertaken in August of 2009 for the provision of social infrastructure in the south-east region of Scotland. The project was valued at £64million (mn) and comprised the provision of health and education facilities. Akin

to other PPP programmes, it is a 20-year joint-venture (JV) Partnership between a private partner and public-sector cohort encompassing the SFT, local councils and other public-sector bodies within the region. The hub initiatives key objectives are to: improve local services through public-private joint service provision; deliver a sustained programme of community infrastructure investment through public-private collaboration; provide a sustainable and effective procurement model for public bodies; and develop a best-practice framework (Scottish Government, 2006). A local HubCo is given the mandate to design, build, finance and manage a portfolio of projects; however, through greater flexibility and community inclusion, it is argued, the hub will be better positioned to deliver enhanced investment impact than that on offer through conventional procurement channels (Scottish Government, 2006). Over its initial 10 years, it is expected the hub will channel £2bn of investment into social infrastructure (SFT, 2016). Notwithstanding these changes in Scotland, as early as 2010, Wamuziri (2010) Raised concerns over the timescales and costs incurred to bring projects to financial close in this nascent PPP modality. Moreover, concerns have been raised regarding competition and excessive profits closely reflecting many of the inherent criticisms of PFI (McCall, 2017).

11. Wales

Just as all other regions have reformed their PPP frameworks, so too has the Welsh Assembly. In 2017, the Mutual Investment Model (MIM) was announced as a successor to PFI. Much like PFI, this is a design, build, finance and management contract between the public and private-sectors, though there are distinctions within this framework from PFI. The MIM now has a requirement whereby during the development of the facilities, the private-sector cohort will create apprenticeships and traineeships by which to benefit the community (Welsh Government, 2017).

Currently, MIM is available for both social and economic infrastructure development, and it is actively being considered for three projects, namely; the Velindre Cancer Centre in Cardiff, the A465, and the 21st Century Schools Programme, which collectively comprise around £1bn of investment (Welsh Government, 2017).

Drivers for Public-Private Partnerships Social Infrastructure Provision

Having provided an overview into the current state of UK PPP, the research will now undertake an extensive exploration of literature to identify the drivers which espouse PPP as a viable mechanism for social infrastructure provision.² Fundamentally, the decision to adopt PPP is predicated on VfM. According to World Bank *et al.*, (2016), PPP can provide better VfM as well as more and better infrastructure through three principal avenues: as a financial mechanism and the associated benefits of private finance; improved productivity and efficiencies; and the wider efficiencies offered to governments. Beginning with the financial advantages of PPP, this can be dichotomised into access to alternative sources of capital and access to cash. PPP offers an alternative financing vehicle for infrastructure provision. By channelling private financing into infrastructure, PPP can expedite infrastructure provision strategies and accelerate capital investment pipelines (Demirag *et al.*, 2015). PPP utilises project financing arrangements comprising private debt and equity. Advantageously, the public-sector can avail of social infrastructure while repayments

² Drivers were broadly identified from all PPP related sources including journal articles, government documentation, and industry reports and guidance documentation. However, by having organisations which are or have been active in the UK PPP market evaluate these drivers, this will produce findings which are pertinent to the UK.

of this service are accounted for systematically over the operational phase. In this regard, repayments do not immediately compromise government budgets and for this reason, PPP is particularly attractive in times of fiscal consolidation as alternative sources of capital enables infrastructure development continuity in times of constrained public budgets (Hare, 2013). Though ultimately the government still pays the cost, the government is afforded the opportunity to repay the capital in smaller payments and thus PPP in the main is favourably kept off capital balance sheets. Use of private financing can also offer governments' greater flexibility in that it mobilises alternative sources of capital, frees up public-sector resources that can be deployed elsewhere and can be used to compliment publicly funded programmes (Della Croce *et al.*, 2015). Notably however, the benefits derived from private financing should be concomitant with several caveats. Governments must be mindful of accumulating debt imposed by PPP and the long-term outgoings as a result (Gardner and Wright, 2011). Also, the efficiencies accrued from the project performance should outweigh the additional costs of private financing, and therefore should be chosen premised on better VfM over alternative financial mechanisms.

Another area where PPP has been extolled for its wherewithal to provide more and better social infrastructure derives from its streamlined efficiencies and effectiveness. In essence, better efficiencies fall under the categories of: cost management; lifecycle management; reliability and effectiveness; innovation, and risk management (World Bank *et al.*, 2016). PPP harmonises what has traditionally been heterogeneous projects phases into a single long-term bundled solution. This holistic perspective theoretically enables the development of an optimal integrated solution for the duration of the contract which should translate to better investment impact than traditionally procured facilities. Conceptually, this is reflected through an overall improved quality of the service, expedited provision of the facility, enhanced operational efficiencies and improved maintainability over the lifecycle (PwC, 2015). This bundled and integrated solution design in principle is permitted using an output specification which grants the private-sector greater space to innovate, design an optimal solution and utilise better technological resources (World Bank *et al.*, 2016). It is also noteworthy, the private-sector is not subjected to the same bureaucratic constraints, social pressures and business frameworks as the public-sector is. Accordingly, the private-sector has greater flexibility to innovate and manage costs. These benefits are underpinned by the usage of the performance based payments to guarantee these efficiencies (NAO, 2018).

Others have argued that PPP offers superior risk management efficiencies. Advocates of PPP claim that the disparity between public and private funding options can be offset through savings derived from effective risk management and risk transfer. Being long-term complex arrangements, PPP and infrastructure provision more broadly, is invariably exposed to significant risks. Ideologically, within the PPP framework, risks and responsibilities are transferred to the party best able to manage them (Pretorius *et al.*, 2008). This allows the public-sector to divert construction, financing and operating risks away from the state and onto private organisations. In return, risks are quantified, priced and managed through sound private-sector risk management practices. The optimal transfer of risk; rather than total, in theory, can produce enhanced VfM above and beyond that if the project stages were disentangled and contracted unilaterally. Furthermore, bearing the risk of construction, there is a strong incentivisation for the asset to be provided on-time and within budget (NAO, 2018). Finally, PPP has been touted as a viable mechanism for infrastructure

investment premised on the overall efficiencies afforded to the government. PPP ensures that there is an up-front commitment to the provision of the infrastructure. The funds allocated to the operations and maintenance of the facility and service are ring-fenced as part of future budgets and thereby safeguards the reliability of the asset and service (HM Treasury, 2012). Furthermore, PPP may pave the way for efficiencies to be adopted and imported into future infrastructure provision as well as ensures transparency premised on the large number of organisations involved (World Bank *et al.*, 2016).

METHODOLOGY

Considered a new discipline relative to others, Knight and Ruddock (2008) Explain there are consequently no pre-defined approaches to research methodologies intrinsic to the built environment. Embracing contributions from social and human sciences as well as a diversity of domains including art, law, economics, sociology, statistics and philosophy, historically, positivist quantitative studies have dominated the built environment. However, advocates of interpretivism have argued over the importance of understanding social phenomena as opposed to explaining it. An outcome of this has been that research patterns have shifted, and over time, the built environment has displayed increased interest in qualitative research, and more recently, mixed-methods approaches (Knight and Ruddock, 2008). Notwithstanding these transitional research trends, fundamentally, a methodological design is contingent upon the research objectives and must therefore be reflective of the research's intent.

From the critical literature review, it was identified that the justification to utilise PPP for future social infrastructure provision is comprised of 20 drivers which fall into three themes. Seeking to measure multiple variables of existing knowledge and confirm their relationships as per literature, this research is confirmatory in nature. Hence, this study adopted a deductive epistemologically positivist and ontologically objectivist stance. Conducive to this methodological stance, a quantitative design enables research to gather large amounts of data regarding multiple variables which can be generalised and evaluated (Bryman and Bell, 2015). In order to conduct the quantitative research design, the research adopted quantitative electronic survey questionnaires. Questionnaires facilitate a standardised, systematic and simple approach to generating large datasets suitable for statistical analysis which are representative of a population. In studies similar to this which have modelled saliency or importance, quantitative survey questionnaire approaches have been the predominant research design, for example, Chou and Pramudawardhani (2015) Employed survey questionnaires to assess critical success factors (CSF) In PPP projects. Equally, Tang and Shen (2013) Utilised survey questionnaires to evaluate effectiveness and efficiency factors for analysing stakeholder needs at the briefing stage of PPP projects.

Adopting the PPP stakeholder identification framework developed by McErlane *et al.*, (2016), stakeholders were deemed to be the Authority, Construction Contractors (BuildCo), Service Providers (FMCo), Equity Shareholders and Debt Funders. To determine a population in the absence of a comprehensive or centralised UK PPP stakeholder database, the research sourced stakeholder information from two sources, namely: HM Treasury (2015) PPP summary data; and Infrastructure Journal (IJ, 2017) Online database. In total, a population of 516 organisations was established. To extract a sample from this population, accounting for stakeholder groupings, a stratified probability sampling approach was conducted to identify participants at a

95% confidence level and 5% margin of error in accordance with Bryman and Bell (2015). Strata size was determined on a pro-rata basis and a systematic random sampling protocol was implemented. Ultimately, a sample of 220 organisations was invited. Surveys were distributed via the SurveyMonkey platform and analysis was carried out using SPSS. Designed to gather opinions of the 20 drivers, participants were requested to evaluate the salience of these variables using closed-ended questions by means of a five-point Likert frequency scale. Kendall's Coefficient of Concordance (W) was opted for to measure statistical degrees of concordance among stakeholder groups and the null hypothesis for Kendall's W is:

12. H_0 = there is no significant degree of agreement among participants, and responses are independent of each other ($H_0 = 0$); and
13. H_1 = there is a statistically significant degree of agreement among participants ($H_1 \neq 0$).

Proceeding this, a Confirmatory Factor Analysis (CFA) was undertaken to test the theoretical findings from literature. CFA enables research to statistically compare a relationship pattern or an a priori hypothesis by statistically testing the relationship between observed variables and their underlying latent constructs. The research tested the accuracy and reliability of the CFA sample through the application of the Kaiser-Meyer-Olkin (KMO) Measure of sample adequacy and Bartlett's test of sphericity. The CFA stipulated an Eigenvalue of one, adopted an Oblimin rotation method and values below 0.4 were suppressed.

FINDINGS

In total, the research received 73 completed and useable responses, equating to a 33% response rate. This was considered robust, surpassing similar research such as Kwawu *et al.*, (2010) who elicited a 20% response rate and Li *et al.*, (2005) who received a 12.2% response rate. Of the 73 completed responses, 18 (24.7%) were received from the public-sector and 55 (75.3%) from the private-sector. According to stakeholder group, in order of size, 24.7% were elicited from the Authority, 23.3% by FMCo, 21.9% by BuildCo and Equity Shareholders equally, and 8.2% by Debt Funders.

To determine levels of statistical agreement, the research conducted the Kendall's Coefficient of Concordance test. From the Kendall's W test, a value of 0.223 was determined. Despite an absence of conclusive agreement pertaining to the codification values spanning zero to one, generally it is considered, a value above 0.20 indicates fair levels of agreement (Legendre, 2010). Furthermore, a P value of 0.00 ($P = 0.00$) was determined³. This signifies the null hypothesis (H_0) should be rejected and the alternative hypothesis (H_1) should be accepted. By doing so, this value confirms there were significant levels of agreement among stakeholder respondents in regard to the PPP drivers. Having satisfied Kendall's W, the research proceeded to the CFA.

Prior to the CFA, to safeguard the reliability and accuracy, the KMO and Bartlett's test of sphericity were applied to test the suitability of the sample size. Premised on the suggestions of Kaiser (1974), the value of 0.910 is considered very satisfactory for CFA. Likewise, the P value = 0.00 indicates the R matrix is not an identity matrix and is highly significant ($P < 0.05$). Together, these tests show the datasets are highly

³ Actual value for Kendall's W is 0.0018528.

appropriate for CFA. Having satisfied these antecedent conditions, the research proceeded to the CFA. Predicated on the responses gathered from the questionnaires, table 1 shows a summary of the CFA and contains the Eigenvalue, percentage of total variance explained, as well as the variables which constitute each component predicated on the findings of the pattern matrix. Three constructs were determined which were above an Eigenvalue of one, and in total, these constructs accounted for 67.52% of the variance. The drivers of 'expedited project delivery' and 'improved financial viability' fell below the 0.4 threshold and were suppressed. Components were named according to the highest loading drivers together with the findings of the literature review.

Table 1: Drivers for PPP Provision of UK Social Infrastructure

Component Name	Driver and Loading Value	% of Variance	Eigenvalue
Improved productivity and efficiencies	Better risk management (0.895); Improved maintainability (0.880); Improved service quality (0.811); Integrated solution design (0.731); Enhanced operational efficiency (0.654); Shared risk and responsibilities (0.618); Better Value for Money (0.579); incentivised private-sector performance (0.555); Transfer of service provision responsibility from public to private-sector (0.516)	55.341	11.068
Financial mechanism and the associated benefits of private finance	Frees up public sector resources to be deployed elsewhere (0.876); Private financing of public services negating budgetary constraints (0.671); Off-balance sheet accounting (0.532); Private-sector efficiencies through superior management skills and resources (0.523); Private-sector innovation and technological improvement in services (0.490); Reduced whole-life costs (0.405)	6.353	1.271
Wider efficiencies offered to governments	Social infrastructure is too complex to be delivered by the public sector (0.723); Reduced project costs (0.448); Circumnavigates bureaucracy (0.410)	5.822	1.164

Research has shown that PPP offers an integrated solution design. Moreover, the private-sector typically is more efficient than the public-sector; hence, component one parallels many of the findings from literature and was labelled 'improved productivity and efficiencies'. In total, it explained 55.34% of the variance and comprised nine drivers with 'better risk management' being the foremost loading variable. Component loading ranged from 0.895 to 0.516 and the three highest loading variables were: 'better risk management' (0.895); 'improved maintainability' (0.880); and 'improved service quality' (0.811). Component two was constituted from six PPP drivers and the loading values spanned 0.876 to 0.405. The three foremost loading variables were: 'frees up public-sector resources to be deployed elsewhere' (0.876); 'private financing of public services negating budgetary constraints' (0.671); and 'off-balance sheet accounting' (0.532). With many of these drivers replicating the literature review, this component was named 'financial mechanism and the associated benefits of private finance'. Finally, component three described 5.82% of the total variance and was branded 'wider efficiencies offered to governments' on the basis that the loading variables pertain to those which were identified in literature. This component captured three PPP drivers and ranged from 0.723 to 0.410. The three highest loading variables were: 'social infrastructure is too complex to be delivered by the private-sector' (0.723); 'reduced project costs' (0.448); and 'circumnavigates bureaucracy' (0.410).

CONCLUSIONS

This research has deliberated on the drivers for the utilisation of PPP for social infrastructure provision in the UK. This investigation, through the application of CFA has empirically evaluated these drivers. In doing so, it has reviewed and provided a contemporary overview of PPP frameworks across the jurisdictional markets of the UK. In addition to this, a critical literature review was undertaken to identify three themes which collapsed into 20 drivers which support the usage of PPP for social infrastructure provision. With this list, this research conducted a CFA and therein empirically confirmed three themes which reflected the findings of the literature review. Thus, this research has several implications: firstly, it offers insights into the drivers for PPP in the UK across the key stakeholder groups. Secondly, as collaboration continues to be promulgated to improve project performance, this research offers clarity around strategic merits which partnerships can align under. Finally, considered to be one of the most mature and transparent markets, this research will have implications both domestically and internationally.

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EXPLORING PUBLIC-PRIVATE PARTNERSHIP CHALLENGES AND THE EFFECTS ON THE CONSTRUCTION WORKFORCE: A SCOTLAND STUDY

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The construction industry, particularly the public sector, plays an important role in providing infrastructure, assets and services that improve the social and economic status of any country. The delivery of public construction projects in the UK and Scotland have since moved beyond the traditional form of exclusive project execution by the public sector to different forms of public-private partnerships. While this approach offers numerous benefits, the challenges remain. This research highlights the challenges of implementing public-private partnerships in public construction procurement in Scotland particularly as it affects human resource motivation and performance in Scottish public construction projects. The emphases on human resource motivation and performance is crucially expressed in this paper. This is stimulated by literature emphasising the significant human resource dependent nature of the construction industry. Adopting an exploratory and interpretivist approach, fifteen purposively sampled participants provided relevant experiences via semi-structured interviews, with transcripts thematically analysed. The themes presented in this paper cover leadership and goal uncertainty, occupational rigidity and public client penalty orientation. This paper also reiterates the influence of external political factors on the construction industry and the importance of decision-making driven by the construction management processes and parties.

Keywords: HRM, public-private partnerships, procurement, public sector, Scotland

INTRODUCTION

The public sector plays an important role in the socio-economic wellbeing of nations (Loader 2007; Reis and Cabral 2015) but specifically in the procurement and management of national infrastructure and assets (Jacobson and Choi 2008; Hartmann *et al.*, 2010). The procurement of construction products and services is vital to the United Kingdom social and economic prosperity. The construction industry in the UK produces over £110 billion per annum and contributes 7% of GDP to the economy; a quarter of this output is public sector driven (Designing Buildings 2017). The construction procurement practice in the UK is perceived as an example for developing countries and economies to adopt for public sector and international procurement (Loader 2007). The successful execution of public procurement in the UK is dependent on the involvement of private sector consultants, contractors and financial institutions (Almarri and Abu-Hijleh 2017). This process allegedly replaces

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a traditional form of public construction procurement based on the sole project execution and delivery by the national and local public authorities (Li *et al.*, 2005). The delivery of public construction projects with the use of public and private sector collaborations has become common across the construction industry (Hartmann *et al.*, 2010; Furneaux and Barraket 2014). Attempts to execute public construction procurement in isolation have become prone to struggle. The increased adoption of this procurement approach has arguably been a result of the perceived benefits of innovation, efficiency, quality, finance and risk sharing to the construction project and the built asset (Li *et al.*, 2005; Almarri and Abu-Hijleh 2017). This has further ensured that that partnerships are, almost by default, initiated and sustained by all parties involved in public construction projects (Pelkonen and Valovirta 2015) without bearing in mind a detailed recognition and awareness of any negative impact. This novel approach, in spite of the intended benefits, does not guarantee a higher likelihood of project delivery or improved construction processes when compared to the traditional approach it succeeds (Jacobson and Choi 2008). This paper emphasises this argument particularly as it relates to human resource experiences on motivation and performance in Scotland.

Public Sector Construction Procurement in Scotland

The construction industry in Scotland delivers £21.4 billion per annum, accounting for 9% of Scotland's GDP, with over 60% of turnover originating from the public sector (Scottish Enterprise 2017). In the quest to further deliver value for money and other benefits of public-private partnerships employed in public construction procurement, the Scottish government established the Scottish Futures Trust to independently work with both the public and private sectors to deliver public sector construction projects (Scottish Futures Trust 2017a). This goal is directly being delivered by a subset of SFTbuild called the Hub. The Hub programme operates with the collaboration of public and private organisations to deliver and manage assets more effectively, improve value for money and measure results through detailed key performance indicators (Scottish Futures Trust 2017b).

This paper also attempts to reiterate a distinct understanding on Scotland and her public construction procurement. The argument for an independent understanding of Scotland's public procurement environment is reiterated by the significant focus on a generalised UK or mainly England representation in research on public procurement (Li *et al.*, 2005) and therefore, a distinct representation for Scotland in construction management research is needed. Similarly, Hood and McGarvey (2002) argued that although the involvement of the private sector in public construction projects is widely accepted in the UK, the response from Scotland has been of reluctant tolerance.

An explanation for this may exist in an assertion by Hood and McGarvey (2002) that the introduction of private sector participation in public construction projects in Scotland is not seen as a construction management decision but represented a political statement by the then labour government in Scotland. This scenario is however played again when the then new SNP government took over power and introduced its own procurement policy in the form of Hub. The need for construction management research to identify and analyse research that recognise a Scottish understanding outside a generalised UK knowledge is also reverberated in Cameron *et al.*, (2008) research that presented evidence of a distinct health and safety knowledge in Scotland when compared to the UK. Similarly, Ankrah *et al.*, (2009) identified a significant

difference in project orientation between Scotland, in the northern part of the United Kingdom, and the southern parts of the United Kingdom.

While the emphasis on the success of public-private partnership in the United Kingdom as a whole and in Scotland particularly persists, the attention towards the challenges experienced by the human resources and the resultant effects within and without these projects remain lacking (Hood and McGarvey 2002). Existing knowledge rightly emphasise the delivery of financial, time, cost, quality and risk management

The human resource involvement in the delivery of public procurement goals is crucial; the significant dependence of construction projects on the human resource attests to this (Grebler and Burns 1982; Nguyen and Hadikusumo 2017). This research draws on Fryer *et al.*, (2004) factors of human resource performance to include ability and skill, motivation, feedback, role clarity, technologies, task, environment and so on. These also inform the analyses and discussions on the research findings. This research aims to explore the human resource experiences of detrimental public-private partnership procurement practices and its effects on human resource performance to deliver Scottish public sector construction projects. This research analyses the lived experiences of construction professional involved in public sector construction projects in Scotland and how these experiences affect their motivational and performance wellbeing.

RESEARCH APPROACH AND DATA COLLECTION

The need to access human experiences in real-world occupational practice in this research informed the adoption of an interpretivist paradigm. Interpretivism stipulates that reality and truth does not exist independently in nature but in the social constructions of individuals who experience the world (Fellows and Liu 2008). The interpretive paradigm is largely valuable in management and social research where truth and reality is constructed by individuals involved (Creswell 2013). Although the use of semi-structured interviews in construction management research is not uncommon, the significant use of quantitative surveys limits the availability of literature and knowledge derived from rich in-depth individual experiences (Agapiou 2002). The challenge of ensuring that respondents are purposively sampled further limits the wealth of knowledge derivable from quantitative research. This study adopts a purposive sampling technique to engage individuals with relevant experience in public-private partnerships in Scottish public sector construction procurement (Fellows and Liu 2008; Khan 2014).

Initial communications with potential participants were made via the contact details provided on webpages of the 32 Scottish local authorities with five contacts agreeing to participate. The resulting contact details of interested private sector parties were also utilised to secure private sector participation. The individuals were interviewed face-to-face for an average of one hour, based on a semi-structured interview protocol, with conversations audiotaped and transcribed verbatim for thematic analyses. The choice of semi-structured interviews as the data collection method is also in line with the exploratory and interpretivist nature of this research to provide further understanding of the research subject (Agapiou 2002; Brinkmann 2008). The presence of open-ended questions enables participants to express the more important experiences on a research subject (Jacobson and Choi 2008). These interviews followed ethical guidelines of seeking informed consent for research respondents, assuring and ensuring participants' anonymity and confidentiality (Preissle 2008).

The interview protocol contained closed and open-ended questions on individual demographic and career details, public construction project goals identification and delivery strategies, characteristics and challenges of public-private partnerships in Scotland, the impacts of these challenges on the human resource wellbeing and recommendations to effectively manage these challenges. Table 1 provides anonymised names and occupational information about the 15 research respondents who participated in this interpretive exploration. The use of pseudo names for the respondents is in the line with ethical practice in research (Khan, 2014).

Table 1: Respondents details and roles

Name	Age Group	Occupational Role	Employer	Years of Experience
Kennedy	22-34 Years	Construction Manager	Public/Private Initiative	13-18 Years
Gabriel	35-44 Years	Construction Manager	Private Organisation	19-24 Years
Tracy	35-44 Years	Quantity Surveyor	Private Organisation	13-18 Years
Mark	35-44 Years	Construction Manager	Local Council	30 Years and above
Vince	45-54 Years	Construction and Project Manager	Local Council	30 Years and above
Clarkson	35-44 Years	Development Manager	Local Council	0-2 Years
Sasha	45-54 Years	Project Consultant	Private Organisation	8-12 Years
Donald	45-54 Years	Project Consultant	Private Organisation	30 Years and above
Simon	35-44 Years	Project Manager	Private Organisation	8-12 Years
Daniel	45-54 Years	Project Manager	Local Council	25-30 Years
Craig	45-54 Years	Project Manager	Local Council	25-30 Years
Clarence	45-54 Years	Client	Local Council	25-30 Years
Hammond	35-44 Years	Client, Project Manager	Local Council	25-30 Years
William	35-44 Years	Service Manager	Local Council	25-30 Years
John	35-44 Years	Project Director	Private Organisation	30 Years and above

RESEARCH FINDINGS AND DISCUSSION

The findings are derived from a thematic analysis and coding of the transcribed interviews into nodes using the Nvivo10 software. This approach is recognised and relevant in construction management research (Agapiou 2002; Ankrah *et al.*, 2009)

Leadership and Goal Uncertainties

The public sector, seen as the client and sponsor of public construction projects, is expected to provide clearly expressed identity and cultural expectation in terms of the projects goals and desired process to be adopted in public-private partnerships. The respondents' experiences and perceptions indicated an absence of clear goal and objective direction. This perception, as it stems from private sector individuals, provides relational challenges amongst public and private parties on a larger scale.

...Public sector clients should be more specific about what they want and avoid changes during the construction project... The less changes, the better... [Gabriel].

...We've got multiple parties feeding into hub whether it's Scottish Futures Trust, the Scottish government, the councils themselves, so there's very limited scope for us to be able to bring in new thinking... [Kennedy].

In agreement with the respondents, it is important for project goals and individual responsibilities to be clearly stated (Fryer *et al.*, 2004; Jacobson and Choi 2008), however the objection towards change expressed by private sector employees is debatable. The construction industry constantly experiences changes and the ability to adapt to change for project delivery to be achieved is crucial. This may reflect an absence or shortage of training and development for the construction workforce on change management in public construction projects. These discussions further inform

the rigid procurement approaches experienced by the respondents in the third theme of this section.

As expressed by Kennedy, the success of the public sector to simultaneously consider government, public institutions, local councils and political representation and needs presents a difficulty in deciding what leadership and vision is identified and shared within the project environment. Local councils, beyond being service providers, hold the crucial leadership position for championing a shared vision, developing beneficial partnerships and supporting the attainment of socio-economic goals (Hood and McGarvey 2002). This situation becomes increasingly exasperating with the higher shares being held by private sector organisations in the SFT/Hub structure, that is, 60% to the private sector, 30% to public sector participants and 10% to the Scottish Futures Trust (Scottish Futures Trust 2014).

The integration of private sector organisations into public sector projects allows the dominance of private sector culture and practices (Hartmann *et al.*, 2010). Hood and Garvey (2002) argued that the practices within public construction project extinguish any distinction between private and public sectors, furthering the absence of any clear public sector identity and culture when interacting with other parties. In addition, Yuan *et al.*, (2010) argued that the private sector is the most important decision maker in public construction projects. This provides significant levels of conflict of interests. Public sector organisations possess different learning journeys and viewpoints on public procurement (Furieux and Barraket 2014) and should address the resulting differences in order to maximise the benefits of their relationships with the private sector (Hartmann *et al.*, 2010).

...long and short of it if a political realm came and it didn't want to use the Scottish Future Trust module anymore, they would disband it... at that stage, I think hub would evolve into something else; another procurement method... [Kennedy].

The leadership and vision conflicts are further enhanced from a political standpoint. The identity of Scotland and her construction industry remains vague as Scotland is argued to be dependent on and reactive to the UK government policy and therefore falls short of the leadership required to meet her own unique needs in public construction projects (Agapiou 2002). This research also recognises the history and influence of politics over the construction industry in Scotland as an important driver to attract either positive or negative results from public construction projects.

The subject of politics in public construction procurement, with recent socio-political events such as the exit of the UK from the EU, uncertainties on power devolution and the likely occurrence of a second referendum vote for Scotland within the space of 5 years, presents the possibility of further negative effects. As the literature provides evidence of the origin of public-private partnerships as a political process reluctantly tolerated in Scotland, the influence of politics and the resulting uncertainties endure through the various governments in power. While the importance of political support to the delivery of construction project goals is valid (Jacobson and Choi 2008), this support seems biased and unstable. Rightly, Pinto and Prescott (1988) stressed the need for management support in construction projects to be prioritised and enhanced.

Occupational Rigidity

In the quest to improve value for money and the standard of construction project delivery, the public sector 'best practice' approach specifies the contribution of community benefits as a pre-requisite to private sector participation in public sector

construction procurement. Private sector respondents reveal the effects on productivity and performance in;

...Community benefit schemes have also been a pain in the neck... Community benefits can be a distraction from the real project as it takes time away from the job ... [Gabriel].

The experience of community benefits as a burden is evidence to the disconnect of the tendering and contracting processes from human resource consultations in this crucial stage (Li *et al.*, 2005). This may also represent an absence of workforce engagement in the policy making process: this is not uncommon in construction projects (Abu-Hijleh and Ibbs 1989). The opposite of this would guarantee improved project performance and delivery (Suprpto *et al.*, 2016).

This rigid approach is also reflected in the limited autonomy level available to the human resource within public construction projects;

... my frame of reference is very contractual and restricted to have to work within the parameters of that contract... within my frame of references looking at construction management, my abilities are quite constrained because I have a contract... [Kennedy].

While most contracts are set up to deal with numerous items such as integration (Ankrah *et al.*, 2009), these contracts largely do not address human resource factors such as autonomy. This places a restriction on the ability of construction professionals to competently manage public construction projects to successful completion. Autonomy for the human resource is considered an important element for optimal human resource motivation and performance (Adedokun *et al.*, 2013). It is important that individuals are involved in creating an organisational culture that empowers professionals to independently and confidently manage projects in line with laid down innovation guidelines (Almarri and Abu-Hijleh 2017). Hood and McGarvey (2002) reiterated the need for individual skills and competencies to be recognised and enhanced for the benefits of public and private sector relationships to be optimised.

I think the public sector, it's a bit more constrained...we have a central procurement unit...they procure everything from pencils to the cubies...the people here are kind of experts purely in procurement, procurement law...everything including motorways and huge developments goes through the CPU...it's just another complication from our perspective that doesn't actually make things any better, in fact it makes things worse...it just makes the timescales much longer...it kind of gets in the way of communication...that is demotivating...our procurement system in recent years is more kind of annoying [Clarence].

The profession of individuals in control influences the orientation of the project (Ankrah *et al.*, 2009), this may provide explanation for the orientation in these projects as procurement managers hold significant decision making powers. The responses shown above question the supposed benefits of these partnerships such as improvements to the public procurement systems (Yuan *et al.*, 2010). This argument also offers evidence into the effects of these challenges on the motivation and performances of the human resources in these construction projects. The Public procurement is argued to thrive on the collaboration between public and private parties and employee engagement within a conducive and mutual working environment; however, this is not reflected in these responses. Communication and consultation is a key human resource management tool, this is much more important when considering construction project delivery (Pinto and Prescott, 1988).

Public Client Penalty Orientation

Literature suggests that public and private sector relationships should be both contractual and relational, however evidence from this research suggests that public-private partnerships are penalty focused and avenues for rewards to foster positive partnerships are limited. The negative effects of an emphasis on penalties, even in recent procurement initiatives such as Hub, are evident in the responses of the research participants.

...my incentives really come from the stick effect of the carrot... I have to use that to say sorry you're not on time, you're not on budget. I will step in here and charge you early day damages... [Kennedy].

...public sector projects are more penalties driven... [Gabriel].

This approach, either for reason of risk management or contract management, leaves a negative effect on the relationship between parties and eventually affects the procurement process negatively;

...contractors get upset when you hit them with early damage ... they take it quite personally...it's always about punishing... [Sasha].

The traditional penalty orientation in the construction industry, despite research arguing against it, persists at the expense of the human resource. These challenges seem identifiable with construction professionals across the globe and therefore may be linked to the rigid and traditional nature of construction projects (Cheng and Ma 2013). Although it is argued that an increase in client influence results in an increase in workforce representation (Yuan *et al.*, 2010), this is not reflected in the participants' responses.

This situation is blamed on an emphasis on cost. The emphasis on cost erodes human resource recognition. This provides evidence of retrogression into traditional cost and finance orientation. These encourage further reservations on the benefits of public-private partnerships in public construction procurement. For construction project delivery to be achieved, the cultures within these projects should be considered. The culture experienced in construction projects is shown in the relationships between participants, individual attitudes and the conditions on site. Construction cultures have been characterised by division, antagonism, suspicion, poor communication, finger-pointing, machismo and sexism, further reiterating the need for cultural change in the construction industry (Ankrah *et al.*, 2009). While these are prevalent in public construction procurement, public organisations are keen to present their efforts in limiting the tense events of awarding penalties;

...We give contractors the opportunity to make things right; this is important. Things happen but we work together to make it work out well. We have a quality audit system that allows us to complete contractor appraisals and if standards are dropped, this is reported and the contractor is then asked to provide an explanation and an improvement plan to prevent further re-occurrences... They know we don't accept substandard work and if they don't do a good job we will tell them it is not good enough and when the bad work continues, we tell them it can't go on... [Vince].

The data presented are in contrast to the concept of collaboration between public and private parties in public procurement. The project's approach to preventing project failure or shortcomings, by stipulating penalties, may be because of numerous factors, which further research should seek to identify and understand.

CONCLUSION

Public procurement is distinguished in its role to provide national assets and infrastructure and deliver valuable services to a variety of customers. While the partnerships between public and private parties are argued provide numerous benefits, the perceived disadvantages and challenges have not been scarce. While this is not surprising, it is necessary for further understanding of these challenges and the drivers of these challenges to be derived. The peculiarity of Scotland and the need for a distinct understanding on Scotland, as argued in this paper, also makes this research more interesting. More specifically, this research focuses on human resource interests and how the procurement practices within these partnerships affect the wellbeing and performance of the construction workforce in achieving personal and project delivery. This research aimed to explore the challenges in Scottish public sector construction projects and the effects on human resource performance by drawing on the experiences of purposively sampled individuals from Scottish local authorities and private sector partners. These challenges and experiences have been engaged and analysed based on human resource management principles and practices proffered in literature.

The collected interview data provided themes of the challenges faced by various parties. From the data collected, the identified challenges presented in this paper were largely expressed by private sector participants. The themes presented in this paper cover uncertainties in organisational identity and culture, political instabilities, occupational rigidity and limitations and the persistence of a penalty driven relationship between public and private parties within public construction projects. While some sections of these findings may be present in the construction management literature, the concentration on public-private partnerships in public sector construction projects in Scotland is a significant contribution for providing further understanding on the operation of such partnerships based on political manifestos without it being engaged with the construction management process and parties.

The importance of cordial and symbiotic relationships between private and public parties within public sector construction procurement is also undermined by the problematic approach of adopting penalty focused terms in public contracts. The perceived absence of project identity and public leadership in the Scottish context reinforces the need for further research in other construction management segments distinctively for Scotland. These findings and discussions reinforce the reservations expressed towards the proposed and perceived benefits of public-private partnerships, specifically in this paper, with regards to the human resources in Scottish public construction procurement.

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PPP PROBLEMS: CHALLENGING ACADEMIC COMPLIANCE WITH ECONOMIC OPPORTUNISM AND EXPLOITATION

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PPPs are joint ventures in which the private sector works in partnership with government bodies to deliver public sector projects with the intention to deliver them more quickly, efficiently and with better value for money. They are also one of the most contentious project delivery mechanisms to have been mobilised in recent decades. Research has demonstrated the lack of realised value within many such projects, yet construction management academics continue to examine ways of increasing, implementing and optimising this approach in practice, even encouraging its adoption worldwide despite growing social and political dissatisfaction. We seek to challenge this dominant academic approach by going beyond myopic construction management perspectives to place them firmly within the wider neoliberal economic context. We unpack three key assumptions around PPP: the role of the partnership, the role of the free-market and continuing de-regulation, and the way this is positioned to generate 'imaginative paralysis'. Through this economic lens, uncritical academic compliance with a procurement process that demonstrably contributes to economic inequalities and, worse, their recommendation of this mechanism to more vulnerable developing economies in which the investment provision is more likely to be global than local, becomes a considerable cause for concern. We seek to confront the unquestioned academic support of this procurement route, and directly challenge researchers to rethink their complicity by revealing the economic mechanisms that lie beneath and support continuing opportunism and exploitation in practice.

Keywords: PPP, economics, critical discourse, academic complicity

INTRODUCTION

Well, that was rather prescient, wasn't it?

ARCOM abstract deadline: 12th January 2018

Carillion (PPP behemoth) collapses: 15th January 2018

Causing problems for many construction workers who were unable to retrieve their tools, equipment and materials (and therefore their livelihoods) from locked-down Carillion sites under threats of trespass from the receivers (BBC 2018a). Not to mention the thousands of construction subcontractors and suppliers that made up Carillion's extensive supply chains, owed around £2bn at the time of the collapse (Mor

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et al., 2018), and who are now facing financial crisis and collapses of their own as their workers face redundancy and unemployment (BBC 2018b).

Yet this paper is not simply a diatribe against PPP, PFI or PF2, or any public-private partnership procurement mechanism simply in and of itself. As our title suggests this is not an evaluation of PPP from client, corporate or commercial perspectives.

Instead, we wish to challenge what we see as a concerning economic myopia as found in the majority of construction management research in the area of PPP, and go so far as to charge such approaches as complicit with ongoing neoliberal exploitation and opportunism within the global marketplace.

We duly acknowledge that there exists a considerable body of literature around PPP generated through construction management research, and recognise that this literature is not entirely complementary. For example, Leiringer (2006) notes that the use of PPP will not necessarily stimulate technical innovation in the private sector and it '... would be rash to claim that PPP is the panacea for change within the construction industry' (ibid: 307). However, the dominant discourse arguably remains positive: one that supports the development and perpetuation of this procurement mechanism. PPP is evaluated and researched by academics on a global stage, with a focus on '...what makes for a successful partnership and [how to] bring this result about' (Grimsey and Lewis 2004:2), critical success factors for such projects are defined and evaluated (Li *et al.*, 2005), and even the PPP Track Call for ARCOM 2018 seeks a 'better understanding of the dynamics of long term stakeholder relationship in infrastructure investment and thus serve to deliver a platform for greater investment.' (McClements *et al.*, 2017).

More worrying perhaps is the way in which PPP is linked to emerging markets and developing economies, presented as the only potential solution for such demand - 'creative thinking and innovative approaches, along with smart risk management are therefore needed to empower higher-value sustainable PPPs' to meet 'accelerating demands for better value infrastructure and services' (Suranga Jayasena 2017). From organisational perspectives, PPPs are also positioned as positive opportunities, enabling organisations to transition from construction companies as fragmented and regional into '... international actors delivering services in most sectors of PPP implementation' (Roumboutsos *et al.*, 2017). And then came Carillion.

As Noam Chomsky pointed out as far back as 1967, the Western model of development is hardly one that we can point to with any pride, and we suggest that it is the global spread of western neoliberalism, and the failure of its associated ideological assumptions, that has resulted in the inevitable breakdown of PPP as a procurement mechanism. Yet such assumptions are essentially economic in their foundations, and understandings or explications of contemporary economic contexts are often lacking in the majority of construction management research of PPPs. Although considerations of 'accessible financial markets' (Li *et al.*, 2005) can themselves be noted as necessary incentives for private sector participation, what accessible means in practice is limited, and simply noted as 'the state of the market' and its 'trends' (ibid: 464). It is therefore arguable that such economic superficiality renders construction management academics complicit (either consciously or unconsciously) in an approach that is able to ignore the 'evidence' and negative consequences of PPPs as realised in practice, and instead enables a belief that evident failures are not due to the ideas underpinning PPP, but to practical 'errors' regarding

their implementation. Therefore all that is needed is for PPPs to be ‘improved’ and they will succeed.

Compliance with this discourse is clearly evident in much of our PPP research and outputs, as we align our research to fit with neoliberal notions of ‘progress’, ‘production’ and ‘growth’ as tied to a market (profit) centric society (Sherratt 2017). Yet our role as academics is arguably to be more thoughtful than this, to be much more critical (Chomsky 1967), to look beyond such unspoken beliefs and ensure they are challenged where appropriate, or at the very least even acknowledged.

Here, three key assumptions are unpacked through a critical discourse analysis (Fairclough and Wodak 1997). The first, implied in the ‘Partnership’ of PPP, is the notion that there is a shared interest between the corporate/ financial entities who deliver these projects and the general public who are their ‘customers’. The second assumption regards the notion of the efficiency and effectiveness of neoliberalism and, in particular, the workings of the ‘free-market’ as an ideal context for PPP; an assumption that goes largely unquestioned in both political and academic spheres. Finally, it will be argued that this confusion (misapplication) of the terminology regarding the market, and the benefits that it can offer the government, along with the ideological assumptions that underpin these ideas, have led to a kind of ‘imaginative paralysis’ where alternatives are not only dismissed as ‘unrealistic’ (Drechsler 2018) but in many cases cannot even be imagined; leading to the ultimate triumph (conscious or not) of Margaret Thatcher’s oft-repeated economic argument: There Is No Alternative (TINA).

A Brief Contextualisation

PFI was officially announced in the UK in Norman Lamont’s Autumn Statement of 1992 as a way of ‘increasing the scope for private financing of capital projects’ (Allen 2001:14). The guiding principles of PFI were twofold; there was to be a genuine transfer of risk from the public to private sector and the projects should provide value for money for the public. The scheme proposed by Lamont was intended to replace the Ryrie Rules that had been in place since 1981. Prior to the PFI initiative adopted by Major and Lamont, the British government had been reluctant to allow private capital to finance public sector projects, and the Ryrie Rules were intended to monitor governmental involvement with private finance, mindful of the impact that close relationships with private contractors could have on the ‘market’. Notably, that ‘government guarantees or commitments... should not result in schemes offering investors a degree of security significantly greater than that available on private sector projects’ (Allen 2001:13).

The concerns expressed above in the Ryrie Rules were based on the notion of ‘Moral Hazard,’ and in this instance the Hazard was the distortion of the market that can occur whenever large players (in this case the government) become involved in the free market economics. Amongst other things it was feared that such governmental involvement could distort the workings of the market and lead to government backed private monopolies becoming ‘too big to fail’.

Prejudiced Partnerships

Despite the high hopes that were initially held out for this new partnership between government and the private sector, PFI and its successor PF2 (a ‘re-brand’ of PFI where the ‘fundamentals of the financing structure and contracts remain essentially the same’ HM Treasury 2018:5) are viewed (for varying reasons across the political

spectrum) as having been costly failures. Criticisms of PPPs include those around issues of excessive costs, and the argument that fundamentally PPP projects have not delivered ‘value for money’. It has also been argued that the government could have borrowed the money used to finance PPPs more cheaply on its own account instead of relying on more costly private finance, which has in turn has led to excessive long-term debt burdens (Benjamin and Jones 2017).

Indeed, there are currently over 700 operational PFI and PF2 deals in the UK, with a capital value of around £60bn. More importantly, the annual cost of these deals (in debt repayments) was £10.3bn in 2016-2017, and if no further PPP deals are entered into, future charges are estimated to be (at least) £199bn until 2040 (HM Treasury 2018). Issues of excessive profits have also been raised, as PPPs have led to windfall gains to private companies at public expense. The insufficient adoption of risk by private sector has arguably led to cases of ‘Moral Hazard’ (Benjamin and Jones 2017) and a flawed procurement process led to an asymmetry of negotiating power between clients such as schools or hospitals and the contractor and resulted in contracts simply described as ‘an ugly mess’ (Mahoney 2018). Furthermore, the lack of accountability and democratic oversight not only allows the government to keep its spending ‘off-the books,’ a short-term measure that masks large long-term costs (Benjamin and Jones 2017), but commercial confidentiality in PPP projects also enables opaque practices that have opened the door to highly profitable re-financing deals, an growing yet unlisted PFI secondary equity market (De Biasio and Murray 2017), and tax-avoidance through offshore ownership.

The failings of PPP projects were even acknowledged at the highest levels of government when George Osborne (prior to becoming Chancellor of the Exchequer) stated in 2009 that: ‘The government’s use of PFI has become totally discredited... Labour’s PFI model is flawed... we need a new system that doesn’t pretend that risks have been transferred to the private sector when they can’t be... The first step is transparent accounting... [and]... remov[ing] the perverse incentives that result in PFI simply being used to keep liabilities off the balance sheet. Needless to say when Osborne became Chancellor he adopted a more pragmatic view of the situation; the hidden debt that was off balance sheet should remain hidden, as Osborne feared that such fiscal candour would see Britain’s credit rating downgraded (HM Treasury 2018:36). Osborne’s replacement for the ‘discredited’ PFI of New Labour was PF2, branded a new approach to PPP in 2012, it essentially remained the same. However, running alongside the largely ignored PF2 scheme was another attempt to successfully harness private initiative, through an alternative PPP scheme with investments totalling over £13bn between 2012-2017, and is even less transparent than PFI or PF2: ‘HM Treasury used to collate and publish information on these deals but has not done so since 2010. Also, unlike new PF2 deals the expected and actual equity investor returns are not disclosed’ (HM Treasury 2018:46).

An interesting aspect of Osborne’s approach was the fact that faced with, and even acknowledging, the failings of the PPP ‘partnership’ idea, Osborne concluded (in ‘classic’ technocratic fashion) that it was not the concept that was at fault but merely its implementation; PPP just needed to be ‘done better’ and it would work, a notion that construction management academics have been more than happy to comply with in their research. The problem is, of course, that the fundamental weaknesses of the model, such as asymmetry of interests, cost of financing, excessive profits etc. that make up the prejudiced nature of PPP partnerships, still remain firmly in place.

This Little Piggie Went to (The Free?) Market

The influence of the global economy on PPP cannot be underestimated, as the interconnectedness of the financial markets and the regulation (or rather de-regulation) of the global economic marketplace have considerable influence on how PPPs can and do operate, as Li *et al.*'s (2005) labelling of 'accessible financial markets' as a critical success factor duly recognised.

A primary aspect of the PPP model that deserves much more critical attention, due to the potential dangers that it holds, is the reliance of PPPs on debt fuelled borrowing as a means to finance and maintain projects. When the government looks to private companies to finance projects, such companies are not simply sitting on 'spare capital' which they are actively looking to invest profitably, as the image of the classic 'capitalist' of the nineteenth century would suggest. Instead these companies borrow money to finance the project. This reliance on borrowing means that PPPs are intimately tied into the world of finance capital: 90% of the money used to finance PPP projects is borrowed, the remaining 10% being 'equity' brought to the project by the contractor (HM Treasury 2018).

It is through such mechanisms that governmental involvement can cause distortions in the free market, whose workings it is attempting to harness. Knowledge that a company has the backing of large government contracts makes them attractive prospects for finance capital, as they are less likely to default on their debts due to their being backed by the government (governments for the most part being diligent debtors), and this in turn means that the company in question can borrow more money on the back of its existing contracts, in the process getting into more and more debt. The perils of such debt-fuelled growth are neatly demonstrated by the collapse of Carillion, an organisation which increased its loans from £242m in 2009 to £1.3bn in 2018 (Mor *et al.*, 2018), and was actively seeking more finance, even requesting £10m support on a week-by-week basis (Marshall 2018) as if it were a payday loan, right up to its eventual failure.

However, the danger lies in seeing the Carillion collapse as an isolated incident of corporate mismanagement, as opposed to the result of a systemic failing based on an over-reliance on cheap credit and a debt-fuelled economy. It should be clearly borne in mind that this situation is not a consequence of 'market forces' but the result of a highly artificial and unprecedented developments in the global economy as a result of the financial crisis of 2008. Firstly, in the UK interest rates have been held at 0.5% since March 2009, a situation which has made corporate debt accumulation much easier. However, should interest rates rise (between 2000 and 2009 interest rates averaged around 4%) this level of debt could rapidly become problematic, interest would consume a considerable portion of profit and the debt become unserviceable.

However, organisations do not need to rely on such traditional forms of borrowing, as they are able to issue their own debt in the form tradeable corporate bonds on the market, a process that has been further 'encouraged' (again, against any notion of a 'free market') by the Bank of England's announcement in August 2016 of its Corporate Bond Purchasing Scheme (CBPS). This scheme is intended to: 'Impart monetary stimulus by lowering the yields on corporate bonds, thereby reducing the cost of borrowing for companies... and... stimulating new issuance of corporate bonds [more debt]. The Bank will look to purchase, via the CBPS, a portfolio of up to £10 billion of sterling corporate bonds representative of issuance by firms making a

material contribution to the UK economy, in order to impart broad economic stimulus. (London Stock Exchange 2018).

This solution to the problem of corporate debt, with bond yields being too expensive for companies to finance, is for the Bank of England (backed by the taxpayers of the UK) to essentially make it easier for them to borrow more money to pay their existing debts. Actions such as these, that form in effect a kind of 'corporate socialism', have seen worldwide corporate debt increase more than 50% since 2007 to over \$68tn; a figure that is put in clearer perspective when it is considered that total world GDP was just under \$80tn in 2017 (Statista 2018).

This reliance of corporations on finance capital, and the enormous proportions this reliance has reached, also raises another key question: where do the banks/financial institutions get the money to lend to fund PPP projects in the first place? This question has been answered by the Bank of England thus: 'One common misconception is that banks act simply as intermediaries, lending out the deposits that savers place with them. In this view deposits are typically 'created' by the saving decisions of households, and banks then 'lend out' those existing deposits to borrowers, for example to companies looking to finance investment or individuals wanting to purchase houses... [However]... viewing banks simply as intermediaries ignores the fact that, in reality in the modern economy, commercial banks are the creators of deposit money.... Rather than banks' lending out deposits that are placed with them, the act of lending creates deposits. Commercial banks create money, in the form of bank deposits, by making new loans. When a bank makes a loan... it does not typically do so by giving them thousands of pounds worth of banknotes. Instead, it credits their bank account with a bank deposit... at that moment, new money is created. For this reason, some economists have referred to bank deposits as 'fountain pen money', created at the stroke of bankers' pens when they approve loans' (McLeary *et al.*, 2014:15-16)

The system as described above collapsed in 2007-2008, when it became apparent that the amount of 'toxic-assets' (debt created ex-nihilo by banks that was worthless or worth far less than its nominal face value) in the financial system had reached critical proportions. The 'bailout' of the global financial system in 2008 involved governments switching these 'toxic assets' for government backed securities that could safely be relied on by banks to continue their lending operations. This process, one that is again diametrically opposed to even the vaguest notion of how 'free markets' are supposed to operate, saw the British National Debt increase from £557.2bn (35.4% GDP) in 2007-2008 to over £1tn (64.6% GDP) in 2009-2010, as the British government (on behalf of British taxpayers) agreed to shoulder this toxic debt on behalf of the banks. This huge increase in government expenditure to prop-up the global financial system has ushered in the policies of 'Austerity' in order to ensure that the government can 'balance its books' and service the increased interest payments on this debt. A question rarely asked is that if the government bailed out a financial system (which they did) that created this money at the stroke of a pen, to whom then, do they really owe this debt? The very same financial institutions that were the recipients of such governmental largess in the first place.

This underlying economic context clearly demonstrates that PPP in reality owes little to 'capitalism' or 'free markets'. Indeed the mechanisms that lie behind PFI and PPP actually distort the very market they are attempting to harness, and have instead supported the development of debt-fuelled corporate finance and lead to the

emergence of vast monopolistic corporate PPP entities such as Carillion. That the financing for PPP projects is also fuelled by economic debt as raised by banks makes something of a mockery of the notion of 'value for money', as making repayments on a loan are all the more galling when that money never really existed in the first place. Whether such underlying economic mechanisms can ever be considered in the public interest in the long term is now certainly up for debate, given that the organisations they have spawned have been demonstrated to have the capacity to fail, with disastrous consequences for the public in so many different ways.

Imaginative Paralysis: There is No Alternative

Yet despite the various critiques from many different sources, despite growing concerns around global debt, and increasing unease and restlessness in global economic markets, it would seem that our political leaders are 'trapped' in an ideological cul-de-sac, affected by an 'imaginative paralysis' in which PPP remains the only logical solution for large construction projects.

The desire to cling to an ideological conceptualisation of the free market is evidenced in the Prime Minister's speech to the Bank of England, in which she stated: 'In essence... [the free market]... is very simple. It consists of an open market place, in which everyone is free to participate...an accountable government, progressively taxing the economic activity which the market generates, to fund high-quality public services which are freely available to all citizens... We should never forget that raising the living standards and protecting the jobs of ordinary working people is the central aim of all economic policy... Not serving an abstract doctrine or an ideological concept - but serving the real interests of the British people' (May 2017).

However, as the previous discussions have shown, the image of the 'simple' workings of the 'free market', although providing a powerful ideological underpinning to the actions and decisions of politicians such as May, is actually based on a fantasy that has no connection to the reality of the global financial situation. Absent from May's description is the fact that global wealth has become ever more concentrated into fewer and fewer trans-national monopolistic mega-corporations, and fewer than 10% of public companies account for more than 80% of profits (World Economic Forum 2017). These corporations, through corporate mergers and takeovers, vast economies of scale and legal protectionism make it farcical to posit the notion that a sole trader and Carillion were all 'simply competing' in the global free market together. Similarly absent is the problem of tax avoidance by these same multinational corporations (Financial Times 2017) who in May's mind are only too happy to help pay for 'high quality public services'.

That such unblushing praise of the workings of the 'free market' was given to an audience at the Bank of England, the very institution that doubled the money supply to bail out bankrupt banks in 2008 and is continuing to buy billions of pounds of corporate debt in order that they can borrow more, should paint a stark picture of the gulf between ideology and reality, and why this should be vigorously challenged. May is (apparently) aware the type of criticism mentioned above when she acknowledges that the government should 'not serv[e] an abstract doctrine or an ideological concept - but serv[e] the real interests of the British people'. However, by utterly disregarding the observable reality of the situation and instead proposing that in essence the only cure for the country's economic ills is more of the same, only this time 'done better', this is exactly what she is doing. Whilst there is no reason to assume that May is cynically ignoring reality, this is in essence at the root of the

problem. May's belief in benefits of free markets evinces utopian beliefs in the power of a myth, however, and most interestingly, these delusional beliefs are regarded by May as being the result of 'rational' thinking regarding how the economy works; this combination makes these utopian beliefs incredibly powerful, so powerful in fact that reality as measured in falling income levels, rising levels of inequality, rising levels of debt etc. (BBC 2017) can be ignored as they reveal only temporary inconveniences that will be resolved by the same 'free market' solutions that caused them.

This mentality was described by Ralston-Saul (1992:401) thus: 'this need to describe reality other than as it is... is merely a facet of the rational conviction that man can and will change circumstances to suit his own plan. The more abstract our economies, the easier it is to believe that imaginary financial situations can be endlessly manipulated. There is, however, nothing in history to prove that this is so'. What we are arguably witnessing in 2018 is an ideological crisis regarding the way the economy does (and should) work in politics, academia and the media. The neoliberal discourse of free markets and growth has become so entrenched that there simply is no alternative.

But of course there is. There are in fact many way to 'do' economics, none of which are value-free nor scientific, and 'behind technical concepts and dry numbers lie all sorts of [unconscious] value judgements' (Chang 2014:111). It is a mistake to assume that economics as it is practiced today is based on science and not an arbitrary view of how certain people assume the world should work. It was such mistaken confidences in the workings of the financial system that led to the financial crisis of 2008 and has allowed the same system to continue in its wake. In an ultimate irony, such thinking also allows criticism of this 'science' to be dismissed as 'ideologically driven,' and can therefore safely be disregarded as 'unrealistic.'

The UK government's approach to PPP is just one example of this kind of thinking. By basing their decisions on utopian visions of the workings of 'free markets' the government's harnessing of private enterprise has, far from leading to a mutually beneficial 'partnership' between the public sector and private finance, instead led to monopolistic corporate behemoths, huge levels of debt and a transfer of wealth in the form of debt obligations for taxpayer backed projects, from the public to shareholders and financial corporations. And these are arrangements which are set to cost hundreds of billions of pounds for generations to come.

CONCLUSIONS

Since the 1990s, PPPs are part of the way the UK construction industry has worked. Despite suggestions that such mechanisms were only suitable for infrastructure projects, the UK government adopted them far beyond that, something also seen as positive by construction management academics (Li *et al.*, 2005). The UK construction industry boomed. Yet whilst the UK was building, the economy was faltering: the moral hazards of such government involvement becoming realised, their influences on a notionally 'free market' began to have negative effects, and unprecedented increases in debt-fuelled growth all meant something had to give. And it did. Twice. But although the notion that There Is No Alternative was able to prop up an ailing economic system in 2008 (and continues to do so today), it was not able to save Carillion. The second largest UK construction company with a hundred years of history went into compulsory liquidation in January 2018.

As stated in the introduction, this paper did not intend to be a holistic critique of PPP, nor did it seek to unpick the collapse of Carillion in any depth - that hadn't even happened when the paper was conceived. It did not intend to be objective, nor balanced, nor anything other than a challenge to construction management academics to more robustly consider economics, on both national and global stages, when evaluating and researching construction procurement and PPPs.

We therefore urge the construction management community to reflect on what we have presented here, and to go beyond the contractual mechanisms, the partnering processes and the project success factors that affect PPPs, and instead to seriously consider what economic systems we are helping to perpetuate and what consequences they can bring. We should ask ourselves if we are content to support organisations in continuing their economic opportunism and exploitation of the public sector, and continue to realise vast profits from a mechanism based on the stroke of a pen. We should perhaps more seriously ask ourselves if we are content to inflict such procurement mechanisms in countries with emerging economies, that are perhaps more vulnerable than the UK - although vulnerability is of course in the eye of the beholder. And we should ask ourselves if we are content to contribute to the ongoing imaginative and ideological paralysis within our society, which refuses to face up to the realities of how our contemporary financial systems work, and instead begin to explore viable other ways of doing things and robustly challenge the notion that There Is No Alternative. There is.

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PROCUREMENT FOR SUSTAINABLE INNOVATION

PUBLIC CLIENTS' POSSIBILITIES TO INITIATE SUSTAINABLE CHANGE - EXPLORING TWO SWEDISH CLIENTS' PROCUREMENT STRATEGIES

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Governments and municipalities often have lofty ambitions to reduce their environmental impact and enforce sustainability in the construction industry. With this in mind, it is important to study the ability of public clients to implement these ambitions in practice. Current research suggests that public clients have a strong potential to support change processes. One way of executing this potential is through procurement. Procurement can, and shall, according to the Swedish government, be used as a mean to reduce the environmental impact of the public sector. The purpose of the paper is to explore what implications the procurement strategies of two public clients have for their role as change agent for sustainability initiatives, within construction projects. The study was carried out by qualitative analysis of two cases, one from a Swedish municipality and one from the Swedish Transport Administration. The findings show that public clients do act as change agents at a policy level but struggles with implementing its ambitions in the project phase. Despite sustainability goals and the clients' pledged potential to act as change agents; they do not actually wish to take on all dimensions of a role as change agent. Practical implications from the findings include increased understanding for public clients of their need to engage in the change process on a management level in order to fully act as a change agent.

Keywords: change agents, procurement strategies, public clients, sustainability

INTRODUCTION

Sustainability goals are increasingly emphasized in the construction industry and the Swedish government has significant ambitions to decrease its environmental impact (Boverket 2018). However, many sustainability objectives are still new to the infrastructure construction industry, and it is not evident how they should be operationalized and implemented in the construction supply chain.

Procurement is identified as a tool to meet the Swedish goals for decreased environmental impact (Ministry of Finance 2017). Research has previously showed that public procurement can indeed form a strategic policy tool to reduce the environmental impact, as well as a mean for introducing more sustainable practices and 'lead the way' (e.g. Marron 2003, Brammer and Walker 2011).

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Public clients stand for a large part of infrastructure construction. Given their prominent role, attention should be given to how these clients can contribute to change (Ingemansson Havensvid *et al.*, 2016). Clients are often understood to have the characteristics to support change processes (Kulatunga *et al.*, 2011), which can be driven by incremental continuous development or larger transformations in processes and products (Eisma and Volker 2014). Grandia (2015) suggest that change agents can help increase the focus on sustainability in procurement but identified a gap of in-depth studies on the role of change agents for sustainability in procurement.

This paper focuses on how public infrastructure clients drive environmental performance through their procurement strategies. The objective is to explore how the procurement strategy impacts which actor should, and actually takes, initiatives to drive sustainability change in project execution (in addition to contractual environmental requirements). Two infrastructure cases have been analysed, where the first case consists of two infrastructure projects in a public urban development project, initiated by a municipality. The second case includes two public infrastructure projects by the Swedish Transport Administration. All four projects use some form of partnering contracts and the two cases are related as the two public clients have developed a common policy, General Sustainability Requirements in Contractor Procurement (Trafikverket 2017).

PREVIOUS RESEARCH

Environmental Policy and Implementing It

Integrating environmental aspects in procurement can be seen as an example of integrated environmental policy (Marron 2003). However, institutional opportunities for success with integrated environmental policy, and implementation of public policies in general, has often proved difficult. Lafferty (2004), for example, suggests that organisations often misallocate resources and forget to focus on ‘meta policies’ and long-term institutional learning.

When implementing an integrated environmental policy, it is important to increase awareness of the choices made within the organisations (Knights *et al.*, 2014). Otherwise it can be difficult to make balanced decisions and managing potential trade-offs for environmental sustainability, especially when time is limited (*ibid.*). Brammer and Walker (2011) identifies four factors which influence how public procurement policy translates into practice; perceived costs, familiarity with policies, supplier availability/resistance and organisational incentives/pressures.

Environmental procurement strategies can be split into ‘win-win’ strategies, i.e. sustainable choices cut costs, and ‘win-lose’ strategies, where sustainable choices entail higher costs and therefore may not always be feasible in an ‘financial sense’ (Marron 2003, Knights *et al.*, 2014). Conflict of interests between the traditional project focus on time and budget and sustainability is one of the barriers facing clients trying to address sustainability issues in construction (Brammer and Walker 2011, Lafferty and Hovden 2003, Sourani and Sohail 2011).

The Public Client as Change Agent

Research proposes that clients and public clients in construction have the characteristics to act as change agents (Boyd and Chinyio 2008, Eisma and Volker 2014, Kulatunga *et al.*, 2011). This, since they can be presumed to actively contribute to improve the industry and enhance innovation because of their public responsibilities (Eisma and Volker 2014). However, Manley (2006) highlights the

fact that construction clients traditionally have shown an inefficiency to induce innovations in their projects.

Depending on organisational level and phase of the project, the public client can use different actions to induce change. As pointed out by Latham (1994), public clients can use policy and procurement as means to request function and quality of the product and thus to act at a policy level and in early project stages. The clients may however also take a more active role during project execution (Kulatunga *et al.*, 2011, Manley 2006, Loosemore 2015). For example, Kulatunga *et al.*, (2011) describes how the client can promote innovation by leading the inter-organisational communication and be at the centre of the project. By being an active client that engages in the project they can promote construction innovation, for example by building strong relationship with other actors, establishing coordination mechanisms and manage information and knowledge (*ibid*).

The main characteristic of a change agent is to actually make change happen and to turn visions into action (Miller and Lawton 2002). But the change agent concept is wide and various models have been developed to describe the different organisational roles a change agent can take. Caldwell (2003) reviewed the literature on change agents and classified the literature into four models of change agency; leadership, management, consultancy or team development. Depending on the model there are multiple possible actions for change agents, either through the role of an adviser or leader that can envision and support others, or through coordinated programs or operating teams dedicated to change processes at different levels of the organisation (*ibid*).

The first two in these classifications (i.e. leadership and management models) are relevant when discussing public clients as change agent since it corresponds to the nature of a client as the project manager that integrate various actors and ensure that the project outcome correspond to the client's goals (Boyd and Chinyio 2008). Caldwell (2003) describes a leadership model of change agency as a sponsor of strategic change through visions and supportive actions. Yet, he stresses that a visionary leader does not per se produce change. In contrast to a 'leader' model, a manager as change agent can be classified by the actions of implementing change (*ibid*).

Finally, it is important to emphasize that the change agent's role is intricate, Caldwell (2003) stresses that there can be combinations of leadership, management, consultancy and teams that in the end affect the change process. To add to the general difficulties of the change agent role is the system in which public clients act which is highly complex, where it can be difficult to manage public and professional values (Eisma and Volker 2014).

METHOD

The purpose of the paper is to explore what implications the procurement strategies of two public clients have on their role as change agent for sustainability initiatives within construction projects. A case study approach was chosen to achieve a context-dependent (Flyvbjerg 2006) understanding of public clients as change agents in the construction industry, through rich amount of empirical material (Eisenhardt and Graebner 2007). In total 27 semi-structured interviews have been conducted, where general questions regarding project goals, procurement strategies and the roles of the actors in each project have been discussed.

In order to explore the client's role as change agent analysis were done based on the two theoretical organisational levels in which public clients can act to promote change, as described in the previous literature review (e.g. Kulatunga *et al.*, 2011, Latham 1994). First, on a policy level, procurement strategies were analysed to identify how the public clients aimed to work with sustainability initiatives. Second, in the project execution level, interviews with key participants in four projects were analysed to understand who initiates sustainability goals and actions, and how the formal procurement strategies were implemented and used.

Case Descriptions

The first case, Case 1, includes two infrastructure projects executed between 2015 and 2016 in an urban development project by the City of Stockholm. One project, The Vacuum Waste project, installed automated vacuum waste collection system for the district. The other one, the Gas Works project, performed ground-work including soil remediation as preparation for later building projects. Both projects used different extent of partnering as procurement strategy. The City considers the overall urban development project, which is primarily a residential area, a testbed for sustainable urban development. The project has had a distinct sustainability profile from the start and there are high set goals to minimize the environmental footprint both long-term and during the project execution. As summarised in Table 1, the interview participants include Project Managers and a Procurement Manager from the City as well as Project Managers and Site Managers from contractors and sub-contractors.

The second case, Case 2, consists of two large and complex infrastructure projects by the Swedish Transport Administration's (STA) in a major Swedish city. Both projects are parts of a mega railroad construction project. The project-specific procurement strategy for Case 2 was based on the STA's general procurement policy. However, the two projects are so called ECI-project (Early Contractor Involvement) which is a two-stage process where the contractor is engaged on a cost-reimbursable contract in the first stage to further develop the design and a target cost. This forms the basis of a design-build construction contract in the second stage. The ECI model represents the highest level of collaboration in STA's Common National Strategy for Procurement, and these two are the first ECI contracts at STA. For each project in Case 2, interview participants include Project Managers and a Procurement Manager from STA and Project Managers, Collaboration Managers and Design Managers from contractors as well as consultants; see Table 1 for an overview.

Table 1: summary of interviews per role and case

Role	Case	Number of interviews
Client, City of Stockholm	Case 1*	5
Contractor		3
Sub-contractor		4
Client, STA	Case 2	7
Contractor		4
Consultant		4

*interviews were conducted by a research group including one of the authors

FINDINGS

Findings are structured by case followed by a short comparison. The findings include a summary of the clients' role in the projects, based on the results from the strategic documents and interviews respectively. Some context of the overarching sustainability ambitions of each client is also presented.

Case 1

The City of Stockholm has a general program with sustainability guidelines and a more detailed strategy for sustainable procurement (Stockholms Stad 2016a). From those guidelines, each urban development project within the City develops its own policy documents from the characteristics of the project. Case 1, with its distinctive sustainability profile, has a sustainability policy document summarising five strategies for sustainable urban development (Stockholms Stad 2016b). The policy includes several requirements for the City, housing developers and contractors. Apart from the General Sustainability Requirements in Contractor Procurement (Trafikverket 2017) several specific requirements and tools were developed to reach the environmental and sustainability goals, as well as enable the implementation. The specific initiatives include a construction logistics centre, a platform for reporting all environmental matters during project execution and a sustainability competence program.

It is clear that the City has taken an initiative to increase sustainability in the urban development project, especially environmental sustainability. The presented aim of the sustainability procurement strategy (Stockholms Stad 2016a) is to initiate and encourage sustainable change and use procurement as a tool. Their goal is to guide, and be a testbed, for innovative sustainable solutions. However, their sustainability goals are presented as 'guidelines and catalyst' for sustainable change, where a lot of responsibility to come up with concrete solutions and implement them is placed on the developers and contractors (Stockholms Stad 2016b). The City, as a public client, does not want to direct or manage sustainable change, but rather it seeks to encourage it. Nonetheless, some exceptions have been identified in the studied urban development project. In particular, the construction logistics centre was developed to minimize the environmental footprint. Here, the City's project management has developed the centre and is responsible for its operation. In addition, all developers and contractors are required to utilise it.

The contractors' perspectives are interesting to understand; how the City's efforts to push sustainability initiatives are perceived and implemented in the construction projects. From the findings in the two explored infrastructure projects it becomes clear that the City's goals to encourage sustainable change are not 'top of mind' for the contractors and sub-contractors. The Senior Project Manager from the City describes a difficulty in communicating the goals to all project actors, i.e. main contractors and sub-contractors. This corresponds to the findings on how the interviewed contractors view the project goals. When asked what project goals they thought important and how they work towards them, all interviewed Project Managers and Site Managers focused exclusively on time and money, not one mentioned the sustainability goals.

The construction logistics centre, as one of the City's tools to implement environmental sustainability, was discussed during the interviews. There was a common understanding among contractors and sub-contractors of the two infrastructure projects that coordinated construction logistics is important in complex

urban development. Still, they did not use the services in their project. They argued that the design of the centre and its services did not fit their infrastructure projects. For example, the centre focused on material transportation to the project sites rather than from the sites, where the latter is more relevant for infrastructure projects with a lot of waste material. It seems that the City did not take the project execution process of an infrastructure project into account when designing the centre.

The project management from the City considered the procurement strategies to increase the understanding of the sustainability goals and enforce the use of developed tools. The city used partnering or ECI contract with contractors in both projects due to the complexity and high uncertainty. The contractors indicate that this benefited the projects, both financially and in order to solve problems together. Still, the compensation form for the two projects lacks incentives, both financial and soft parameters, to work towards the sustainability goals and usage of the developed tools.

Case 2

The main purpose of the STA is the long-term infrastructure planning for road traffic, rail traffic, shipping and aviation, as well as for the construction and operation of state roads and railways. They execute their work through policy development and procurement which is aimed to enhance innovation and efficiency by market mechanisms (Ek Östberg 2016). In the context of the STA, the term innovation should be understood in the broader sense i.e. optimization, development and change processes. This overall goal is translated into the STA's General Procurement Policy, where it is stated that the STA should take a 'pure client' role (ibid). STA further has instructions from the Ministry of Enterprise and Innovation to work towards Sweden's environmental objectives and if necessary, propose measures for environmental development (SFS 2010).

The project-specific procurement strategy of the two projects follows the general requirements on the STA's proposed role as a 'pure client'. This implies a focus on function rather than method, thus giving the contractor a possibility to present change as described at the STA's official website (Trafikverket 2018). The role of the client is to evaluate sustainability initiatives and enable its implementation (ibid). According to this strategy, each contract should be designed in a way that enables change and creates incentives for innovative environment work, to benefit both client and contractor as well as the public good.

The aforementioned joint public client policy on sustainability requirements presents a baseline of procurement requirements that can be altered due to local or project specifics (Trafikverket 2017). According to these requirements the engaged contractor should initiate and lead change within the project, whereas the client has a more controlling role, i.e. to ensure that the environmental requirements made are met by the contractor (ibid). In summary, the STA has a responsibility to act in an environmentally sustainable way and environmental requirements are included in individual contracts. However, in line with the STA's role as 'pure client', sustainability initiatives or improvements should primarily come from the contractor.

When asked, all interviewees argued that ECI, as a form of contract, in some way or another was positive for sustainability. Several interviewees from the client as well as the contractor/consultant side claimed that the early contractor engagement enables different parties, with different skills and competences, to sit down and discuss solutions and ideas. This creates an understanding of the other parties' roles, driving forces and positions and therefore facilitates creative outcomes. They emphasize that

the mix of professions and competences stimulates and enhances innovative solutions. As a Project Manager for one of the projects describes it, the melange of professions together with a common ‘best for the project’ attitude was considered to enable change. However, this demanded that all parties, including the client, were prepared to invest and engage in the project and sometimes do what could be considered “someone else’s job”. Some interviews with the contractor/consultant indicate that they wish the client to develop organisational tools to work together, in order to facilitate innovation.

The interviews in Case 2 indicate that the contractor is actually taking on the role as an initiator of change. For example, in one of the projects the contractor initiated a change to the design. This turned out beneficial both environmentally and in terms of costs. An assistant Project Manager from the STA and a Senior Design Manager suggested that the STA should apply their knowledge and drive change in order to get results that correlates with the public good, since the driving force of the contractor are foremost financial. They believed that the client could endorse sustainability initiatives, for example new recipes of concrete in order to reduce CO₂ for climate calculation. This through the collaborative context and by adjusting the budget in favour of such initiatives or ensure that additional costs related to sustainability initiatives would be STA’s responsibility. As for now, there are no financial incentives purely connected to environmental benefits that the interviewees were aware of. Since the project goals, including the budget, in the ECI contract are set in collaboration with the client some interviewees from the client and consultant side pointed out that this could enable sustainability initiatives that might be more expensive to be included in the project. Yet, in other corresponding client interviews such initiatives were not seen as the ones most prioritized.

The Two Public Clients as Change Agents

From their common goal to increase long-term sustainability, the City of Stockholm and the STA has more or less similar ways of reaching these goals through their procurement strategies. They promote change through their procurement strategies which focuses on collaboration between client and contractor. Although, the joint public client policy on sustainability requirements states that the contractors should be innovative and lead design. The roles of the two clients differ in the respect that the STA has an established ambition to be a ‘pure client’, whereas the City of Stockholm urban development project was seen as a testbed for high profile sustainability initiatives. This indicates that the City of Stockholm wishes to take a more prominent role as a change agent with a sustainability profile. The STA encourages contractors to sustainability change and improvements, but only through general goals on innovation and financial incentives.

DISCUSSION

From the findings presented in the previous section neither The City of Stockholm nor the STA could fully be considered change agents for sustainability. Whilst they have included sustainability goals in their procurement strategies and a baseline of environmental requirements in their contracts, the clients do not to a significant extent manage or implement sustainability initiatives in their construction projects.

According to the findings, these public clients act as change agents primarily at a policy level and during early phases of the project. This can be seen as one type of initiatives taken to create sustainable change (e.g. Ingemansson Havenvik *et al.*, 2016, Eriksson and Szentes 2017, Latham 1994). Later, during the construction phase and

on a project management level, this responsibility is moved to the contractors as a part of a strategy to rely more on market competence and initiative. This, in contrast to actions suggested by Kulatunga *et al.*, (2011) which propose the client to act as a driving force within the project, in order to promote innovation. As explained by Manley (2006), clients have had troubles with promoting change. That is, even if they have ambitions of initiating sustainability they seem to fail at the execution since they do not actively engage in leading the project planning and execution.

The City of Stockholm, in addition to the sustainability goals, puts forward some sustainability initiatives such as the construction logistics centre. Partnering and ECI were used to encourage their contractors to take initiatives for sustainability and implement the overall policy goals in their projects. Despite the aim of closer collaboration, STA in the explored projects mainly kept to their role as a 'pure client' and did not specify solutions and designs or took active part in defining them. Thus, although partnering and ECI were found to encourage initiative for change by increased collaboration and gain sharing in accordance with literature (e.g. Eriksson and Szentes 2017) it does not necessary lead to clients assuming roles as change agents. In correspondence with Loosemore (2015) and Brammer and Walker (2011) some of the contractors requested that the client should reduce the risk of innovation by providing a financial, legal and regulatory stable environment in order to give organisational incentives for change to occur. Here, questions regarding the implementation of sustainability initiatives were left to the contractors, which did not seem to prioritize sustainability goals or initiatives. This means, in the end, that implementation processes are left unattended and none of the actors have the right support or incentives for realizing high level sustainability goals. Lafferty (2004) points out that a lack of focus on the implementation process can be an obstacle since the organisation does not fully comprehend how it should adapt. These findings indicate that public clients should consider an increased focus on project engagement and implementation process if they want to ensure that their ambitions are implemented. Otherwise their role as change agent will only reach a policy level and early phases. However, as the experiences with the logistics centre in Case 1 showed, a more active role also requires an understanding of the implementation context to ensure that measures are adequate (Manley 2006).

The change agent's role is complex and incentives to be a change agent can vary (Loosemore 2015). In addition, the context of public infrastructure clients involves many different requirements (Eisma and Volker 2014). The findings indicate that the public clients' goals differ between the cases. The City of Stockholm's urban development has a high sustainability profile and the client aimed to 'lead by example' as suggested by Marron (2003). The sustainability initiatives are used as a tool for branding the City. The same incentives do not apply to the STA. The leeway in the procurement laws is tighter in industries with few public actors as major buyers such as in infrastructure (Ek Östberg 2016). In its client role, the STA tries to influence the market and push for efficiency and innovation and sustainability can, in the case of the STA, be seen as an integrated parameter in a general will to endorse change by market mechanisms. Yet, the findings indicate that there are only some forms of change which fall in the win-win category and thus are enhanced by market mechanisms. This is an often-occurring conflict between the traditional project goals and sustainability (Lafferty 2004, Knights *et al.*, 2014). In other industries there may be buyers in the other end requesting qualities related to sustainability. In commercial real estate and residential construction, for example, sustainability practice is more

elaborated much because green building certificates etc. are valued by investors and tenants (Ott and Hahn 2018).

CONCLUSIONS

By combining environmental policy literature with organisational theory of change agents, the paper has explored what implications the procurement strategies of two public clients have on their role as change agent for sustainability initiatives within construction infrastructure projects. The findings show that public clients do act as change agents at some organisational levels and in certain phases of their construction projects. Yet, the study concludes that in the two cases there are no one, neither the public client nor the contractor that fully takes on the role as a change agent for sustainability.

Much previous literature advocates public clients' potential as change agents. The findings presented here indicate that although public clients may have higher level ambitions to drive development, they do not actually wish to fully take on a change agent role. In the two cases, the clients limited their role to inducing the contractor to take initiatives, but without establishing sharp requirements or incentives in this area. Further, while partnering and ECI were found to increase the collaboration between public clients and their contractors there was still a lack of both active organisational support and collaborative innovation.

Conclusively, sustainability goals set in policies and strategies do not seem to be enough for sustainability change to actually happen, as the implementation process is deemed difficult. Therefore, practical implications from the findings include a recommendation to public clients to extend their role as project managers to comprise activities to promote change to a full extent. This is especially important for sustainability measures that imply higher costs. Focus on financial incentives cannot be considered enough for sustainability initiatives, mainly because this shows to benefit only sustainable change that also reduce (or do not affect) project costs.

Further studies should include exploring cases in other national contexts and cases aiming for sustainability change using other types of procurement strategies and leadership models than the ones presented in this paper. It is also relevant to further discuss the differences between public and private clients to take into account differences in long-term goals and incentives for sustainable initiatives in order to improve implementation of governments' ambitions to reduce environmental impact.

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CULTURAL COUNTERFACTUALS: ASSESSING THE IMPACT OF INDIGENOUS SOCIAL PROCUREMENT IN AUSTRALIA

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In countries like Australia, Canada and South Africa with large Indigenous populations, governments are increasingly turning to social procurement to solve entrenched social problems like Indigenous disadvantage. Social procurement works by leveraging construction and infrastructure spending to encourage construction firms to give back to the communities in which they build. It does this through new partnerships with governments, not-for-profits and social benefit organisations like Indigenous enterprises, which deliver construction products and services in ways that benefit Indigenous communities. However, the success of social procurement policies is typically judged from an outsider's perspective, ignoring Indigenous notions of value: the intended beneficiaries whose lives social procurement is aimed at improving. Mobilising strain theory and undertaking a critical literature review to conceptualise social procurement in a new way, this paper explores the proposition that current methods of assessing the success of Indigenous social procurement. It finds that policies are culturally insensitive and fail to articulate adequately their social impact on the communities they are designed to benefit, presenting an overly optimistic view of success that does not align with Indigenous perspectives of social value. We also argue that the project-based nature of construction appears to conflict with Indigenous notions of social value by undertaking temporary endeavours that lack local knowledge. The paper concludes by presenting a new conceptual framework of cultural counterfactuals that will allow future policy social impact assessments to represent better the views of Indigenous people in the social procurement policy debate.

Keywords: Indigenous, social impact assessment, social procurement, social value

INTRODUCTION

In Australia, an Indigenous person is someone who is of Aboriginal or Torres Strait Islander descent who identifies as Aboriginal or Torres Strait Islander and is accepted as such by his or her community (Department of Aboriginal Affairs 1981). This population group suffers from severe and long-standing social and economic disadvantage in the areas of living standards, life expectancy, education, health and employment (DPMC 2017; Fuller *et al.*, 2005). It is generally accepted that this disadvantage originated from European settlement of Australia in the eighteenth century and the subsequent effects of colonisation (Cooke *et al.*, 2007; Short 2011). While Indigenous disadvantage has been targeted by a number of successive policies

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and programmes funded by the Australian Government (Australian Government 2009; Short 2011), there has been regression or little to no progress in the areas of life expectancy, incarceration, psychological health and substance abuse (CTGCSC 2017; DPMC 2017). Such is the importance of this problem, in the financial year 2015-2016, six per cent of government expenditure was spent on policies and initiatives to address disadvantage for Indigenous Australians (SCRGSP 2017) who make up only three per cent of the population (AIHW 2017: 3). This situation is repeated in many other countries with large Indigenous populations such as Canada, New Zealand, and the United States (Cooke *et al.*, 2007).

To address this apparent failure of traditional welfare policy to address Indigenous disadvantage, governments in Australia and other countries are turning to social procurement as an innovative social policy intervention. Social procurement involves the acquisition of a range of assets and services, with the aim of intentionally creating social outcomes (both directly and indirectly) (Furieux and Barraket 2014: 269). The construction industry is a major focus of this new agenda because of its size and impact in the wider community and because, unlike many other industries, it often operates in areas of disadvantage (Loosemore 2016). As an object and tool of 'new public governance' (Furieux and Barraket 2014) social procurement reflects trends in governments seeking new solutions to intransigent social problems through partnerships with private business, not-for-profit, third sector and community organisations.

This contemporary partnership-based approach to dealing with enduring social problems is not without its critics and their effectiveness in terms of social impact are largely unproven. According to LePage (2014) and Barraket *et al.*, (2016), the social procurement trend in the public sector is driven by a range of motives including: ideological neo-liberal agendas which advocate greater outsourcing of public services to the private sector; a desire for innovative and locally relevant and engaging public service delivery; increased focus on maximising the value from public spending; the diminishing fiscal capacity of governments to support social benefit activities through traditional means; increasing recognition of complex social issues which seem resistant to traditional interventions; emerging evidence of achieving social impact through social enterprises; growing interest from the private sector to integrate social value into their business practices; and consumer and taxpayer demand for socially responsible supply chains and products.

From an Indigenous perspective previous research has argued that the methods used to evaluate Indigenous social procurement policies in Australia are reliant on financial information that may not be compatible with Indigenous worldviews and notions of social value (Denny-Smith and Loosemore 2017). While social impact assessments typically involve stakeholders in assessments and include various counterfactuals to ensure that social impacts being claimed are attributable to an intervention (Nicholls *et al.*, 2012), they fail to account for different notions of value which can vary significantly from culture to culture (Berry *et al.*, 2013). These complex cultural issues can result in formal findings and recommendations of evaluation reports frequently having material variances between evaluator and Indigenous understandings and perceptions (Taylor 2003). Building on this research, this paper aims to critically examine the literature on strain theory and Indigenous social values, combining them for the first time to propose a new conceptual framework of cultural counterfactuals contributing to the possible negative impacts of Indigenous social procurement policies which are currently hidden from view in traditional social

impact assessments of such policies. We develop Nicholls *et al.*'s (2012) definition of counterfactuals as being 'displacement' (opportunity costs for those involved) and 'substitution' (losses for others who might have missed out), causing negative social impact, to include additional cultural costs. Cultural counterfactuals, therefore, may be viewed as factors of an individual's cultural environment that contribute to realising a negative social impact. This research is particularly relevant in the number of Indigenous procurement policies that have been put in place in Australia and other countries (e.g. Government of South Australia 2014; Australian Government 2015a). This paper will contribute to an existing paucity of research on social procurement in construction (Loosemore 2016) especially with a focus on Indigenous people who suffer significantly higher levels of disadvantage than many other groups (Denny-Smith and Loosemore 2017).

SOCIAL PROCUREMENT

Although there are many ways in which social procurement can be undertaken, Furneaux and Barraket (2014) propose a model, which classifies them into four main types. These are Type 1 - 'Direct' procurement of pure (non-construction related) social services from non-profit organisations such as charities; Type 2 - 'Indirect' procurement of social outcomes from the private sector with social outcomes embedded as secondary outcomes in construction products and services contracts; Type 3 - 'Direct procurement of construction products and services from social benefit suppliers (social enterprises, Disability Organisations, Indigenous enterprises, cooperatives, minority businesses, etc.) which combine social and financial outcomes with construction related products and services; and Type 4 - 'Corporate social responsibility' management of supply chains to ensure they do no harm through employment of private sector socially responsible businesses.

Depending on the nature and focus of a social procurement programme, there are a range of potential immediate, intermediate and long-term benefits which are claimed for social procurement. In reality, however, the benefits are rarely empirically tested against other forms of social intervention and the methods used to measure their social impact are controversial and in their formative stages of development (Barraket *et al.*, 2016; Loosemore 2016). Claimed benefits include: breaking down existing employment barriers; building community resilience; social inclusion; improving local sustainability by strengthening local economies; social inclusion that promotes openness and equal opportunity for disadvantaged and vulnerable community groups; providing local employment and training opportunities for disadvantaged groups; promoting diversity and equality; fostering services innovation; encouraging fair trade; improved mental and physical health; improved children's developmental outcomes; higher rates of home ownership; higher-quality housing; lower rates of incarceration; and lower likelihood of being a victim of crime (Gray *et al.*, 2014; LePage 2014; Burton and Tomkinson 2015).

Strain Theory as a Conceptual Model for Understanding Cultural Counterfactuals

While a number of authors have qualified and questioned the claimed benefits of social procurement, there have been no attempts to conceptualise them. To this end, strain theory represents a useful tool because it can conceptualise how positive social impact is created when individuals accept their culture's goals for its members and accept the institutional means by which to achieve those goals (Denny-Smith and Loosemore 2017). This is especially useful in an Indigenous context because it can

holistically capture Indigenous views of social value and account for the cultural relativity of Indigenous Australia (*ibid.*).

Used extensively in criminology to explain the psychological and structural explanations for crime and delinquent behaviour, strain theory was presented first by Merton (1938) as a response to sociological theory attributing biological drivers as the reasoning for malfunctioning social behaviour. He argued that these drivers failed to provide any basis for non-biological conditions that cause individuals to engage in conduct that deviates from prescribed behaviours and actions. Strain theory attempts to a systematic approach to discovering how social structures exert pressure on individuals to engage in non-conformist behaviour (Merton 1938).

In strain theory, social and cultural structure are broken up into two parts (Merton 1938). Firstly, culturally defined goals, purposes and interests comprise a frame of aspirational reference for members of a society. The acceptable modes of achieving these goals is then defined, regulated and controlled by the second phase of social structure. This creates a moral or institutional regulation of permissible and required procedures for achieving these culturally defined goals. Individuals are thus given prescribed cultural goals to achieve through approved institutional means. In an Australian Indigenous context, this is represented by calls from community leaders for Indigenous people to take up employment as a way of lifting themselves out of passive welfare (Pearson 2001, 2003).

Recent research has proposed that strain theory could be a valuable theoretical lens to better understand how social forces influence Indigenous perceptions of social value, thus highlighting the potentially negative impacts of social procurement in a social impact assessment of Indigenous social procurement (Denny-Smith and Loosemore 2017). Strain theory holds that society and culture have culturally acceptable goals (such as getting a job and economic wealth) to achieve through approved institutionalised means (Merton 1938). Individuals may accept or reject either or both of these two factors, leading to a range of possible behavioural responses: conformance, where one's culture's goals and institutional opportunities are accepted; ritualism, occurring when someone rejects their culture's goals but accepts they must take up institutional opportunities, thereby performing a ritual of showing up because they have to; innovation, where it is accepted one must attain their culture's goals, but a lack of opportunities leads them to create new ways of doing so; and retreatism, a complete rejection of both factors leading one to retreat away from their culture or society. Denny-Smith and Loosemore (2017) argue that a positive social impact resulting from Indigenous social procurement will occur when individuals have high acceptance of both cultural goals and available institutional opportunities. As rejection of both these factors increases, a strain is created on the individual and Denny-Smith and Loosemore (2017) argue that this strain will lead to a negative social impact.

Although Denny-Smith and Loosemore's (2017) model is of potential value in better understanding the impact of social procurement policies aimed at reducing Indigenous disadvantage, it requires refining to include variables that have been identified as missing in current approaches to social impact measurement. Further, while the social impact literature considers counterfactuals such as displacement (opportunity costs for those involved) and 'substitution' (losses for others who might have missed out) (Nicholls *et al.*, 2012) consideration of cultural differences in the way that people perceive social value is missing from the counterfactual debate. Lastly, Price *et al.*,

(2012) argue there has been scant attention given to Indigenous evaluation methodologies, with evaluations often generalising their findings across varied and different communities and contexts. This is supported by Seivwright *et al.*'s (2017) recent calling for the development of a Western Australian Indigenous outcomes framework to provide a more transparent monitoring and reporting structure on Indigenous outcomes and this could potentially be developed to a greater scale for outcomes of Indigenous social procurement policies. There is thus a need for a new approach to social impact that considers what we term cultural counterfactuals" and an accompanying need to conceptualise what form these new types of counterfactuals might take. In the context of Indigenous social procurement, cultural counterfactuals are hypothesised to lead to the creation of strain, thus negative social impact.

Cultural Goals/Values

The Indigenous literature proves useful in helping to develop an understanding of the cultural counterfactuals associated with Indigenous social procurement and how these might contribute to the creation of strain. Pearson (2001, 2003) has advocated for Indigenous people to lift themselves out of passive welfare dependency through mainstream employment as the solution to the social problems that Indigenous people face, in a way that government resources and services cannot. This is indicative of cultural goals that could be placed on individuals to achieve and is a notion supported by the existence of several organisations who specialise in encouraging and improving Indigenous supply chains or helping Aboriginal people find work. They may therefore be used to show how cultural goals and values can be utilised to place pressure on individuals to take up any employment opportunities.

However, Peterson (2005) argues that people living in remote communities may have to displace themselves away from their home and culture and integrate into a mainstream culture, to take up employment. This is supported by Dockery and Hampton (2015). They argue the importance of attachment to country, culture and kinship networks are drivers of mobility (to travel to work, etc.), and this may affect notions of wellbeing. These factors are found to substantially limit employment outcomes and force these communities to mobilise, negatively impacting on the wellbeing and socioeconomic outcomes of the displaced people (Dockery and Hampton 2015). In addition to this, there are many barriers faced with regard to travel, for instance, not having a driver's license and for those that do travel, instances of mobility were also found to be combined with time to visit friends and family, engage in cultural and sporting activities and maintain reciprocal networks of accommodation supporting mobility along kinship lines (*ibid.*). It has also been argued that culture may have a much larger role to play in people's economic choices than previously thought (Guiso *et al.*, 2006). Thus, Indigenous culture could influence people's decisions to take part in employment opportunities that can give economic benefit. Cultural, social, and spiritual factors may thus all contribute towards the creation of cultural counterfactuals in Indigenous social procurement.

Institutional Opportunities in Construction

Construction is an inherently site-specific, project-based activity (Dubois and Gadde 2002). Construction projects operate in communities, generating jobs and enabling the efficient transportation of goods and services between businesses (Hansford 2013). However, once a project is completed, the construction business and associated benefit moves on to the next project in a different area. This characteristic can create learning discontinuities, restricting the development of knowledge bases and learning

cycles (Blayse and Manley 2004), in addition to requiring a mobile workforce, which the above review shows is not a characteristic of Australia's Indigenous population.

Dubois and Gadde (2002) argue that the construction industry is a loosely coupled system. This loosely couple system is created owing to four causes of uncertainty in the industry: 1) management is unfamiliar with local resources and the local environment; 2) no complete specification for activities on construction sites; 3) no uniformity of materials, work and teams with regard to place and time, because every project is unique; and 4) an unpredictable environment (Dubois and Gadde 2002). If construction professionals are unfamiliar with local conditions, they may not be able to make use of the potential Indigenous workforce in the project area. They may also not be aware of cultural activities that are of high importance to local Indigenous people and lastly, as construction projects move from one area to the next, the low mobility of the Indigenous workforce means they could be unlikely to relocate with them. Such a characteristic may lead project-based construction firms to privilege 'hard', objective measures of performance, such as meeting their contractual targets for Indigenous procurement, over 'soft' and sometimes intangible criteria (Brensen 2007).

Unintended Negative Impacts of Social Procurement

Despite the many claims around the benefits of social procurement for disadvantaged communities such as Indigenous peoples (e.g. Bonwick and Daniels 2014), several authors warn of potential negatives impacts of using this approach. At an individual level, Rogers *et al.*, (2008) also argue that social procurement can negatively affect intended beneficiaries. For example, if someone moves to paid employment this may incur extra costs associated with rent and transportation and it may also reduce the time they spend with their communities, family or friends, thereby causing a negative impact as they retreat from their social network. In an Indigenous context, Dockery and Hampton (2015), Dockery and Milsom (2007) and Peterson (2005) suggest these potential negative impacts can be significant because of profound differences between the cultures, values and customs of Indigenous and non-Indigenous people which can be compounded by the loss of a 'safety net' that comes from a disconnection with their land, communities and families.

Barraket and Weissman (2009) have also argued that overly onerous requirements placed on social benefit suppliers to measure and articulate social value could reduce competitive neutrality by disadvantaging smaller suppliers. Overly prescriptive requirements could also reduce supply chain diversity and undermine social innovation within supply chains. By removing this competitive neutrality, governments may engage in anticompetitive market distortions that distort competitive interactions and trade flows by limiting the number and range of suppliers; limiting the ability of suppliers to compete; reducing the incentives of suppliers to compete; limiting the choices and information available to consumers; or by applying to state-owned enterprises (Abbott 2016). This may be a form of unjust economic discrimination that does not comply with international law (Moon 2017). A number of complex challenges associated with social procurement could also include: unfair advantage being provided to social benefit suppliers through government grants and opportunities; ongoing funding to ensure social benefit suppliers remain sustainable; and the effects of employment displacement, though it is noted that these are currently based on anecdotal case studies (Burkett 2014).

Esteves and Barclay (2011) argue that while social benefit organisations and local companies are one way to deliver social and economic benefits to communities

through social procurement, it can also lead to adverse social impacts, such as the establishment of ‘fronting’ companies where the decision-making and benefits are held by other individuals who are not the targeted beneficiaries. This means that any financial benefits flowing from social procurement can be diverted away from those that the policies are intended to benefit. Communities may also become dissatisfied if they see only menial work being given to a beneficiary group as companies seek to make up the numbers as part of contractual requirements to undertake social procurement (Esteves and Barclay 2011). Smaller local businesses and social benefit organisations that rely on social procurement initiatives also may become reliant on larger firms who practice it, thus becoming vulnerable to the larger company’s business cycle and limiting their ability to provide sustainable benefits to the community (ibid.). Further, it is difficult to find empirical evidence of the tangible social impacts that social benefit suppliers, such as Indigenous businesses, create.

A Conceptual Framework for Cultural Counterfactuals

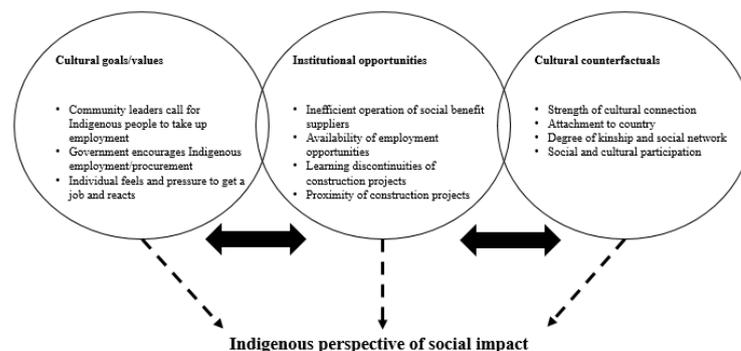


Figure 1: Conceptual framework to map the cultural counterfactuals of Indigenous social procurement using strain theory.

Drawing on the above discussion, Figure 1 presents a conceptual framework for mapping the cultural counterfactuals in Indigenous procurement policies. The conceptual framework draws on strain theory, construction industry characteristics and Indigenous worldviews and values to propose how these factors contribute to Indigenous perceptions of social value. Using this framework with Denny-Smith and Loosemore's (2017) model it is possible to map an individual's acceptance or rejection of their culture's goals and values. This could be done by asking a series of questions about pressure they have felt to get a job. Having identified several limitations to institutional opportunities in rural and remote construction, we can then test respondents' level of acceptance or rejection of these opportunities. For example, using our above review, we may find that someone accepts cultural pressure to become employed, but they reject an institutional opportunity because it is an extended distance away from them and they lack the transportation to be able to attend that opportunity, or because they must remove themselves from their kinship circle to do so. We hypothesise that this rejection will result in a strain being created, hence a negative social impact.

While this framework is useful for mapping how a future assessment can uncover the social impact created through Indigenous social procurement, further refinement is required. For example, Indigenous people will need to be consulted to confirm or deny the cultural counterfactuals we have identified in our literature review. We can also use this consultation to confirm how Indigenous people perceive various institutional opportunities. In this way, the development of our framework should be

of more significance to its intended community as they will have had a meaningful contribution in its development. In doing so, we also aim to build up an Indigenous understanding of social impact creation through the population's own experience of this phenomenon and avoid previous bad practices in research conducted in Indigenous communities (Taylor 2003). This will inform social value theory and how it relates to Indigenous communities, as well as Indigenous social procurement so that it can be targeted to create more relevant and sustainable social impacts.

CONCLUSION

This paper set out to examine critically the social procurement literature because of its use to address Indigenous disadvantage in Australia. It found that social procurement evaluations largely ignore cultural factors in their methods, presenting a westernised view of social value aimed at programme funders and policy makers that neglects Indigenous notions of social value. Through our critical review, we have conducted the first inquiry into possible cultural counterfactuals that may produce a negative social impact through the current context of Indigenous procurement policies in the Australian construction industry. Our review found that the project-based nature of construction might mean it is not conducive to facilitating a culturally understanding environment that promotes social outcomes for Indigenous workers. Our review has led us to produce a unique and innovative conceptual framework that acknowledges these factors and how they may contribute to a social impact assessment from an Indigenous perspective in a new conceptualisation of social procurement. Our framework is currently purely conceptual; as such, it must be refined through a process of collaboration with Indigenous groups. This testing could involve the development of initial scoping activities that draw on an emerging literature of Indigenous research methodologies. Policy makers and construction practitioners, particularly procurement managers, will benefit from this framework to refine and improve their Indigenous procurement strategies.

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MOTIVATIONAL FACTORS FOR ADOPTION OF PUBLIC-PRIVATE PARTNERSHIPS (PPPS) IN HOUSING PROJECTS IN TANZANIA: A QUALITATIVE STUDY

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The National Housing Cooperation (NHC) and National Social Security Fund (NSSF) are public sectors in Tanzania which have adopted Public Private Partnership (PPP) as an alternative housing delivery strategy. NHC PPP projects have been carried out in Tanzania since the 1980s and 1990s in the form of Joint Ventures (JVs) prior to the formulation of PPP policy, guidelines and the act. But the NSSF started its housing PPP project in 2013. However, since inception of the formulation of policy guidelines, there have been limited empirical studies undertaken to identify motivational factors in undertaking PPP housing projects. In order to bridge that knowledge gap, the aim of this study is to identify the motivating factors for adopting PPPs in housing projects. Based on the infancy of PPP in Tanzania, the sample was purposely selected whereby 10 semi structured interviews were conducted and data was analysed by content analysis. The following findings; lack of capital, benefit to enjoy the economies of scale, fear to lose condemned properties, increasing revenue, opportunity to own land in prime location, challenges from other investors, the feel of security when partnering with public sector, resource and risk sharing were identified as the motivational factors influencing the sectors (public or private) to adopt P. Therefore, this study recommends that, in order to enhance the motivational factors to yield successful outcomes in terms of housing cost, quality and quantity, it is imperative to seek the views of both the private and public sector practitioners. There is a need for government to provide support, utilize its PPP unit to assess viability of such projects, amend the PPP laws and policy, and put in place a PPP housing policy to improve, encourage and support private sector participation.

Keywords: PPP, housing projects, motivational factors, development, Tanzania

INTRODUCTION

As with most developing countries, the population growth and urbanisation are among the challenges which face this East African country with the current housing deficit is projected as three million houses and is growing at a rate of 200,000 houses per annum (NHC 2010). The situation has been worsening in urban regions where the data show that the urban population has grown from 14.8 per cent of the total

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population in 1980 to 37.5 per cent in 2005 and was considered likely to rise to more than 46.8 per cent by 2015 (NHC 2010). Consequently, the supply of housing in Tanzania is failing to keep up with the urban growth trend. Likewise, the 2012 census showed that the Tanzanian population has tripled since 1967 and is continuing to increase. To mitigate the population growth and subsequent consequences of shortage of housing, as with most governments in developing countries, Tanzania has been encouraged to adopt the popular PPP strategy as solution to delivering affordable/low-cost housing projects for those on low incomes (Trangkanont and Charoenngam 2014). Public Private Partnerships (PPPs) are considered more efficient and provide better value for money. (Akintoye et al., 2003; Moskalyk, 2011). However, PPPs are more complex (World Bank, 2016) when compared to traditional procurement process, requiring a huge amount of preparation, training and experience as well as good monitoring and management skills (Moskalyk, 2011). A current study by Akintoye and Kumaraswamy (2016) recommended more research on PPP and identified the following seven research themes requiring further investigations: 1) Financing, and financial models and structure; 2) Risk allocation and management; 3) Transparency and Accountability including Regulatory and Institutional frameworks; 4) Public Policy and Private/Public Sector relationships and behaviours; 5) PPP Project Evaluation; 6) Contractual structure; and 7) PPP Performance indicators. Despite these calls, PPP empirical studies are inadequate within the developing countries such as Tanzania. Therefore, this study reviews the motivational factors for adoption of PPPs in housing projects in Tanzania. First as a response to the research agenda and knowledge gaps identified by Akintoye and Kumaraswamy (2016), and second is to tap in their existing state of knowledge and later compare with the empirical findings obtained from other developing countries. Most developing countries such as Nigeria (Ibem, 2011); Ghana (Kwofie et al., 2016); Malaysia (Abdul-Aziz and Kassim, 2011); India (Sengupta, 2004) as well as Tanzania (Kavishe, 2010) to mention a few have adopted PPP in housing provision. These countries have experienced varied outcomes with most of them experiencing failures in their Housing PPP (HPPP) projects. Subsequently, from the literature review it is noted that Tanzania lacks empirical evidence on how the private and public sector are better motivated to achieve improved results in PPP housing projects unlike other mentioned countries. Therefore, this study intends to bridge the knowledge gap.

LITERATURE REVIEW

Partnership has been very popular concept in both the public and private sectors since the 18th and 19th century. (McQuaid, 2000; Akintoye et al., 2015). This stems from the mutual benefits, potential for synergy, development catalyst, cooperation, resource and risk sharing, efficiency and creativity as many have discussed this (Hatton and Schroeder, 2007). The partnering concept offers an opportunity for parties to establish mutual objectives amongst the team by providing a framework that motivate them to build trust, teamwork and focus to achieve their goals in an efficient manner (Naoum, 2003). A working definition for partnership which, incorporates a policy perspective has been provided by Stratton (1989 cited in McQuaid, 2000), which states that, partnership is a collaboration between business, government and or non-profit organization where by resources, skills and risks are shared in a project to benefit each partner and the community as well. The PPP concept grew from the partnership concept to become one of the most popular partnership approaches used (Shah, 2015). It is currently used to foster development and deliver public infrastructure in both developed and developing countries. Public sector inefficiency, lack of sufficient

funds and poor performance necessitated government or its agencies collaborate with private parties to improve the delivery of public services. Stakeholders involved in PPP include public sector, private sector (for profit and non for profit), state agencies and multilateral donor agencies (Shah, 2015).

PPP Housing Experience in Tanzania

Housing PPP (HPPP) is still at its early stages in Tanzania primarily because of a lack of direct experience and inadequate new investment in housing projects. To date, two public organizations, the National Housing Corporation (NHC) and the National Social Security Fund (NSSF) have used the PPP method for housing provision (Kavishe et al., 2018). Since the 1990s, NHC used the PPP approach in building development but most of these partnership projects were not very successful Ibid. NHC adopted partnership projects as a means of developing more houses. The corporation had prime plots, which were hosting condemned buildings. Fear of losing some plots, which were declared by the Ministry of Lands ripe for redevelopment, influenced NHC to secure financial support through the partnership model. Likewise, the increasing shortage of housing in the urban centres, made the Government seek alternative means of addressing this issue and PPP strategy has been thought to help bring relief to the existing situation (NHC, 2010). Thus, government redirected its housing agencies to adopt PPP strategy (NHC, 2010).

Motivation for Adopting PPP Housing Projects

Both public and private parties, before embarking on to any partnership experience have motivations which drive them to act. Table 1 gives a summary of the identified motivations/drives obtained through literature review. It was observed that different authors (Sengupta, 2006; Abdul-Aziz and Kassim, 2011; Ismail, 2014; Onyemaechi and Samy, 2016) have identified the key motivations for adopting PPP strategy in procuring public goods and services. However, it was noted that from these studies two types of drivers emerged. The first type was general drivers for adopting PPPs whereas the second type was specific drivers for adopting PPPs in housing projects. The second type is the focus of this study.

Based on Table 1, it's interesting to note that in Nigeria, profit creation was a common motivation for both public and private partners hence affordability to low income groups became impossible in HPPP projects (Ibem, 2011; Ukoje and Kanu, 2014). This finding implies that it is contradicting and unrealistic for the government/public agency to aim for profit maximization and at the same time desire to deliver affordable housing. Unlike Nigeria, the main motivation for adopting HPPP in Kolkata India was to bring, "equity" among their people (Sengupta, 2006). It was revealed that the housing provision under PPP strategy in Kolkata was remarkable in terms of costs and quality (Sengupta, 2006). The generalization that can be made is that; right motivations can add up to the success factors for HPPP projects.

Therefore from the literature it is clear that individual countries and sectors were differently motivated to adopt PPPs thus creating the need for more studies in this subject that examine the influencing factors and their role in achieving success in an intended project. To bridge the knowledge gap, this study aims to identify the motivating factors for adopting PPPs in housing projects within the Tanzanian context.

Table 1: Summary of motivational factors (or drivers) for adopting PPP projects

Country	General PPP motivation	Author
Nigeria	<p>For public sectors: solves the problem of budget constraints; make profit from the sale of the housing units; provision of decent and affordable housing to the citizenry; It reduces burden of housing provision from the government; Development town and cities; Faster project completion; Reduce the acute housing shortage; It is cheaper for the government since the funding comes from the developer; It creates room for influence by the officials as they determine who to partner with and on what terms.</p> <p>For private sector partners: Profit maximisation; Large market; Availability of land for the project; Marketability of the housing units; Project viability and quick return on investment; Location of the project; Price of housing units; The profit margins are competitive; Fast approvals for building and less interference from the government housing regulatory bodies</p>	Onyemaechi and Samy (2016)
China	<p>Provide an integrated solution</p> <p>Solve the problem of public sector budget restraint</p> <p>Reduce public money tied up in capital investment</p> <p>Reduce the total project cost</p> <p>Benefit to local economic development</p>	Chan <i>et al.</i> , (2009)
Tanzania	<p>Desire to bring about sustainable development</p> <p>Poor health services and the need for improving them</p> <p>Huge budgetary constraints</p> <p>Increase efficiency and effectiveness</p> <p>Improving public services</p> <p>Housing PPP drivers</p>	Ngowi (2006); URT, (2009); Itika <i>et al.</i> , (2011); Chediell (2012); Mboya (2013).
Malaysia	<p>1) Enhancing organization reputation; 2) Project reputation</p> <p>3) Early completion; 4) On time delivery; 5) Attaining value for money; 6) Political pressure; 7) Islamic state councils forbidden to engage commercially; 8) Obtaining technical expertise; 9) Transfer of defect risks; 10) Obtaining marketing expertise; 11) Cost certainty; 12) Quality workmanship; 13) Transfer of financial risks; 14) Transfer of delay risks; 15) Innovation in design; 16) Transfer of sales risk; 17) Obtaining lowest development costs</p>	Abdul-Aziz and Kassim (2011).
India	To bring equality in the society	Sengupta (2006)
Ghana	Huge housing deficit and Government inadequate resources	Kwofie <i>et al.</i> , (2016)

METHODOLOGY

This study adopted a qualitative data collection approach whereby semi structured interviews were preferred and used to collect data due to their ability to produce detailed/rich information. However, because PPPs were relatively new phenomenon or approach in Tanzania, a criterion-based approach was used in the selection of the interviewees as claimed by Maxwell (2005), this required the respondents, from the sector type to have being a public partner, or private partner or a financier, consultant or a contractor to the housing PPP projects. Secondly, a purposive sampling was used to select the interviewees for the same reason of PPP being a new approach in Tanzania. The key criterion used in selecting was that, the respondents needed to have been a public partner, or private partner to the housing PPP projects. According to Kavishe *et al.*, (2018) it was identified that only two public sector organizations were undertaking the HPPP projects. Similarly not all stakeholders were familiar with PPPs. In view of the total population only 10 semi-structured interviews were undertaken between July and August 2016 in Dar-es-Salaam, Tanzania. Despite the small sample, it is considered sufficient, because the threshold of between 5-50 interviews can be enough for the purpose of reaching saturation (Patton, 2002). More so, other studies which relied on the qualitative approach alone such as Osei-Kei and

Chan (2018) had a sample size of ten interviewees. This study forms part of an ongoing PhD research thus the duration of a complete interview was between approximately 45 -100 minutes. The transcribed interview ‘participation checks’ and ‘validation’ involved having the transcripts emailed to the interviewees to obtain their agreement on the correctness and their feedback, to enhance the validity and reliability of the collected data. Out of 10 interviewees, 8 had master’s degree qualifications, 1 was a PhD holder and 1 was an Associate Professor. According to the level of HPPP projects experience, 4 had over 10 projects experience, 2 had 1-2 projects experience, 1 had 1 waste water project experience while 1 was a PPP advisor but with no HPPP project experience. 6 were public partners and 4 were private partners. Demographic background of the respondents demonstrated that all interviewees had adequate PPP experience. Like past PPP studies for instance Zawawi et al., (2016), the qualitative data was analysed through content analysis. This involved having the patterns and themes around the motivation factors or drivers derived by identifying them as they appeared in the interview scripts.

FINDINGS

Interview participants were asked: “What were the driving factors for adopting PPP in housing delivery in their organization”? As shown on Table 2 Interview participants identified 19 factors. Responses were tallied, in the occasion where the response was only given once it was considered less significant and significant for the responses given more than once. Therefore based on Table 2 the findings show that amongst the 19 factors identified, the following three factors are the most mentioned based on the count (n=5): the need for redeveloping condemned properties, Lack of sufficient capital, and fear to lose their condemned properties. The remaining 16 factors, three were tallied twice and the remaining majority 13 were tallied once. The lack of consensus of the results may be since they were only two participants from the private sector whereas the remaining 8, were from the public sector. Additionally, due the qualitative nature of the study, the identified factors are considered as emerging themes from the findings.

During the content analysis process, some differences in the identification of the motivational factors between the public and private sector interviewees emerged. Therefore considering the pattern the identified driving factors are grouped into two main parts in order to reflect each sector (public and private) independently. Some similarities and differences are drawn in order to bring deeper understanding and implication of the identified factors.

Public Sector Factors

Based on Table 2 it was noted that public sector respondents for instance Interviewees A, B, C, E, F and H identified six different factors. The first three factors on Table 2 had the highest responses, (n=5counts) hence indicating their importance towards the adoption of PPP by the public sector in the housing projects.

Lack of enough financial capacity to undertake housing project

For instance Interviewee A highlighted that;

NHC was attracted to partnership project because it lacked funds required to adequately support re-development of its prime plots which were hosting condemned buildings to raise their values and revenue”. Additionally the organization feared to lose some of its potential plots which were confirmed by the Ministry for Lands ripe for redevelopment.

Table 2: Driving factors for adopting HPPP

Driving factors	Interviewees										
	A*	B*	C*	D	E*	F*	G	H*	I	J	F ¹
The need for redeveloping condemned properties,	✓	✓	✓		✓			✓			5
Lack of enough financial capacity to undertake housing project	✓	✓	✓		✓			✓			5
Fear to lose their condemned properties	✓	✓	✓		✓			✓			5
Government circular No. 1 of 1992 which required all public enterprises to operate commercially in order to be self-sustaining.	✓										1
Organization major role of facilitating the provision of housing and other buildings to the general public.	✓										1
Prime location				✓			✓				2
Being a previous tenant,				✓			✓				2
The deal looked viable				✓							1
Negotiations were straight forward				✓							1
Ability to share and minimize risks in case of loss or failure						✓					1
Replace deficits like funds, equipment, Technology, materials etc.						✓					1
Share resources						✓					1
The bragging behavior from other private investors particularly the Indians, claiming to be the only ones capable to undertake joint ventures with government.							✓				1
Desire from many other private developers wanting to redevelop the same plot I wanted to.							✓				1
Public sector failure									✓		1
Motivation to adopt “new ways of doing things”.									✓		1
It seemed to work in other countries									✓		1
Increasing revenue (profit)			✓		✓					✓	3
To enhance the value of property which was lower than the value of land				✓							1

Note: * Denotes Public Sector partner; ¹F = Frequency of counts

Furthermore, Interviewee A added on the issue of circular no 1 of 1992, namely the Public Corporations Act 1992 or structural reform policies which required public organizations to operate commercially to be self-sustaining.

Provision of housing and other buildings to the general public

The motivational factors of “organization major role of facilitating the provision of housing and other buildings to the general public” and “the need to increase revenue” were among the least observed as public sector motivating factors. The former was mentioned once (Interviewee A) while the latter was mentioned twice (Interviewees C and E). This finding suggests that uplifting revenues was also a significant factor to the public sector considering the fact that they were allowed to operate commercially. Interviewee F who is also from the public sector identified that the need to replace deficits like funds, equipment, technology, materials motivated their public organization. For instance, he explained that;

The private partner owned a vast majority of land (300 acres) and this was valued to 20% of the whole project cost. Similarly, the selected contractor recommended by the private partner was from Turkey and was bringing in a new building technology to Tanzania known as tunnel form construction that had a major benefit of saving time through speedy construction.

These findings are also consistent with literature on motivational factors for PPPs (Kavishe, 2010; Onyemaechi and Samy, 2016). For instance Onyemaechi and Samy (2016) emphasized that eliminating budget constraint and reducing the acute housing shortage among the public sector motivating factor in adopting PPP in housing

provision in Nigeria. Likewise in the Tanzanian context similar studies Kavishe (2010) which also studied HPPP projects from Tanzania identified similar findings.

Private Sector Factors

Examination of Table 2 shows that the respondents from the private sector identified different factors from those identified by public sector. These factors; ‘prime location’ and ‘being an existing tenant’ were each mentioned twice by private partner respondents indicating that they were important and attracted private investors.

Negotiating for PPPs

Osei-Kyei and Chan (2017) identified “length delay in finalizing negotiations” among the major implementation constraints in PPPs in both Ghana and Hong Kong. However, examination of Table 2 shows some contradictory result. For example, the following driving forces or motivational factors of “the deal looked viable; negotiations were straight forward”, “the bragging behavior from other private investors claiming to be the only ones capable to undertake joint ventures with government” and “desire from many other private developers wanting to redevelop the same plot” were mentioned only once by Interviewee G. However, these factors; “the deal looked viable” and “negotiations were straight forward” made the interviewer ask a probing question why he claimed negotiations were straight forward? The Interviewee G responded that;

Being an existing tenant to NHC and being able to come up with a good proposal and a financial report was enough qualifications to be awarded the project for redevelopment. There was no competition it was on first come first served basis and thus negotiations were mainly centred on improving the design since private partner funded the construction of the whole project.

Being a previous tenant

‘Being a previous tenant’ and ‘prime location’ (n = 2 counts) were the most important motivational factors identified by the private sector. Supports of these findings are also consistent with PPP literature in emerging economies regarding the motivational factor or drivers for its adoption. These findings further appear to be very unique to Tanzania HPPP projects but consistent with (Kavishe, 2010). What is notable from this confirmation from literature (see Table 1) is that whilst some motivational factors for adoption of PPPs might be country specific, the factors associated with “being a previous tenant” and “prime location” appeared to be not common to both less developed and more developed economies.

Commonalities in Driving Forces

Examination of Table 2 shows that the most common driving force or motivational factor between the two sectors was “increasing revenue (profit)”. The following sub section presents a brief discussion of this driving force.

Increased revenue (Profit)

The driving force of “increased revenue” was common between the Public sector (Interviewee C and E) and Public sector (Interviewee J) with the driving force being cited or mentioned a total of three times. Likewise, increasing revenue is consistent with both Tanzanian (Kavishe, 2010) and non-Tanzanian (Onyemaechi and Samy, 2016) studies undertaken in Nigeria and Ghana respectively. For instance, Onyemaechi and Samy (2016) study aimed at investigating the motives and motivation for partnership between public and private sector in housing provisions in Nigeria identified among the 9 individual reasons for public and private sectors partners as “make profit from the housing units” and “Profit maximization”

respectively. Interestingly, the same study recommended the reduction of the profit margins on the PPP housing for private sectors. This observation further confirms and validates the observation by Akintoye and Kumaraswamy (2016, pg. 5) that there are diverse drivers for PPP development, different practices and varying degrees of success of PPPs across countries, and that the PPP field continues to evolve, hence the need our study further contributes to this research agenda by allowing practitioners to learn more about PPP in relation to its drivers from a lesser investigated context such as Tanzania.

CONCLUSIONS

This present study examined the motivation factors or driving forces for PPP implementation in Tanzanian housing projects and compared the public and private sectors perceptions. The findings revealed that there were contrasting motivations for both sectors. The common three motivation factors among the public sector were “the need for redeveloping condemned properties”, “lack of enough financial capacity to undertake housing project”, and “fear to lose their condemned properties”. In contrast, the private partners identified the following 3 as their most important motivating factors for PPP adoption: “prime location”, “being a previous tenant”, and “increasing revenue (profit)”. The most common driving force or motivational factor between the two sectors was “increasing revenue (profit)”. The findings of this study are important to the public and private sectors respondents in several ways. First, for PPPs to flourish within the Tanzanian housing sector or project, due to varying motivation factors across the sectors, a better understanding and information around the motivation factors for each sector would be cardinal in setting up the initial arrangements. Interestingly, it was surprising that even the public sector was interested in obtaining more revenues hence the reason why these houses were not affordable as the focus was on profit and not quality or affordability.

Based on the findings, we highlight a few further important implications for PPP practitioners, policy makers, and government. By understanding the driving forces or motivational factors for PPP adoption, both the Tanzanian private and public sectors practitioners might be in a better position to adopt PPP schemes arising from the increased understanding of the driving forces or motivational factors. Subsequently, this could lead to improved performance outcomes within a sector and economy acknowledged as having earlier PPP project terminations. Secondly, the findings would provide the government with policy directions for creating an enabling PPP environment for all actors involved. For example, this would entail having the government to provide support, utilize its PPP unit to assess viability of such projects. Thirdly, for both policy makers and the government, an opportunity to amend the existing PPP laws and policy particularly with regards to restrictions around redeveloping condemned properties. Fourthly, the findings provide some direction to the Tanzanian government to provide support, utilize its PPP unit to assess viability of such projects, amend the PPP laws and policy, and put in place a PPP housing policy to improve, encourage and support private sector participation especially around levelling the playing field (equity).

Limitations

Some limitations of this study as presented based on the empirical findings of the interviews are acknowledged. The main limitation was the small sample size (10 semi structured interviews) as achieved. One plausible explanation for this was due to the relative infancy of PPP approach in Tanzania. Similarly, the results may not be

generalized to other surrounding countries sharing similar economic conditions such as the East African community. Nonetheless, data were obtained from appropriate respondents having acceptable education level, (i.e. at least a bachelor's degree), PPP experience and awareness to provide reliable and valid information on the research questions.

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THE IMPACT OF SHIFTING VALUES ON THE ROLE AND RESPONSIBILITIES OF THE CONSTRUCTION CLIENT IN DELIVERING PUBLIC GOODS

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In today's construction industry we witness an increase in public private collaboration in the delivery of public goods. By transferring operational responsibility to private contractors, public construction clients have fewer possibilities to directly influence and steer the outcomes of these processes while remaining socio-political responsible. In this paper we aim to explore how public construction clients try to find a balance in public value management activities by rethinking their roles and responsibilities in the client-contractor relationship. This paper results of a set of semi-structured interviews with different actors playing a part in commissioning of organisations with different degrees of publicness are presented. Results indicate that the alignment of the client role and change in responsibilities should be rather flexible in order to deal with the restrictions that procedural values such as lawfulness, reliability and transparency bring along. This requires significant changes in the interpretation of the commissioning profession and the transformation of the collaborative relationship in public private collaboration. Further research should look more closely into the alignment of the shifted roles and responsibilities and organizational- and steering mechanisms that could be applied to enhance this value shift in practice.

Keywords: public value management, PPP, value shift, responsibilities

INTRODUCTION

In today's European society we witness an increase in public-private collaborations in the delivery of public goods (products, services, financing) with which public values are created (Benington, 2011, Eversdijk, 2013). This increase appears to have two main motives. First, the financial situation brought along a growing pressure on the public sector, leading to a growing dependency of public organisations on private market parties to deliver public goods (Cornforth, 2003). Second, public entities are expected to contribute to innovation and improvement of the building sector and therefore increasingly need the expertise of market parties to come up with innovative solutions to societal challenges, such as growth of the population and cities (Cornforth, 2003, Kuitert *et al.*, 2017). Consequently, public organisations increasingly depend on private market parties to carry out public purposes. Especially in the construction industry we see a growing percentage of integrated contracts, where public parties subcontract (outsource) at least a part of its responsibilities in

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respect to the built environment towards private parties (Noordegraaf, 2015), changing the role of the client and its relationship with private parties (Boyd and Chinyio, 2008). By transferring operational responsibility by commissioning (part of) the tasks to the contractor in public private collaboration, there are fewer possibilities for the client to directly influence the outcomes of these processes (Eversdijk, 2013, van der Steen *et al.*, 2013). Socio-political responsibilities for value standards in the built environment, however, remain with public parties, requiring other kinds of safeguarding mechanisms to come into play (de Bruijn and Dicke, 2006).

The increased use of public-private collaborations caused an ongoing shift of focus in public value management at public client organisations from procedural values related to lawfulness and public responsibilities, towards steering directed at product values of innovation, sustainability and quality of public goods (Kuitert *et al.*, 2017). This triggers different kinds of reactions. Proponents of PPP, for example, emphasize the ability of private market parties to deliver services more efficiently, whereas opponents complain about the reduction of ‘governments’ ability to adapt to changing needs’ due to the long-term contracts (Ross and Yan, 2015). Hence, in this paper the following question is addressed: ‘What are the perceptions of public clients on values, roles and responsibilities in the context of the ongoing value shift in public-private collaborations in construction?’ We start the paper with a theoretical elaboration on public value management for construction clients, after which the research approach is explained. The findings include insights from a set of interviews on how public construction clients are looking for ways to facilitate the value shift; both in rethinking their role and responsibilities in relation to increasing societal value and in the context of the increasing volume of integrated contracts in construction. This is followed by a conclusion and some directions for further research.

Public Value Management by Construction Clients

We consider public commissioning as the way in which a public organization, in relation to its responsibilities in the built environment, both externally and internally shapes and implements its interaction with the supply market (Hermans *et al.*, 2014). Public Value Management literature describes management paradigms prioritizing certain values above others, choosing one or multiple logics, or combining specific values belonging to community and market logics (Smets *et al.*, 2014). In the public sphere this gets reflected by successive time periods of prevailing governance models in an ongoing governance reform. One mechanism of this reform has been partnering between the public and private sector to deliver services previously provided exclusively by the public sector often referred to as public private partnership (PPP) (Ross and Yan, 2015, Bao *et al.*, 2013, de Graaf and Paanakker, 2014). The move towards PPPs shows significant similarities with what we know as the public value thinking paradigm of Public Value Management (van der Steen *et al.*, 2013, Benington, 2011).

In previous research we noticed that this value shift in construction causes a move towards steering on increasingly important product-related values and market logics. In market logic the basic strategy is based on profit maximization, dominated by performance values of effectiveness and efficiency is visible (Kuitert *et al.*, 2017). This indicates a movement away from the focus on community logic, in which affect, loyalty, common values and personal concern are pursued. Community logic is dominated by procedural values that indicate the quality of the process using integrity and associated values such as transparency, equality, lawfulness, and honesty (de

Graaf and Paanakker, 2014, Smets *et al.*, 2014). In this value shift, clients are searching for a balance between procedural obligations and seemingly opposing 'new' values (Bao *et al.*, 2013). A fresh 'repertoire' to shape these adjusted relationships is required for the renewed division of roles, tasks and responsibilities between government, society and market (van der Steen *et al.*, 2013). This results in a need for innovative auditing, monitoring and evaluating mechanisms which focus specifically on the economy, effectiveness, efficiency and value for money (Willems and Van Dooren, 2011).

Social scientists acknowledge that pressure on public organisations leads to unintentional deviant behaviour in reaction to value conflicts instead of using set organisational processes (Van der Wal *et al.*, 2011). In searching for a new value balance, value conflicts, that are common when combining multiple logics, influence the complexity of ensuring and safeguarding public value. In addition, new public private structures affect the traditional notion of accountability, bringing along a strong emphasis on performance and outcome (Boyd and Chinyio, 2008). As public parties remain social-political responsible, public parties need to find other, more indirect, ways to achieve the desired values. After all, it does not seem fair to impose the achievement of certain values to private parties when they are carrying most of the risk related to the operational responsibilities.

In line with the search for a new value balance, the public value approach emphasises that the public domain is not just about money, but should also be concerned with requirements of the process and, next to the outputs, the outcomes of processes of delivery of public goods. Public Value Theory especially examines the limits of management, where the individual manager can only help to set boundary conditions. One of the main contributors to this theory, Mark Moore relates the importance of shifting values to one of the ingredients of public action, the social objective, clarifying the public goals and value outcomes (Moore, 1995). In relation to achieving the social objective in construction, we see an increased focus on different values types that are considered important in the context of shaping the interaction and collaboration with the market (Kuitert *et al.*, 2017). This implies that in order to facilitate the value shift in the commissioning profession, a balance needs to be sought with the other two activities to ensure public value; first, legitimacy which is about mobilizing commitment from all stakeholders needed to provide legitimacy for the value proposition, and second, capacity referring to aligning operational resources to the desired outcomes.

In discussing legitimacy, it is interesting to look into the accountability and reliability discussion in the context of the expansion in the use of networks of interdependent public and private parties in the delivery of public goods (Michels and Meijer, 2008). Transferring value creation tasks to a private contractor doesn't influence the main responsibilities of public organisations; only the contractual responsibility is shared, the social-political responsibility remains with public parties (Eversdijk, 2013). The new structures resulting from the search for innovative ways of procurement and partnerships affect the traditional notion of accountability and brings along a strong emphasis on performance. Emphasis is now on what is expected, the way to achieve it is disregarded. Where the current hierarchical presumes a principal-agent relationship, in PPPs clear principal and agent roles are disappearing and the typical horizontal nature of PPPs challenges this traditional notion of accountability even more explicitly (Willems and Van Dooren, 2011). The traditional, vertical, hierarchical mechanism of accountability no longer adequately fits the current social

and administrative developments. In addition more horizontal, informal mechanisms of accountability should be deployed by public agents (Bao *et al.*, 2013). Accountability becomes multi-faceted and both mechanisms can together form a hybrid accountability arrangement (Michels and Meijer, 2008). Moreover, both mechanisms must meet the requirements of the democratic constitutional state (Michels and Meijer 2008), so public-value trade-offs need to be imitable, and decision-making should be transparent. Quality assurance by public clients aims more and more at organizing the process, making it plausible that there is compliance with the process requirements and product requirements (de Bruijn and Dicke, 2006, Smets *et al.*, 2014).

Regarding capacity, ensuring different kinds of public values by aligning operational resources to the desired outcomes becomes more important (Benington, 2011). Making value trade-offs, aligning operational resources to the desired outcomes, from both within and outside the organisation, and thereby providing capacity is essential (Moore, 1995). Traditionally, in the construction industry the government used to be in control as a client and the private contractor was commissioned the execution of a construction work. The growing percentage of integrated contracts changes the role of the government in the public value process. In ensuring, producing and safeguarding of public values this means a different division of responsibilities; production, distribution and supply of services become the responsibility of both public and private parties. So outsourcing of public tasks does not mean that the task disappears, the tasks change. Hence, more and more the public client needs to focus on control of the executive network on which they depend to achieve public values. This asks for changes in management of processes of the delivery of public goods. The role of public clients becomes more directive and facilitating from a producing body to a frame-setting body, or in other words, an enabler and regulator (van Montfort and van Twist, 2009). Partnering is about encouraging parties to transcend the conflicting interests that lie at the heart of their exchange relationship by appealing to common interests centred on specific project goals and more strategic long term relationships (Eversdijk, 2013, Ross and Yan, 2015). Because especially in short term contracting situations the presumed level of mutual interest is arguably unrealistic (Bresnen and Marshall, 1999), this long term focus becomes increasingly important.

RESEARCH APPROACH

The main purpose of this study is to gain a profound understanding of the perceptions on the roles and responsibilities of public clients in the context of the reform of the public commissioning profession in delivery of public goods. An (inductive) qualitative approach was chosen (Miles and Huberman, 1994), using an semi-structured interview guide with open-ended questions in order to discuss the sensitive topic of public values in relation to experiences in various parts of the commissioning role (Hennink and Hutter, 2011). Respondents are members of the Dutch Construction Client Forum, representing a group of large and middle sized public and semi-public clients, including the Dutch Real Estate Agency, the National Highway Agency, water boards, housing associations and municipalities. To increase generalizability a wide range of public client organisations was included. In the Dutch construction industry we distinguish between organizations that are required to apply public procurement law - public (P) parties and organizations that are governed by the public law (GbL) - and semi-public (SP) and private organizations which only have to obey to common law. For each participating organization the aim was to involve three to four public actors: the general manager (GM), the director of procurement

(CPO), the director of real estate development and or infrastructure developments (DD), and or the asset management or maintenance director (AM). Hence a set of 44 semi-structured interviews with 47 respondents (due to some joint interviews) of 17 Dutch public and semi-public construction clients provides the empirical basis for this paper.

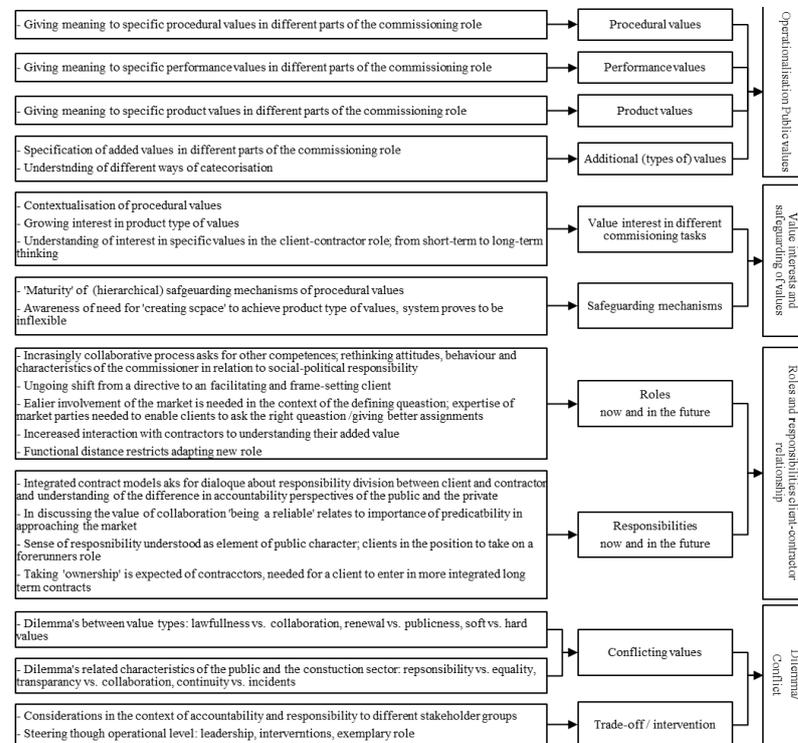


Figure 1: Data Structure

All interviews were conducted by the first author and each had a duration of 45 to 60 minutes. During the interviews 25 value cards separated in the categories of procedural, performance and product values were used following from a literature study into public values that could be considered of importance in public commissioning tasks (Kuitert *et al.*, 2017). This list provides the theoretical basis for the interview series and is used in the analysis of the interviews. To ensure reliability of the data all interviews were audiotaped and fully transcribed. We adopted a systematic inductive approach to concept development as described by Gioia *et al.*, (2013) allowing for studying social construction processes focussing on sensemaking of our respondents. We built a data structure in ATLAS.ti. (see figure 1) using a set of five transcripts and an additional set of another five transcripts for a second round to become familiar with the data (Altheide, 2000, Gioia *et al.*, 2013). To explain the impact of dynamic value interests on the perception of the public client's role in the client-contractor relationship, we included data about both in the current situation and in the desired situation, with special attention to changing perceptions about specific collaboration and contract models. The same current and future view counts for the impact on the perceptions on the responsibilities in the client-contractor relationship, in which data is included about accountability, being a reliable partner and a sense of responsibility in relation to the publicness of client organisations. To validate the outcome of the analysis, code reports of most of the coded transcripts were read by the second author and interpretations, also of the data structure, were compared and discussed with all authors for further validation. This resulted in a final distinction of

the findings in the rethinking the client roles and a section on rethinking the client responsibilities.

FINDINGS

The findings indicate that the interplay between the different ingredients of public action (Moore, 1995) shapes the 'new' commissioning profession. Currently client organizations are searching for the balance in the increasingly collaborative and interdependent environment of delivering public goods in construction. We found that with the value shift thinking about values changed. We also saw that thinking about long-term goals and long term contracts becomes more important. However, it also becomes clear that 'the system' (e.g. procurement regulations) is inflexible, while 'space' (e.g. strategic partnerships) is needed to pursue increasingly important product related values such as sustainability in this new collaborative environment. Hence, to facilitate the value shift in construction, to enable clients to steer on other values than traditional procedural types of values, there is a need to rethink roles and responsibilities.

Rethinking the Clients Role

We found that with the changing relationship between public client and private contractor, the public client aims to adopt a more facilitating and framework-setting role. Where the role used to be quite directive "In the past it was very reasonable to be very directive: we find something, you will do that. Now it becomes much more facilitating and participatory, and sometimes initiating and sometimes an intermediary, that sort of thing." (DD, P) respondents emphasize that nowadays, there is more attention to the collaborative nature of the relationship and the resulting implications, both for the approach towards the market and the interaction with contractors. For public construction clients changes in playing a certain part in this collaboration are ahead: "We are getting a new environmental law, and that also means another role for the government. We also need to anticipate on that" (CPO, P).

However, many respondents also mention that often the rule is not adequate for the desired behaviour. Contextual changes may cause a 'rule' to not be sufficient anymore. For example, desired innovation may not be reached or limited because of technology that is 'not proven' yet and therefore not applicable. Another example given during the interviews is a situation in which you need certain capacity but the procedure to contract these services takes longer than the actual project itself. "Today I have to hire someone and for example, I come in with a procedure that states that it will take a month. This fits lawfully, but I have the problem and a larger risk in a project today. So the situation will be under pressure" (GM, P).

The general perception among the interviewees is that the client's role is about re-shifting the attitude, behaviour and character so one can still act according their social-political responsibility in the changing environment: "You see that your roles change, so your pattern of behaviour must also change" (DD, P).

Often it was mentioned that the aim was to focus on trust instead of legalization of commissioning role. This requires another market approach, focusing on an equal level playing field instead of directive competition. Hence, it is important to recognize the interest of the potential contractors but also accepting their interests. By equality I mean that you have to recognize each other's qualities and recognize each other's worlds and also that you have to accept that one has a different focus than the other" (DD, P).

So the respondents indicated that in order to accept the perspective of the private party, it is important to understand their added value; to recognize the quality in the supply market. Especially performance based collaboration asks for a greater understanding of the needs and ambitions of private contractors. This also means that the level of information and expertise within the client organization needs to be sufficient, otherwise one is not able to assess this value sufficiently. By being aware of their interests, risks and accountability structures, assignments can be drawn up that are aligned with private needs and thereby enabling the public clients to use the market party in striving for public values put in the assignments. To deal with values involved in long-term goals, such as sustainability and innovation, it is even more important to let the supply market think along in an earlier stage of the process. In particular in relation to formulation and defining in delivery of public goods, there are many unknowns. We found that the question arises how to define these 'new' types of values. Clients do not seem to have many experience with this and they often need the market parties to understand these types of values. However, respondents also emphasize the need for a certain 'functional distance' in being a public client, making it more difficult to consult market parties. "I am more cautious when I am in a commissioner's role. So I make a distinction in general exploration, we do not yet have a concrete object, but I want to talk to someone about developments in the construction industry, or developments of the university campus, how does he or she see my campus." (CPO, GbL).

The respondents really considered that it is the clients' task to facilitate what is expected of the market. Therefore, they often reached out to the market earlier to discuss the latest developments in the market. They, for example, organise market consultations, are involved with different collaborative initiatives and organise meetings with SME's to inform their future suppliers about possible collaborations: "Simply by agreeing and sharing common developments, both public and private, in a client contractor relationship or in relationships to discuss general market development, we increase the contact with the market" (AM, governed by law). Better facilitation and coordination provides the market parties with an opportunity to prepare and develop to become eligible for the future assignments. To a large extent this also relates to managing the expectations of the different roles and responsibilities in the contract. Respondents mentioned transitions in the organisation, both at the level of the structure and processes as well as with the attitude and behaviour of employees. Building these types of relationships asks for other, more soft skills in the commissioning role. "If you observe it, than it depends especially on the collaboration, wisdom and honesty. It consists more of soft skills instead of the hard skills. It is all a part of it, completely" (DD, P). Despite the desire to change, today's commissioning is still quite directive. The political context also makes it difficult to carry things through and 'stick to' the new interpretation of the commissioning role. Within the pressure of projects in the public and political domain, one often reverts to old habits, again picking up the directive role. "If it gets tense, we directly turn back to our old habits, we become the directive client again, which puts pressure on the collaboration. A governmental context is present, which makes it sometimes difficult to implement correctly because you always have a mayor or alderman who shouts something which is in conflict with the broader view" (AM, P).

Rethinking the Clients Responsibilities

In the process of changing the relationship between client and contractor by adapting the role, the public client gets confronted with their public character and

corresponding accountholders. Public clients are expected to answer to the expectation of society and to answer to the market regarding their role and responsibilities in collaborating with the market. This turns out to be all related to reliability. Whereas the public body is social-politically responsible, the market must be financially accountable. However, together they should aim for 'best for project'. "But what I would try to see is the collective responsibility. [...] I do not mean fraternally, but you do want to create an atmosphere of shared responsibility. The best for project. We do this" (GM, government).

In the context of this reliability and accountability, it is important to think about risk allocation and distribution. The public client needs trust in their contractors since they will remain ultimately responsible for achieving public values. Public clients are increasingly concerned with ensuring that the private party shows ownership. They do need to take on more responsibility and take the risk of longer term contracts. "Integrity is something that you can ask for in the assignment you provide. [...] If we have a large building assignment, we start working in the construction team. This means that parties are forced to look beyond the limits of their own field of expertise. And also take responsibility together" (GM, GbL). Since public clients are well aware of their dependency on market parties, the decision about outsourcing or in house delivery is part of their accountability. This is also underlined by current developments in the Dutch construction sector, such as the collaborative 'Building Agenda' which emphasises risk sharing between client and contractor. In order to continue to be accountable there is a need to meet the procedural obligations and with that a certain distance between public and private is required. Findings indicate that public clients are more and more concerned with their approachability; they are in search for connections instead of contradictions in order to build an equal, sustainable relationship on the basis of common values. This is meant to enable public clients to go from 'lawfulness' to 'content'. In discussing the value of collaboration, being a reliable partner appears to be discussed most often. "It is very important that we, as a public client, are reliable and predictable, so you know what could be expected of us" (CPO, GbL).

Due to the growing need for expertise of private market parties, being an interesting clients is becoming increasingly important. Especially because after the financial crisis the position of market parties is improving again. "We should be able to say; well, it is totally inconvenient to put that and that on the market right now. Or talk about it with the market, or announce it, so they can prepare themselves" (CPO, P). Sometimes it appear to be more about 'the sense of responsibility' of public organisations themselves than the actual expectations. As a public organisation one serves the public good. The interviews show a strong sense of this responsibility and there appears to be a strong awareness of the public task with officials of all types of public organisations. "Intrinsically, people working at governmental bodies feel that they are there to serve the general interest, not the interest of the organisation." (CP, GbL) and "I just have to retain integrity. That is part of the public value I represent. A government official should always keep this in mind" (CPO, P).

The results also indicate that this feeling of responsibility relates to the complexity of the inner city and regional tasks that public construction clients are dealing with. A need exists to more and more incorporate values such as sustainability in order to cope with the current issues. As a public client you are in the position to be a forerunner, be progressive. "Look, we are in a period in which incredible changes take place and I think that we as an organization should have the moral duty to act as a pioneer.

Also, we, as an organization towards the city, because we can safeguard or even accelerate and improve the social-cultural-, the economic- and the ecological sustainability” (GM, P). Public clients aim to take on a ‘leader’s role’ as they feel this is their responsibility from a social-political perspective. They believe it is their task to initiate renewal and walk ahead: “We have to be innovative as well. We also have to initiate innovation. We also have to give a good example, but also try something, making testing ground possible, asking challenging questions to the market and testing new processes and procedures” (CPO, GbL).

CONCLUSIONS

This study contributes to theory development on managing different interests in public private collaborations by using public value theory to explicate the importance of rethinking roles and responsibilities in construction. We found that public agents need to adopt a more facilitating and frame-setting role to build sustainable relationships that are based on trust. However, limitations exist both regarding adopting the new interpretation of the commissioning role and the transformation of the client-contractor relationship. For public clients it becomes increasingly important to recognize and accept contractor’s interests and recognize their added value so one can ask the right questions. Facilitating, formulating and defining what to expect of the market is becoming vital when aiming for long-term relationships to realise social-political aims. Our results also show that public construction clients are concerned with their reliability and predictability towards the supply market. As they are well aware of their dependency of market parties, the decision about outsourcing or in house delivery is becoming part of their accountability. The sense of responsibility and the expectations contribute to the willingness to construction clients to take on a leading role in changing the industry. It is shown that in order to facilitate the value shift in construction from a focus on procedural values towards steering on performance and product related values and to ensure in public values the context of increased value and volume of integrated contracts in construction further alignment of values, roles and responsibilities is needed. We are definitely not there yet and further research will have to look more closely into the concrete alignment of the shifted roles and responsibilities and the accompanying organizational and steering mechanisms. In the search for governance mechanisms and frameworks for this multi-level public value management challenge, further research will have to look into mechanisms at the organizational, program and project level that are both flexible and able to deal with the restrictions that lawfulness brings along.

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PROJECT MANAGERS AS INVOLUNTARY POLICY IMPLEMENTERS? THE CASE OF IMPLEMENTING BIM

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Public procurement has the potential to drive change in the construction industry. In this process project managers play an important role as change agents and system integrators. This paper explores how public client's project managers translate BIM through procurement. The purpose is to develop better understanding of the public project manager's role as change agents and system integrators in the implementation of systemic innovation such as BIM. Findings are based on a case study of the BIM implementation initiative at the largest public infrastructure client in Sweden and interviews with construction project managers tasked with implementing BIM in their projects. The analysis is based on the theoretical perspective of sociology of translation. Findings show how project managers struggle with translating BIM when procuring and that there is a hesitation among project managers in accepting BIM policies. Project managers do not prioritise BIM and do not request BIM when procuring. In other words, they are not enrolled in the change process. Findings are important for research on project managers in their role as change agents, and on research systemic innovation such as BIM.

Keywords: innovation, BIM, procurement, project manager, translation

INTRODUCTION

Building Information Modelling (BIM) is described as systemic innovation (Cao *et al.*, 2017) that will substantially change the construction industry (Azhar, 2011). BIM is described as “a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle” (Succar, 2009, 357) that supports multi-disciplinary, collaborative and integrated work processes (Hartmann *et al.*, 2012) that contributes to the development of business processes (Eastman, 2008). Following this rather normative view, BIM is expected to impact most actors associated with the construction and maintenance of a building. However, while studies show initial benefits of BIM (e.g. Azhar, 2011), widespread BIM implementation is yet tentative (Smith, 2014). Implementing and BIM-usage pose difficulties, for example “BIM's seven deadly sins” (Holzer, 2011) and there is research needed exploring challenges related to BIM implementation (e.g. Bosch-Sijtsema *et al.*, 2017; Dainty *et al.*, 2015).

Client organisations are suggested as drivers for industry change in construction (Lee and Yu, 2015). In particular, public procurement is suggested as a “catalysts” for

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change (Grandia, 2015, 119). Porwal and Hewage (2013) also pinpoint public procurement as important for BIM implementation. Public clients have the position to demand BIM in procurement and they have the greatest potential benefit from wide BIM implementation (Elmualim and Gilder, 2014). This argument is further developed by Linderoth (2010), who claim that the discussion around BIM will change as soon as clients and regulatory authorities demand BIM in procurement. According to Linderoth (2010), the discussion will no longer be about if to use BIM or not, but to promote more advanced BIM-use.

There are a number of public client initiatives driving industry change by implementing BIM; for example Sweden (SOU 2012:39), Hong Kong (HKCIC, 2014) and the US (GSA, 2007). However, to use technology to drive organizational change is not easy and previous research in information systems (Ciborra, 1997; Holmström and Stalder, 2001) and organizational studies (Czarniawska-Joerges and Sevón, 1996) show that such initiatives often drifts away from the initial intentions. Hence, initial intentions of implementing BIM, for example industry change, may very well result in something else. This drift is indicated by Vass and Karrbom Gustavsson (2017) studying BIM implementation at the same large public client in Sweden. Their study identified a potential mismatch between expectations and outcome and that there is a need for more in-depth studies on the public client's role and possibilities in driving change by implementing BIM.

As client's representatives, project managers are expected to play a vital role in BIM implementation, especially during procurement of design and construction. The aim here is to explore how project managers translate BIM. Findings are analysed based on sociology of translation (Callon 1984) and provide better understanding of how project managers interpret and translate policy directives on BIM when procuring. The findings contribute to research on the public client's project manager's role in change processes, in particular implementing systemic innovation such as BIM.

LITERATURE OVERVIEW

Innovation in Construction

Client organizations are acknowledged as key actors introducing innovations to the construction industry (Blayse and Manley 2004; Loosemore 2015). In particular, clients are found to important in the implementation of systemic innovations such as BIM (Azhar, 2011; Lee and Yu, 2015). Also in situations where the client organization does not have direct need for the systemic innovation, they can benefit from its implementation as this might fulfil other needs (Singh, 2014).

Construction innovation typically happens in projects (Harty, 2008; Winch, 1998) and they happen as a response to client's demands or by the implementation of innovations developed in other industries (Harty, 2008). As the client's representative in projects, project managers are identified as key actors in the innovation processes. The project manager is a possible "systems integrator" (Winch, 1998; Tylor and Levitt, 2004), linking actors together and supporting change towards use of systemic innovation. However, for project managers to be successful as system integrators they need to be convinced of the merits of the innovation. They also have to have the necessary skills to be able to integrate the specific innovation into the system (Nam and Tatum 1997; Winch, 1998). More specifically, Slaughter (1998, 228) states that these individuals have to be "able to exercise the technical competence and project responsibility and control to achieve coordination cooperation across the system(s)".

Hence, the ability for a ‘systems integrator’ to adapt to the circumstances in the particular project is an important factor. Further, large degrees of freedom have been shown to be important among systems integrators, as this enables them to adapt to the preconditions in the specific case (Singh, 2014). However, to limit the degrees of freedom for other actors within the project is also important, as this might otherwise enable them to disregard the implementation process.

A strong systems integrator can effectively steer and manage the implementation process and such efforts can be viewed as relatively bounded (Harty, 2008). However, when the innovation extends beyond the control of a strong system integrator the same patterns do not follow and the innovation is viewed as relatively unbounded. Harty (2008) show how systems integrators can have problems in influencing actors within the loosely-coupled construction industry (Dubois and Gadde, 2002). Relative boundedness supports understanding of systems innovation and the fact that systems integrators are not as influential as initially thought. Instead the perspective of relative boundedness argues for tracing networks of association (Harty, 2008), i.e. to follow connections in which one actor strives to influence others, a process which can be understood as a process of translation (Callon, 1984).

THEORETICAL FRAMEWORK

Innovation as a Process of Translation

The diffusion model is common in technology innovation research. An alternative is the theory of sociology of translation (Callon, 1984), which takes its departure in the people involved in the change process (Latour, 1984). Sociology of Translation describes how actors try to impose themselves and their understanding of a situation onto other actors and tie these actors to an Actor-Network (Callon, 1984). Sociology of Translation builds on Actor-Network theory (ANT) and its description of actors partaking in a translation process. ANT is a well-used method, or tool, to understand organizational change following the implementation of information systems (Walsham, 1997). Studying the implementation of BIM as the creation of an Actor-Network provides an opportunity to map activities taken in order to tie actors to the network as well as different actor’s needs and motives for being enrolled into the network (Linderoth, 2010).

In the creation of an Actor-Network the desired program of actions can be inscribed into specific artefacts linked to the Actor-Network (Latour, 1990). Inscriptions refer to how artefacts can be used to lead actors towards deserted programs of use, guiding and restricting the use of said artefact so that the program is followed (Monteiro, 2000). In the case of technical artefacts, for example BIM, the initiator tries to define the potential user and thereby inscribe the requested program of use into the artefact (Linderoth and Pellegrino, 2005). Such inscriptions can, for example, consist of instruction manuals, requests, demands or the design of the artefact itself. But programs of use can also be inscribed in other, non-technical artefacts. Procurement documents are filled with inscriptions, influencing actors which are in some way associated with procurement.

Inscriptions are not absolute; they possess varying levels of strength and flexibility. While strong and inflexible inscriptions guide the use of the inscribed artefact, making it difficult to follow anything but the intended program, weak or flexible inscriptions open for less clear guidance (Linderoth, 2000). The strength of an inscription, the degree to which it must be followed or if it can be avoided, depends on the level of

irreversibility of the Actor-Network in which it is inscribed (Hanseth and Monteiro, 1997). The flexibility of inscriptions refers to how much the inscription influence the patterns of use. Flexible inscriptions only have a limited influence, while inflexible inscriptions dictate the patterns of use to a large degree (Hanseth and Monteiro, 1997).

Understanding change as process of translation, and not as diffusion, has an impact on how the concept of power is understood. From the perspective of translations, the obedience to an order will require alignment of the interests of the actors affected by the order. Following Latour (1984, 269) “power is always the illusion people get when they are obeyed”. There are reasons why actors follow orders given by someone in a position of power. Hence, power is nothing in itself. Therefore, to view a change process as a process of translation is to understand power as a consequence, and not as a cause of collective action (Latour, 1984). This view is in line with the concept of “relative boundedness” (Harty, 2008) and the underlying assumptions when describing the construction industry as loosely-coupled (Dubois and Gadde, 2002), i.e. as an industry in which no actor have perfect influence over the industry.

METHOD

This paper draws on a case study of the BIM implementation process at the Swedish Transport Administration (STA). A case study is appropriate when understanding social practices in complex organizational contexts (Flyvbjerg, 2006). STA is the largest public client of infrastructure in Sweden. The case study gives the context in which project managers are influenced by BIM implementation. The case study covers the period between 2014 and 2018, and was supplemented with participant observations at meetings and workshops in order to serve as contextual background. The main data in this paper consists of interviews with project managers at STA. The BIM implementation process is analysed as a process of translation (Callon, 1984). This provides “a language to describe how, where and to what extent technology influences human behaviour” (Monteiro, 2000, 5). In this process, several policy documents were developed on how project managers were to procure BIM. These documents have also been analysed to give insight in the ways in which BIM has been translated at the STA.

To fulfil the aim of this paper, eight one-to-two hour semi-structured interviews with project managers at the STA have been performed. The interviewees are project managers for small to mid-sized projects. The project managers have been selected as individuals with no direct connection with the BIM initiative, instead only influenced by the new BIM policy documents. Focus during the interviews was on exploring how the BIM guidelines were interpreted when developing requirements in procurement.

FINDINGS

BIM Implementation Initiative at STA

Based on suggestions made in a Swedish government official report (SOU 2012:39), the general director of STA decided to implement BIM at the whole organization. This decision was made in 2013 and it resulted in the initiation of a BIM implementation project. This specific project had objectives to make STA more efficient and to insure that all project managers from 2015 onwards demand BIM when procuring.

Construction project managers at STA work as a link between STA and the construction industry. They have the responsibility to interpret specifications made by the planning and facilities management departments at STA and reformulate them into a request for proposal (RFP) document. Project managers use standardised procurement templates when reformulating specifications into RFP. The procurement templates include references to numerous guidance documents expressing further specifications on the project. This way, the guidance documents reflect STA policies on how projects shall be procured. Such policies relate to, for example, sustainability goals, worker safety etc.

A deliverable of the BIM implementation initiative is the creation of BIM-related guidance documents. These documents specify demands on BIM, demands which shall be included in the RFP when procuring projects. In June 2015, the procurement templates are updated to explicitly refer to two BIM related documents. These two documents are: The current procurement template (UB-mall 10.0, 2017), which specifies how information models shall be created in line with the demands for 'Object Oriented Information Model' (TDOK 2015:0181) and the 'Digital Project Management' (TDOK 2012:35). These two documents specify how digital models shall be produced and managed. They also specify other technical specifications, file-formats etc. Further, the documents specify that it is the main contractor who is responsible for the development of a coordinated information model, including all relevant project information. It is also specified that it is this model that shall be available for the client at project meetings. In addition, the supplier is responsible for designating a BIM coordinator to projects.

The Project Manager's Perception of Their Role in Procurement

The project manager's role at STA varies. A BIM expert linked to the BIM implementation project expressed that:

Project managers do not understand for what they should use BIM, therefore they exclude demands for BIM when procuring

Project managers are seen to have large degrees of freedom when formulating the RFP documents and therefore are able to exclude demands they find risky or costly for their respective projects.

A project manager describes the work as:

My task is to interpret the specifications made by the planning department; the planning department act as an internal client for me, and then I create the RFP documents. However, this is not as straight forward as it sounds, often planning is not sure what they want, and want to have help from suppliers to suggest a solution.

Due to uncertainty, RFP document are often developed in collaboration with suppliers, in what can be understood as a collaborative process. This makes the project process more efficient and saves time. This way of working has resulted in situations when the internal client's perception of what is procured does not always correspond to what is actually procured.

One of the project managers express that they are not well informed about the numerous references to the policy documents in the procurement templates. Another project manager explains this further:

There are a lot of 'TDOKs', however they are not always relevant for the specific project and I'm not knowledgeable in many of them.

To handle the circumstances in their respective project, project managers make individual adjustments to the procurement templates when creating RFP. It also happens that suppliers disregard requirements when bidding. A project manager explained:

Suppliers want to win the contract, therefore they to optimise their offer and disregard demands they know we often do not ask for, demands which are part of the standardised procurement template. It can be problematic in projects where we actually want to follow up on such demands.

As project managers do not prioritise all issues in the policy procurement templates, some issues are not followed up on and this is well known among suppliers.

Project managers often perceive BIM to be difficult to understand. Therefore, some of the project managers exclude parts or all references to BIM in their RFP:

The procurement templates currently say a lot about BIM, but I remove it. I don't know which demands to specify. I have far too little knowledge about BIM and did not know how to use it.

The role as change agent and innovation supporter is not prioritised by project managers themselves. A project manager explains why:

As project manager I'm evaluated on two main parameters: if the project is on time and within budget. I can see the point in promoting change from a client perspective, but I have too many things to take care of and not the right expertise to promote BIM

Several of the interviewed project managers also said that it was difficult to gain enough BIM-expertise in a project to be able to control and evaluate the BIM-use that was demanded in the BIM-guidance documents. Therefore, project managers found it hard to follow up on BIM demands, and this included BIM demands that included in the procurement process.

The project managers see a potential in BIM but at the same time they perceive they have a lack of BIM-competence. It also turns out that BIM is not something they want for their own projects. Instead, all of them claim that BIM is probably better in other projects with other characteristics.

My project is quite simple; we are building a relatively short railway passage enabling trains to meet. In more complex projects I definitely see the value in BIM but in my project, it is not needed, it would only increase the cost with no substantial gain.

DISCUSSION

STA is actively trying to influence the industry to use BIM. They do this by initiating a BIM implementation project and by establishing a BIM policy including a mandatory BIM requirement when procuring. In this process, STA aims to take on the role as change agent, or innovation champion (Kulatunga *et al.*, 2011) and influence the loosely coupled construction industry (Dubois and Gadde, 2002). STA is not a homogenous, but rather a complex client with several sub-organisations and departments, making both intra-organizational and inter-organizational change challenging. Implementing BIM, as a systemic innovation (Cao *et al.*, 2017), by establishing a demand for it in procurement, will not only influence the industry, but also the internal roles, processes and procedures at STA. Thus, translating BIM-use means translating it intra-organizationally (within STA) and inter-organizationally among a multitude of actors active in construction projects.

The strategy for implementing BIM, both inter- and intra-organizationally, has been the attempt to inscribe BIM-use as requirements in procurement templates. However,

earlier research has shown that there is currently no clear framework or support for procuring BIM (Porwal and Hewage, 2013). Instead, BIM is often viewed as an administrative issue and generally not the first priority for clients. Thus, specifying demands for BIM is not a trivial task but rather connected with several difficulties, further discussed by for example Holzer, (2011).

Earlier research has emphasised the role of systems integrators in the implementation of systemic innovations (Winch 1998). At STA, the system integrator role is given to the project managers procuring projects. This role is assigned by making changes to procurement templates and use of new policy documents, thus trying to inscribe (Monteiro, 2000) it into the project management process. The new and changed documents express how the project manager should include demands for BIM when preparing RFP documents. This strategy of implementing BIM-use assumes that the strength of inscriptions in guidance documents is strong enough to enrol project managers into the BIM Actor-Network. However, as Latour (1984, 269) explains: “The obedience to an order given by someone would require the alignment of all the people concerned by it”, as such a situation is very improbable, and orders are often modified as they are interpreted by the actors they are supposed to influence. As presented in the findings of this paper, this has happened in the translation of BIM. Project managers interpreted the intentions behind the BIM related inscriptions and try to adapt them to the circumstances in their projects.

When the BIM Initiative tried to inscribe the role of systems integrator into the project management system, what they actually tried to translate was the willingness to continue the translation of BIM. That is to say, the translation became sequential: first enrolling the project manager into understanding the importance and benefits of BIM-use and then making them continue the translation to the Actor-Network of their project. However, successful systems integrators have been shown to need several specific characteristics in their role. First they need to be convinced of the merits of the innovation (Winch, 1998), which the findings question as it is indicated that project managers perceive BIM as being connected with costs and risks to their project. Secondly systems integrators should be able to exercise the needed technical competence, however several project managers expressed that they did not have the needed expertise and how it was difficult to acquire BIM experts in projects. Further the findings of this paper indicate how project managers at STA primarily view BIM as an innovation relevant for other actors in the industry, not STA. Project managers view BIM as a tool, which can help actors in their projects given the right circumstances, in complex projects for example. The findings further shows how project managers view BIM as an innovation introducing new risks into projects (Porwal and Hewage, 2013), risks connected with extra costs (Vass and Karrbom Gustavsson, 2017).

By analysing how BIM is implemented at by STA, it is possible to study how a new and changed role is inscribed to influence project managers. However, findings argue for how these inscriptions have been lacking in strength and possessed too much flexibility. An open demand for BIM gives the project manager the ability to adapt its use to the specific circumstances in the project, which has been shown to be desirable for systems integrators (Singh, 2014). However, as several project managers have not been enrolled into the BIM Actor-network, this flexibility has been used to limit the inscription's influence over projects. While not being enrolled, project managers view new policies as guidelines which might be relevant but which can be disregarded based on the circumstances. Implementing policies through procurement is thus not

easy and seems to make project managers take on the role as involuntary policy implementers rather than engaged systems integrators.

CONCLUSION

Client organizations are argued to play a vital role in enhancing performance and increasing productivity in the construction industry. By using their influence, they are further argued to be able to take on the role of innovation champions and demand the use of systemic innovations such as BIM (Azhar, 2011; Elmualim and Gilder, 2014). However, this view disregards difficulties linked to procuring BIM which has been shown and it takes a clear departure in the diffusion model of innovation (e.g. Lee and Yu, 2015).

When analysed as a process of translation, the findings in this paper shows challenges in establishing demands for BIM in projects. The translation process has become sequential; first, trying to enrol project managers into taking on the role of systems integrators and then continue the translation of BIM in their projects. Trying to inscribe new demands for BIM into the templates used in procurement has been the main strategy in this translation process. However, the findings argue that the inscriptions have been too weak to enrol project managers into the BIM Actor-Network. Instead of taking on the role as system integrator and continue the translation of BIM, project manager has actively used the flexibility of the inscriptions to minimize or totally remove demands for BIM in procurement.

Degrees of freedom among project managers and a large amount of flexibility in inscriptions have made it possible for project managers to disregard the translation. The findings show how project managers are currently not enrolled into the BIM Actor-Network, therefore they use this freedom and flexibility not to benefit the BIM implementation but rather their interests in regard to project performance. In order to achieve better results in the translation of BIM, the strength of inscriptions needs to be increased, achieving more irreversibility in regards to BIM-usage and enrolling project managers to the BIM Actor-Network. Un-enrolled project managers take on the role of involuntary policy implementers, using the flexibility in the inscriptions to minimize the policy's influence on their project.

Findings contribute to research on BIM implementation, in particular on the need to better understand the role of the projects managers. In addition, this research also pinpoints the procurement process, more specifically the RFP, as important to BIM implementation and more research on procurement of BIM is needed.

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FROM AGENTS TO STEWARDS? EXPERIENCES FROM A DUTCH INFRASTRUCTURE CASE STUDY

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In the construction industry clients largely depend on contractors to deliver projects. According to agency theory problems of goal conflict and information asymmetry arise in this delegation of work because both the principal and the agent are self-interested. The control-oriented governance mechanisms that agency theorists propose as a means to resolve these problems can act counterproductive and give rise to new problems. Stewardship theory offers a counterweight to agency theory and assumes a relational reciprocity between the principal and the steward. Recently, a large group of Dutch public construction clients and contractors have collaboratively expressed their desire to improve their relationship in a manifest called 'the market vision'. This phenomenon can be interpreted as a desire to shift from a principal-agent towards a principal-steward relationship. The aim of this paper is to explore how public clients engage in stewardship relationships with contractors. This research is based on a case study of one of the most ambitious projects under the umbrella of this market vision trajectory. The analysis of the documents, observation notes and semi-structured interviews with project team members indicate that they developed a relationship which can be characterised as a principal-steward bond. By investing in relationship-building from the pre-commercial phase, throughout the tender phase and the execution phase, they put their individual differences aside in order to reach their initially defined common goal. It remains however to be seen whether this can be considered as a complete stewardship relation.

Keywords: agency theory, stewardship theory, public commissioning, partnering

INTRODUCTION

The construction industry is often criticized for its lack of cooperation, generating cost and quality problems. Especially in the public sector, the relationships between clients and contractors are said to be adversarial and competitive rather than cooperative. It is argued that traditional procurement procedures and contract forms discourage cooperation between those involved (Eriksson, 2008). In 2015, a large group of public clients, contractors and advisory firms in the Dutch construction industry collectively proposed a move towards cooperation in a manifest called 'the market vision'. In this manifest they expressed their dissatisfaction with current building practices and reported on a multitude of problems. Problems described include high transaction and procurement costs, misallocation of risks and liabilities, cost and time overruns and legal processes. Dominant in the manifest are the desire to focus on collective rather than individual goals and the wish to transform the current

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hierarchical client-contractor relationship into a relationship based on equality and complementarity. Even though in the market vision there are no explicit references made, the description of the current relationship seems to be based on agency theory and the desired relationship seems to hinge on stewardship theory. Whereas agency theory has been widely applied in construction management research, stewardship theory remains relatively underexposed in this domain. In the market vision, experimenting with and within actual projects is encouraged and the first initiatives have slowly started to unfold. However, the shift in the relationship seems to be a slow and cumbersome process and it is still unclear under what conditions this shift is most likely to happen. Therefore, in this paper the following question is addressed: how do public clients engage in stewardship relationships with contractors? To answer this question, first a theoretical elaboration of agency theory and stewardship theory is provided, which are in essence two contrasting perspectives on how to manage contractual relationships (Van Slyke, 2006). This exploratory research is based on a Dutch infrastructure case study under the umbrella of the market vision trajectory. Based on a qualitative data analysis of project-related documents, observations and semi-structured interviews with the project members the findings are presented. The procurement and project management implications are discussed in the conclusion.

THEORETICAL BACKGROUND

Agency Theory

Agency theory has its roots in economics and is based upon the key assumption that both the principal and the agent are self-interested. As the principal delegates work to the agent, he also delegates some of his responsibility. The agent is expected to act on behalf of the principal, however, the interests of the agent may conflict with those of the principal. In addition, the two parties have asymmetric information, so there the agent has a discretionary space in which to behave opportunistically. Adverse selection is a pre-contractual problem that arises in the selection of the agent and refers to "misrepresentation of ability by the agent" (Eisenhardt, 1989, 61). Moral hazard is a post-contractual problem that arises once the agent has been selected and refers to "the lack of effort of the agent" (Eisenhardt, 1989, 61). The principal has two options to curb the opportunism of the agent: investing in monitoring systems to discover the agent's actual behaviour or to contract on the outcomes of the agent's behaviour (Eisenhardt, 1989). As agents are assumed to be extrinsically motivated, these control mechanisms are focused on financial rewards or sanctions (Davis, Schoorman, and Donaldson, 1997).

In the context of construction, agency theory has been widely applied (Ceric, 2013). Winch (2010) specifically refers to the concepts of adverse selection and moral hazard and suggests procurement procedures to contest the former and complex contracts to counter the latter. In theory, a competitive tender can eliminate adverse selection, as "the buyer induces sellers to reveal their valuations of the contract so as to eliminate information asymmetries between buyers and sellers, so the buyer pays the lowest price to the most efficient seller" (Winch, 2010, 107). This is based upon the assumption that information is complete. However, in the competitive tendering of construction projects, information is incomplete. For example, clients are not fully aware of their requirements and contractors can interpret requirements ambiguously.

Agency theory has not been without criticism, because it is based upon a one-sided view of man (Davis *et al.*, 1997). Indeed, there are several extensions to agency theory, such as a relaxed assumption of goal conflict in situations where selfless rather

than self-interested behaviour is displayed (Eisenhardt, 1989). However, at the heart of agency theory remains self-interest and opportunism. The instruments proposed in agency theory to curb opportunism can also work out counterproductive, as they can lower the motivation of selfless delegates (Davis *et al.*, 1997). There is a need for additional theory that assumes intrinsic motivation of delegates as a starting point.

Stewardship Theory

Stewardship theory offers a counterweight to agency theory. Stewardship theory is based upon psychological and social insights. In contrast to agents, stewards value collective rather than individual goals and therefore behave in a cooperative manner. In stewardship theory a relational reciprocity between the principal and the steward is assumed (Davis *et al.*, 1997). The principal then uses mechanisms to facilitate and empower rather than to control the steward. As stewards are intrinsically motivated, these mechanisms are based on intangible rewards such as reputation, responsibility and autonomy, stability and tenure. Stewardship theory "relies significantly on the principal's and steward's initial trust disposition" (165), in which trust is described as "the willingness and risk of being vulnerable, on the part of both actors, to the possibility that one actor in the contract may pursue his/her own self-interest to the exclusion of the collectively agreed upon goals of the contract" (Van Slyke, 2006, 165).

Few studies have been conducted on stewardship theory in the construction industry. Snippert, Witteveen, Boes, and Voordijk (2015) identified barriers to realizing a stewardship relation between the public construction client and the contractor through the implementation of the Best Value approach. In a multiple case study of four projects of the Dutch Highways Agency, the interactions between the client and the contractor in the clarification phase of the Best Value Procurement were analysed from the perspectives of agency theory and stewardship theory. It was found that the observed behaviour could mainly be explained by agency theory. Snippert *et al.* (2015) observed a tendency of the project members to relapse into more control-oriented management styles, due to the traditional background of the project teams.

Davis *et al.*, (1997, 24) adopt a situational perspective on stewardship theory, arguing that it "was designed for researchers to examine situations in which executives as stewards are motivated to act in the best interests of their principals". The question is whether these situations (can) exist within the context of the public construction industry. Public procurement regulations are based on the principles of equal treatment, non-discrimination, proportionality and transparency, but inhibit the development of long term relationships between public clients and contractors over the course of multiple projects. This may not be a viable situation for a principal-steward relationship to develop between the client and the contractor, but no further research has been done on this topic. In this paper both theories are used to analyse this relationship.

METHODS

Research Approach

A single case study was considered to be the most suitable to answer the research questions, given the exploratory character of the research and the importance of the context in which the project is embedded. In a case study the researcher explores a bounded system "through detailed, in depth data collection involving multiple sources of information (...) and reports a case description and case-based themes" (Creswell,

2007, 79). The case that is studied is a pilot project of the Dutch Highways Agency. The philosophy behind the pilot came out of a session of the Dutch Public Client Forum in 2013 and was a reaction to the ongoing legalization in the industry. The director-general of the Dutch Highways Agency launched the pilot within his own organization and greatly supported it:

- All rules may be challenged, except for the law. Think outside of existing frames! Be open-minded, but not naïve (Director-General of the Dutch Highways Agency).

The renovation or replacement of a bridge, was later appointed to the pilot. A market consultation took place in June 2015 and the tender procedure comprising of four phases started in May 2016. In July 2017 the tender was awarded to a consortium of two middle-sized contractors (from here: the contractor). The construction activities on site started in September 2017 and the project is expected to be delivered in September 2018. The project budget is 12 million euros.

Data Collection and Analysis

Schillemans (2013) studied the principal-agent and principal-steward relationship between ministries and agencies. His operationalization of the theories is used as a basis for this research and translated to the context of public clients and contractors in construction and is presented in Table 1.

Table 1: Operationalization of agency and stewardship theory in the public construction context, based on Schillemans (2013).

	Agency theory	Stewardship theory
Selection of the contractor	Based on mitigating potential abuse of discretionary space of the contractor. Competitive tendering to align the various interests and to reach agreement through a contract.	Based on engaging with candidates that have maximally overlapping interests and goals.
Task specification	Based on a top-down approach in which the client writes down in a contract exactly what is expected of the contractor.	Developed conjointly, creating a shared perspective on goals and the implementation of tasks.
Monitoring	The contractor reports in detail so that the client can verify what has been done in practice.	The client trusts the contractor that its work and/or services are of high quality.
Incentives	Based on extrinsic motivation: financial incentives or expansion of tasks.	Based on self-actualization: verbal praise.
Relationship management	The formal contract is the main device, informal contact is avoided.	The relationship characterized by equivalence and collaboration.

The data used for this research were collected from documents, observations on site during the execution phase and semi-structured interviews with project team members. The documents are secondary data and include articles from the project's website, as well as the contract documents and tendering documents. The observations were made during the execution phase of the project in February and March 2018. In the observation period the researcher worked at the joint site office to have informal conversations with the project team members and to attend project team meetings. In that same period thirteen interviews took place with project members of the client and the contractor, including management and operations staff. The interviews were conducted face-to-face in a meeting room at the joint site office and lasted between 25 and 85 minutes. The interviews were recorded and transcribed verbatim. Documents, interview transcripts and observation notes were analysed using ATLAS.ti based on the analytical framework as depicted in Table 1.

FINDINGS

Selection of the Contractor

The client started the project with a market consultation in which the industry was invited to think about the procurement and contracting procedure. These procedures were then developed further in eight sessions with delegates of the sector's trade associations.

- We thought about eliminating the mechanisms that lead to undesirable behaviour, [...] opportunistic behaviour for example [...] everything that leads to a hassle after awarding (delegate of the contractors' trade association).

Because of the public character of the client and the budget of the project, the client was legally obliged to set up an open tender. Therefore, a competitive dialogue procedure was chosen, which suggests a rather traditional approach of contractor selection. However, the way in which the tender was designed and the selection criteria that were used, indicate that the project team of the client was actually opting for a more collaborative approach. In the first phase of the tender, the fifteen interested candidates were asked to hand in a vision document. The five teams that were selected proved to have the best fit with the pilot's philosophy.

The second phase of the tender consisted of a collaboration assessment, which was intended to find out which of the contractors' teams made the best 'match' with the client's team. This collaboration assessment was designed and judged by an independent party and lasted for five days in total; every day, the client's team paired up with a different contractor's team. The composed teams were invited to discuss a fictional case, were observed and then judged by the independent party. The assessments criteria were focused on the team's ability to take and bear joint responsibilities; the capacity for open communication, reflection and feedback; and having mutual respect and empathy. Three out of five candidates were selected.

In the third phase the final candidate was selected based on his plan of approach with regards to the interpretation of the customer's need, engineering, price and risk. In this project, the operator of the bridge was considered to be the customer. This phase ended with a provisional award. During the fourth phase the client and the contractor team worked collaboratively on the task specification and on the design. The final awarding criterion was the price, which was collectively developed and agreed upon by both parties based on the principle of "honest money for honest work". The whole procedure breath the wish of the client to engage with contractors with maximally overlapping interests.

Task Specification

The task was initially specified by the client in six relatively general functional requirements. The client required a safe bridge with a lifespan of 25-30 years, without the current restrictions for certain types of traffic, at least suitable for the current amount and type of traffic, connected to the existing abutments, foundations and movable bridge section, and completely available for all traffic at the end of Q3 2018.

During the fourth phase of the procurement procedure, the client-contractor team worked collaboratively on a more detailed task specification, for which they visited the customer (the operator of the bridge) and other stakeholders to collect their wishes and demands. The initial, rather general task specification was chosen to avoid misinterpretations of the requirements: from the customer to the client and from the client to the contractor.

- Normally we [the client] translate the customer's needs into requirements, and we put these requirements in the market. In this way, we generate information that is sensitive to misinterpretation: did we correctly understand the wishes of the client; did we translate them correctly into requirements [...] So now we said: we have to do this together (client).

The misinterpretation of requirements can result in disputes between the client and the contractor even after a project has been delivered, and this is something that the client specifically wanted to avoid in this project. The development of the more detailed task specification, collectively by the client and contractor, proved to be difficult. The wishes and demands of all stakeholders were supposed to be the direct input for the design, but the customer wasn't always able to clearly specify these. For some of the technical staff of the contractor, the lack of a detailed task specification was challenging to work with.

- That is difficult, because most designers would say, provide me with detailed requirements and then I'll make a drawing and a price and then we'll just start. And now it's all open for discussion, I have to consult the customer or a stakeholder, and that is something we are not used to as technicians. [...] They get stressed out because everything is open (contractor).

The client was also strongly involved in the design process of the client, which also took place during the fourth phase of the tender procedure. This proved to be challenging for the client as well as for the contractor.

- [The greatest challenge within the project was] making sure that we, as the client, had enough time to deliberate with the contractor. It's quite an intensive period, the design period. Usually we receive a document that we test within three weeks, and then we send it back. Now, we were a part of the design process and sometimes we had to make choices on the spot (client).
- They want to show, "we are not just the client, we also think with you about the plans". That was really contradictory, so designing took longer and when the designs were actually made, their comments did not really make sense, because of a lack of knowledge and experience. We [the client and the contractor] had built trust and maybe I should have pointed that out more: [...] maybe you just have to let go (contractor).

During the fourth phase of the tender, the client and the contractor wrote the contract together, in which they developed shared goals, made agreements on how to collaborate and how to deal with risks. The project team members refer to the contract as the "manual", as it lacks detailed specifications.

During the execution phase it became clear that this manual also has a downside; the lack of detailed specifications seems to have resulted in disputes between the (sub) contractors. The subcontractors were not involved in developing this manual.

- That fact that there is no [traditional] contract does create some fights [between the contractors and subcontractors]. [...] If it is not clear what you should and should not do, you try to transfer the costs to someone else. We are not the only ones who do that - contractor A and B also do that (subcontractor).

For this project, the task specification revolved around the development of a shared perspective of the client and contractor on goals and the implementation of tasks.

Monitoring

The Dutch Highways Agency has a standardized procedure to monitor the execution of the works. These procedures are based upon the principle of lawfulness. The contract management method that is normally applied by the client is based on remote

control and supervision. The project team deliberately chose to deviate from this method as it did not fit with the pilot's philosophy.

- The 'old' framework of contract management focuses on ensuring that the requirements of the contract are fulfilled. The contract management within this project focuses on achieving our collaboratively agreed upon principles, agreements, goals and customer value. In other words, do we jointly meet the obligation that we have made with each other and the customer? (contract management plan document).

To achieve this, the client and the contractor appointed one best-for-project contract manager, who is formally employed by the client, but is supposed to safeguard the interests of both the client and the contractor. In addition, the client and the contractor collaboratively check the quality of the work in the execution phase. The contract manager and an experienced advisor from the client's organization have a central role in this.

- Once or twice a week, he [the advisor] joins me to check the quality of the work or to see how the work is proceeding, to see if everything is going well; he also does this with the contractor (contract manager).

Based on these findings we can conclude that the client is checking the quality of the work of the contractor; even though they seem to trust the contractor and monitor the work collaboratively with the contractor.

Incentives

With the "honest money for honest work" principle from the fourth phase of the tender, the parties found a balance between the private interest of the contractor and the public interest of the client. The client explicitly did not want to work with a bonus-malus system, which was proposed by the contractor during the tender procedure, as it did not fit with the pilot's philosophy. By means of open cost estimates, the parties agreed upon a profit margin of 5% for the contractor: high enough to assure the contractor's continuity and low enough to assure the effective spending of tax money. The profit margin was then set absolutely based on the lump sum. Based on the documents, this was intended to cancel out conflicts that arise from the pressure on money. Within the contract the client and the contractor also agreed that wrong estimates would not be compensated for, to incentivize optimization of the scope. However, the "honest money for honest work" principle now greatly relies on the reliability of the estimates made, and it is not sure whether this collective interest will be served.

- During the calculations phase we made a calculation of how fast it [applying concrete] would go, so the production is based upon that estimate. And we don't really make it. [...] We have to have longer shifts with more people, and there we are making a loss (subcontractor).

No further incentives structures were found in the data and it is unclear to what types of incentives the project members (would) respond. However, the interviews indicate that there seems to be a distinction between the drivers of the management team and the drivers of the operations staff. The management staff of the client and the contractor is clearly driven by the collective interest and the pilot philosophy of "doing things better in the industry".

- I am driven by wanting to do things better [in the industry] (management team member of the contractor).
- I like to find out how we can do things differently, and better. I believe that by working together, we can achieve more (management team member of the client).

Most of the operations staff is driven by "delivering a good project", meaning best-for-project but also best serving the interest of the contractor.

- Sometimes they [the management team] discuss something that doesn't land with the operations team, because they [the operations team] just want to produce and make money... and that gap, I really notice, that is real (contractor).
- I am driven by trying to do the work as efficiently and as profitable as possible. [...] That drives me in all projects: trying to make a profit for the firm (subcontractor).

This could be a result of the selection of project members: for the management staff, a fit with the pilot's philosophy considered very important and was also in important criteria to be a part of the project team. The operations staff was mainly selected because there was a position to fill, a deadline to catch or work to finish.

The client tried to eliminate financial incentives in the project and engaged with an intrinsically motivated team of the contractor in the procurement phase. However, in the execution phase the rationale of the contractor to make a profit is still apparent.

Relationship Management

During the fourth phase of the tender, the client and the contractor started working together in one office. At the start of the execution phase they moved to a joint office on site in which all facilities are shared. During the observation period the project members frequently discussed work matters informally, lunched together, and had transparent meetings with one another.

- What I notice here: we share everything quickly. We don't keep anything to ourselves. We do not discuss a certain strategy or tactic, we just share it (contractor).

The client and the contractor think of themselves as equivalent; they do have different roles but their relationship is non-hierarchical. In the interviews the respondents all underline that the contact, and not the contract, is the focus point. However, the contract was important to make clear agreements between the parties and is sometimes referred to when unexpected events occur.

- I think that the contract that we made helps us. Especially in the process of deviations from the work. We have made very clear agreements about how we deal with this. That helps a lot. [...] The meetings go smoothly because the agreements were clear in advance and we can use them well (client).

So far, there have been some incidents that could have caused conflict between the client and the contractor as they put pressure on the deadline, such as delays as a result of asbestos and cold weather. In these situations, the project members feel the tendency to relapse into "old behaviour", but so far have managed to refrain from it.

- In the end, we had weeks of delay. Then we were challenged, because there are two interests: on the one hand it is meeting the deadline, and on the other hand it should not cost too much, because then I will leave this project empty-handed. [...] In such a situation, it is important that you find a solution together that suits everyone. That was the first big challenge we encountered. Realizing: what is my behaviour? What is expected of me? And how do I have such a conversation? (contractor).

The client and contractor have different roles but think of themselves as equivalent; their relationship is not hierarchical. The team does however, have formal meetings and sometimes uses the contract, even though it is not the main device.

DISCUSSION

The findings of the research, as depicted in Table 2, indicate that the relationship that was developed between the client and the contractor in the project contains elements of both agency and stewardship theory.

Table 2: Overview of the research findings

	Findings and their relations to agency or stewardship theory
Selection of the contractor	Based on a competitive dialogue procedure (agency theory) because of the public character of the client. However, aimed at engaging with candidates that have maximally overlapping interests and goals and finding the best partner to collaborate with (stewardship theory).
Task specification	First specified in six general requirements; then developed conjointly in the tender phase and collectively written down in a contract, creating a shared perspective on goals and the implementation of tasks (stewardship theory).
Monitoring	The client is checking the quality of the work of the contractor (agency theory); even though they seem to trust the contractor and monitor the work collaboratively with the contractor (stewardship theory).
Incentives	The client tried to eliminate financial incentives in the project and engaged with an intrinsically motivated team of the contractor in the procurement phase (stewardship theory); however, in the execution phase the rationale of the contractor to make a profit is still apparent (agency theory).
Relationship management	The client and contractor have different roles but think of themselves as equivalent; their relationship is non-hierarchical (stewardship theory). However, the team does have formal meetings and sometimes uses the contract, even though it is not the main device (agency theory).

The project team of the client tried to facilitate a principal-steward relationship between the client and the contractor in all phases of the project. The foundation of this relationship was mostly laid in the procurement phase. The selection of the contractor was designed to engage with candidates with maximally overlapping interests and to further develop the rather general task specification with the contractor. The client was, however, obliged due to its public character and the size of the project, to competitively tender the project. Snippert *et al.*, (2015) found that the project members tend to relapse into more control-oriented management styles due to their traditional background, therefore inhibiting the development of a stewardship relationship between the client and contractor. The project team in this case study had little prior project experience and also deliberately wanted to develop a non-hierarchical client-contractor relationship that revolved around shared goals. In the execution phase this relationship was maintained by working together in the project site office and by collectively checking the quality of the work. However, the client team still wanted to monitor the work during construction and the contract was also sometimes referred to. In addition, even though the rationale of the contractor to make a profit was not on the foreground, it was still apparent in this project. Reflecting on the situational perspective of Davis *et al.*, (1997) on stewardship theory, the client team tried to create a "situation" in which the contractor was motivated to act in the best interest of the client. Due to the public obligations of the client and the private interests of the contractor, a situation was created in which a hybrid client-contractor relationship was developed.

CONCLUSION

Stewardship theory has offered a new lens to describe the relationship between public clients and contractors and has the potential to enrich construction management research. Public clients can engage in stewardship relationships with contractors by

selecting candidates in the procurement phase that have maximally overlapping interests and by collaboratively developing the task specification. To maintain this relationship in the execution phase, the client and contractor should be actively involved in each other's processes. In our specific case individual differences were put beside in order to reach their initially defined common goal. Hence, our findings also indicate that a true stewardship relationship between public clients and the contractors might not be suitable, feasible or even desirable for all construction projects. As the foundation for this relationship is laid in the procurement phase, public clients have an important role in laying down this governance structure. However, this type of relationship should also be governed appropriately by the project managers of both the client and the contractor, with special care to not relapse into the more traditional principal-agent behaviour. Further research is required to study the development of this relationship and its implications.

This research is based upon a single case study of a Dutch pilot project, which has its limitations. This project is very exposed in the media and the project members have also indicated that this results in a wish to actually make the project successful. Furthermore, observations were only done during the execution phase; the data collected about the previous phases entirely relies on documents and interviews and therefore remains retrospective.

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CLIENT STRATEGIES FOR STIMULATING INNOVATION IN CONSTRUCTION

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The construction industry is often described as a fragmented, loosely coupled industry, slow to innovate and lacking in productivity. In order to address these issues, the role of client organizations is commonly acknowledged as a key actor for change. However, what this role constitutes of is less clear e.g. questions arise such as: should innovation be mainly supplier-led or client-led? The aim of the research is to explore different strategies clients can adapt in realizing innovation in transportation infrastructure. The method used to fulfil the aim can be described as a case study performed at the Sweden's largest transportation infrastructure client, exploring two strategies deployed simultaneously to stimulate innovation. The organization is on the one hand trying to stimulate innovation through providing more flexibility in projects, enabling suppliers to propose new solutions and emphasising competition on the market; while on the other hand, found in the implementation of Building Information Modelling (BIM), the client is trying to dictate demands and actively influencing the supply chain, which builds on innovation being actively led by the client. Although the strategies essentially deal with different types of innovation, either a known innovation in the case of BIM, or an unknown innovation for the client organization; the research finds that the simultaneous use of both these strategies has created tensions within the organization, causing the favouring of one strategy over the other. The findings provide insights in different strategies clients can use in order to stimulate innovation.

Keywords: client, fragmentation, innovation, integration

INTRODUCTION

Fragmentation is a multifaceted concept and it has been suggested to hamper innovation and performance in the construction industry (Dulaimi *et al.*, 2002). In the construction industry, for example, fragmentation of actors involved in construction projects threatens incentive chains for innovation (Winch 1998) and fragmented project teams raises concerns of liability and risk in implementing product innovations (Rose and Manley 2014). While fragmentation of the production process hampers transferring knowledge between actors involved in different stages (Dubois and Gadde 2002; Rose and Manley 2014), and supposedly creates barriers for coordinating innovation efforts (Dulaimi *et al.*, 2002). Thus, fragmentation has received a somewhat bad reputation, something the industry should aim to reduce by

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emphasizing more integrated processes in construction projects (Blayse and Manley 2004). However, as Fellows and Liu (2012) states, fragmentation is simply the consequence of differentiation and high degree of specialization among actors in an industry, two words with far more positive associations.

Innovation in construction typically happens in projects (Harty 2008; Winch 1998), Harty (2008) suggest that the dominant model of innovation in construction is that it either happens in response to client needs or by implementing innovation originating from elsewhere; similar to a technology-push and demand-pull model of innovation (cf. Bygballe and Ingemansson 2011; Loosemore 2015). Bygballe and Ingemansson (2011) further elaborates on the implications of such 'push-and-pull' model and suggest that in such market-based view of innovation, innovation is mainly driven by the forces of price and demand. But such 'push-and-pull' model does not seem to fit well in how innovation is developed in construction, since much of the innovative activity is happening in projects, in response to problems (cf. Harty 2008; Loosemore 2015); thus, some researchers have argued that this creates a need for interaction among organizations for innovation to happen, viewing innovation as something that is co-created, requiring interaction and cooperation among actors (cf. Bygballe and Ingemansson 2011; Loosemore 2015). In a similar vein, Harty (2008) suggested that the relatively unboundedness of innovation in construction i.e. the effects of an innovation extends beyond the implementer, creates a need for cooperation or alignment of multiple actors across different organizations in order for innovation to be successfully implemented. Although the strong emphasis on cooperation- and collaboration efforts in much research, Dubois and Gadde (2002) suggest that there exist two camps prescribing two different solutions on the assumed poor performance of the industry: either a focus on competition or on cooperation to increase the performance of the construction industry.

Clients are often acknowledged as playing a key role in creating the right conditions for innovation in construction (Blayse and Manley 2004; Bygballe and Ingemansson 2011; Loosemore 2015; Winch 1998). However, research has reported and suggested several different roles clients could enact to support innovation. Some research has indicated that clients might be in a particular good position to facilitate cooperation and coordination in projects, for example Nam and Tatum (1997) emphasized clients' active involvement in projects, showing commitment and leadership in projects; and Kulatunga *et al.*, (2011) suggest that client's influence can decrease the fragmentation of different stakeholders and facilitate innovation activities. However, in Bygballe and Ingemansson's (2011) study on public policy and innovation in the Swedish and Norwegian construction industries, they suggest that the principal effort clients had made to support innovation is through emphasizing competition. They further suggest that such view of innovation being developed by a single actor fails to address the interdependencies and interaction among actors that requires attention for innovation to be implemented in construction projects.

In Sweden, the Swedish Transportation Administration (STA) is the client organization responsible for investment and maintenance of state transportation infrastructure. The STA have through government directives the explicit mission to stimulate and facilitate for increased productivity and innovation in Sweden's transportation infrastructure industry (cf. SFS 2010:185). Based on this mission, the STA has initiated several initiatives to support innovation and change within the industry. Among these, is one initiative communicated as the 'professional client', which incorporates efforts in order to adopt the client role necessary to facilitate for

supplier-led innovation in the industry. This ‘new’ role entails giving more responsibilities to the suppliers performing the design and production of the construction projects and promoting competition on the market. Furthermore, the STA has also adopted an initiative to support the implementation of BIM in the Swedish transportation infrastructure industry by actively demanding BIM use in projects. Previous research studying the BIM initiative at the STA has highlighted the difficulties for clients to act as change agents and highlighted the existence of various degrees of intra-organizational acceptance of the BIM initiative (Lindblad and Karrbom Gustavsson 2017). These two initiatives seem to build on two different ideas about the client role in stimulating innovation and change in the industry, either emphasizing competition or a more demanding role of change in a specific direction.

The aim of this paper is to explore the client role in stimulating innovation in the construction industry, more specifically by presenting findings addressing the STA's initiatives to on the one hand facilitate supplier-led innovation and on the other hand to demand BIM in projects. The objectives are; to present the rationale behind these two initiatives; to analyse the strategic implications of the two initiatives at the STA; and to discuss how the two strategies interact with each other.

Client Role in Construction Innovation

Construction innovation distinguishes itself from other fields in which innovation takes place, generally because constructed facilities are large, complex, long lasting and is developed by a temporary project team with various disciplines (Slaughter 1998). All types of innovation in construction are not equal, and therefore present different opportunities and require different actions in order to be successfully implemented. Slaughter (1998) presents a set of innovation models which organizes types of innovation based on, the magnitude of change and the expected linkages between the innovation and other components in the system. For example, the incremental innovation, providing small improvements to isolated components; and the system innovation, influencing most, if not all components in the system which is a construction project or even the projects entire lifecycle (ibid). System innovations can be understood as “a situation where an innovation system goes beyond the boundaries of a single organization, and multiple innovations need to be co-ordinated” (Midgley and Lindhult 2017: 2). In contrast to the simple incremental innovation that requires only a small change (Slaughter 1998), system innovations require coordination between different actors (Taylor and Levitt 2004).

As one of the currently most discussed innovations in construction, BIM has been described as a typical systemic innovation (Cao *et al.*, 2017). From the perspective of innovation models described by Slaughter (1998), this understanding provides insight in how BIM can influence different actors in a project. The role of public client organizations is emphasized for implementation of systemic innovation and often described as critical for BIM implementation (Azhar 2011; Smith 2014). The client organization has also been found to be able to benefit from a diffusion of the systemic innovation even when without a direct need for systemic innovation, as this diffusion might fulfil other client needs (Singh 2014). Client organizations has also been described as ‘innovation champions’, able to support the diffusion of the innovation by establishing a supportive environment through promotions, incentives regulation and guidelines (Kulatunga *et al.*, 2011; Singh 2014).

The client representatives in projects, often the project manager, have also been found to play an important role in the implementation of systemic innovation. This

individual is described as a 'systems integrator' (Winch 1998; Tylor and Levitt 2004). However, in order for the 'systems integrator' to be successful, they need to be convinced of the merits of the innovation and have the necessary skills to integrate the specific innovation in the system (Nam and Tatum 1997; Winch 1998). Slaughter (1998: 228) argues that these individuals have to be "able to exercise the technical competence and project responsibility and control to achieve coordination cooperation across the system(s)". Without these prerequisites, implementation will be slow or not taking place at all. Therefore, Winch (1998) and Slaughter (1998) emphasise the importance of 'systems integrators' in mediating the implementation of systemic innovation. How large degrees of freedom various actors have in relation to the implementation of systemic innovation have also been found to be a relevant factor in the implementation process. For 'systems integrators', large degrees of freedom have been found to be desirable as it enables adaption to the preconditions in the specific case (Singh 2014). For other actors influenced by the systemic innovation, large degrees of freedom are un-desirable from an innovation diffusion standpoint as it may enable actors to disregard the implementation process.

METHOD

The aim of the research presented in this paper is met by adopting a case study approach, assessing how the STA tries to stimulate innovation, more specifically the two initiatives: 'professional client'- and 'BIM' initiative have been explored. The two initiatives serve as empirical examples of innovation promoting actions with resulting strategies to support innovation in the industry. The two initiatives have been developed in coexistence and demonstrate different understandings of the client role in stimulating innovation in construction and expose how these two initiatives interact with each other. Even though the actions taken in the two initiatives are very different, their objectives are similar, supporting innovation. BIM is in this paper viewed as a specific systemic innovation. Thus, STA's strategic efforts to implement BIM, following the BIM initiative, are viewed as an innovation strategy; whereas, the strategic efforts to stimulate innovation in the industry in line with the 'professional client' initiative are viewed as an alternative innovation strategy.

The empirical material presented in this paper is the result from joining two research projects (Project A and Project B). Each project was independently led by one of the two authors of this paper and was conducted at the STA. The main purpose of Project A was to explore the project manager role at the STA to support supplier-led innovation. Whereas the main purpose of Project B was to investigate STA's efforts to support implementation of BIM in the Swedish transportation infrastructure industry. The aggregated empirical material presented in this paper is extracted from these two research projects.

Data in Project A was collected during 2017-2018 and includes official reports, internal documents and interviews. Fourteen semi-structured interviews were held with project managers at the STA, ranging between 1-2 hours. Official reports and internal documents were used to understand the rationale behind STA's 'professional client' initiative and how it is understood to support innovation. Data from the interviews, official documents and internal documents were used to understand the strategic implications of the STA's initiative to support innovation.

Data in Project B was collected during 2013-2018 and includes official reports, internal documents, interviews, observations of 2 workshops and 8 meeting where the development of new BIM related documents were discussed. A total of 28, 1-2 hours,

semi-structured interviews were conducted with project managers, BIM-coordinators and participants in the BIM implementation project. Interviews with BIM-coordinators, official reports and internal documents were used to describe the rationale of STA's initiative to support implementation of BIM in the industry. The data extracted from the interviews and internal documents was used to understand the strategic implications of the STA's policies to implement BIM at the STA. Furthermore, data from interviews, observations from meetings and workshops from Project B were used to understand how the BIM initiative interact with perceptions of the client role based on the strategic implications of the 'professional client' initiative.

Findings are discussed to illuminate different roles clients can take in stimulating innovation in transportation infrastructure. Further, the underlying arguments behind the two innovation initiatives have been evaluated as well as exploring how the two initiatives interact and influence each other.

FINDINGS

The Professional Client Initiative

The STA was founded by merging two public agencies responsible for road- and railway infrastructure separately. Since the merger, the STA has started an initiative to define their role as a client, which has been communicated both internally and externally as becoming a 'professional client'. According to government directives, stating the mission of the agencies, it explicitly states that STA has the mission to increase productivity and innovation on the Swedish market for infrastructure investments (SFS 2010:185). From STA's official website (retrieved in February 2018) it is communicated that the purpose of the 'professional client' initiative can be broken down to four main purposes which are; increase (1) innovation-, (2) productivity-, and (3) competition on the market, and, (4) clearly defined roles of the STA and its suppliers. Clearly defined roles is communicated as the STA should aim to assign more responsibility to suppliers for developing infrastructure project while STA's role is to purchase their services and govern the development of the projects. In interviews with project managers at the STA, their description of their role to support innovation was coherent with the communicated 'professional client'. The project managers explained their role to stimulate innovation as to open up for the possibility for the market to come up with new solution, as one project manager defined the STA's role to support innovation: "Our role is to provide freedom to our suppliers through our contracts, that allows them to come up with their own solutions".

This new role is realized by three main strategic principles according to STA's official website. First principle, the client has strategically aimed at increasing fixed-price commissions to consultants responsible for the early design-phases of investment projects. This has been communicated with a strategic goal of at least 40% by 2018. From interviews with project managers, it was understood that they should aim at having fixed-price. The reason of using fixed-price is maybe best illustrated by one of the project manager's elaboration of the rationale and benefits of using fixed-price: "In these relatively complex projects with a lot of technicians you need a lot of coordination in the project team... by using fixed-price the consultant is responsible for this coordination and thus has incentives to work as efficient as possible... Another benefit is that the STA has to define the initial project mission more clearly and thus prepare the project more competently".

Second principle, the STA has strategically been working toward increasing Design Build (DB) contracts, stated once as a goal that at least 50% of the procured volume should be by DB contracts. The interviewed project managers were generally in agreement that using DB contracts is the way to go in order to facilitate for innovation, one project manager stated “in a DB contract you always leave the contractor with more possibilities [compared to a Design Bid Build contract] to make their own decisions”.

Third principle, to favour the use of performance-based specifications in the contracts instead of using detailed technical solutions. The idea by using performance-based specifications is to allow the contractor to come up with their own solution, thus, using contractors' expertise instead of dictating and prescribing solutions in the contracts. From the interviews, most project managers emphasized the use of performance-based specifications as one of the main principles to facilitate for supplier-led innovation. By using performance-based specifications, the project managers suggested this would give contractors the possibility to come up with new innovative solutions, one project manager stated “if I have performance-based specifications it is up to the contractor to come up with the innovation, you give the possibility to the market to come with their own solution”.

The BIM Initiative

At the time the STA was founded, a couple of project managers got interested in the new innovation of BIM. These project managers tried out the technology in their projects and group themselves into a BIM-network to exchange experiences and improve their BIM competence. The BIM-network later influenced the outcomes in a Swedish government official report, which expressed suggestions of how the STA could improve productivity and drive innovation in the construction industry (SOU 2012:39). In the official report, the possibilities with the BIM technology are presented and suggestions are made in regard to how the STA should work towards implementing BIM in the infrastructure industry. Based on the suggestions in the official report, the general director at the STA made a formal decision to implement BIM in the whole client organization. This decision was made in 2013 and follows the same rationale as in the official report i.e. STA should implement BIM to increase efficiency and productivity both internally and the infrastructure industry.

After the general director's decision, the BIM issue gained legitimacy at the STA and a BIM-implementation project was started. Fourteen individuals from various departments at the STA were involved in this project and it was conducted until late 2014. As per the project specification, the BIM-implementation project's objectives were outlined as follows: BIM shall be used by all infrastructure projects to some extent from 2015 and onwards; make the client organization more efficient; establish the organization as a professional client procuring BIM in both design and production.

At its conclusion the BIM-implementation project delivered a handful of new- and developed documents specifying the use of BIM models in projects. Among these was a new BIM strategy for the STA in which BIM is described as: “the use of information models in a linked information flow through the work processes relating to buildings and other facilities” (TDOK 2013:0688, 1). Further, new guidance documents were created, specifying the creation and maintenance of models throughout the project process. Together with an updated version of procurement templates these new guidance documents specifies how projects should be procured using BIM-models, thereby establishing a demand for BIM-use among project

participants. More specifically, the new procurement template demands the delivery of coordinated BIM models as a deliverable from the main contractor. This is in turn expected to incentivise the main contractor to work collaboratively with other actors in the project using BIM-centric work practices.

After the completion of the BIM-implementation project, the BIM implementation has been continued in other forms at the STA. The guidance documents and procurement templates have been continuously updated to better support the change towards BIM. However, several interviews with project managers at the STA have shown how project managers have large degrees of freedom when they specify procurement documents in their projects. Thereby project managers have a large opportunity to choose which parts of BIM to include in the procurement in their specific project, resulting in a situation where BIM is currently implemented to varying degrees in different projects. The main purpose of promoting BIM-use as described in the official report (SOU 2012:39), for the client to act as an innovation champion of BIM, has therefore been problematic to achieve.

When the new BIM guidance documents were implemented several problems arose. According to the individual responsible for implementing the documents into one of STA's departments, the guidelines and demands specified in relation to BIM was perceived to be in conflict with other policies. Mainly the problems were perceived to arise from the limitations presented by the 'professional client' initiative. The issue of how the people responsible for the BIM initiative perceived the limitations established by the 'professional client' initiative and how these could be circumvented was discussed at length at several meetings linked to the BIM implementation project and in following development of BIM related documents. Actors within the BIM-implementation project expressed that by limiting the demands to performance-based specifications; it was not possible for the BIM initiative to specify demands for BIM-centric work practices. Thus, in order for the new BIM guidance documents to be implemented, changes had to be made in the guidance documents. All demands for specific work practices were removed to be in line with the directives dictated by the 'professional client' initiative. Instead the documents focused on establishing incentives for projects' participants to work collaboratively with BIM. This was mainly achieved by demanding a 'coordinated information model' from the main contractor. The proposed model (or models) should include all project related information and should be made available at project meetings throughout the project. This demand was intended to incentivise the main contractor to lead the BIM implementation in their project, as it is expected to be simpler and cheaper to create such models when working collaboratively in the project coalition rather than create them before each meeting. Thus, the 'professional client' initiative directly influenced the actions taken in the BIM implementation. Among the individuals leading the BIM implementation these limitations were seen as problematic and hindering in the process of influencing the industry to change towards BIM-usage.

DISCUSSION

Public client organizations are widely discussed in terms of their role in supporting innovation in the construction industry. The specific client organization this paper builds upon has undertaken two initiatives to influence and stimulate innovation in the industry, initiatives following two different innovation strategies: 'supplier-led' and 'client-led' innovation.

The communicated purpose of the ‘professional client’ initiative is explicitly stated to increase competition, innovation and productivity by giving more responsibilities to their suppliers. The strategic efforts within the ‘professional client’ initiative, what we call a ‘supplier-led’ innovation strategy, is mainly through competition, more specifically through: emphasizing fixed-price commissions of consultants; giving more responsibility to contractors by promoting DB contracts, and; performance-based specifications. Bygballe and Ingemansson (2011) concluded that public policy in Sweden tend to view innovation as a being achieved through competition between single actors, mainly through the mechanisms of “push-and-pull”. Our results indicate that this view is prevalent at the STA, these results may not be so surprising since the studied client organization to a large extent is guided by the reports Bygballe and Ingemansson (2011) based their conclusions on.

The other studied innovation initiative, the ‘BIM’ initiative, was developed to increase efficiency and productivity, thereby sharing the same underlying rationale as the ‘professional client’ initiative. However, BIM is by itself an example of a systemic innovation (Cao *et al.*, 2017), and is understood to require changes among all actors linked to a construction project. The strategic efforts of implementing BIM, the ‘client-led’ innovation strategy, entails actions to directly influence industry actors to change towards BIM-centric work practices. These strategic implications of the ‘BIM’ initiative is directly in line with earlier research which has argued that clients can act as innovation facilitators by demanding innovation (Loosemore and Richard 2015) and support innovation (Gambatese and Hallowell 2011).

Findings suggest that the focus of giving more responsibility to suppliers in the contracts by using performance-based specifications in accordance to the ‘supplier-led’ innovation strategy was seen as problematic and even in conflict with the desired client role in the BIM implementation project. The ‘professional client’ initiative was perceived to weakened STA’s ability to dictate and demand the solutions they want in their contracts; thus, limiting efforts to implement BIM. BIM is described as a typical systemic innovation (Cao *et al.*, 2017), and the client's demands are argued as one of the most important aspects in implementation of BIM or other systemic innovations in construction projects (Azhar 2011; Smith 2014). Although the benefits of clients using performance-based specifications are lauded by researchers as a means to facilitate innovation (cf. Blayse and Manley 2004; Loosemore and Richard 2015; Rose and Manley 2014), our findings suggest that the dominant rationale of the STA to emphasize a ‘supplier-led’ innovation- rather than ‘client-led’ innovation strategy seemed to hamper effort to facilitate and drive complex innovations that BIM is an example of. Whereas researchers have emphasized clients' active involvement, commitment and leadership facilitates and may even drive innovation (Kulatunga *et al.*, 2011; Loosemore and Richard 2015; Nam and Tatum 1997), our findings suggest that such efforts are restricted in favour of the ‘supplier-led’ innovation strategy.

Findings from interviews with project managers suggest great individual variations in how and to what degree BIM is implemented in STA's project. One potential explanation is that the lack of clear demands in STA's guidelines to implement BIM has led to high degree of flexibility to individual client project managers to dictate the use of BIM in their projects. In a similar vein, Nam and Tatum (1997) suggest in their study of innovations in ten projects, that every observed account of innovation implementation seemed to be very dependent on individuals with competence and authority. However, as individual dependence certainly can create novel solutions and drive innovation, it may prevent the implementation throughout an organization.

Even though the motives behind the two initiatives are similar, improving efficiency and productivity in the construction industry, the actions taken to reach this objective is very different. The ‘professional client’ initiative is aiming to stimulate industry actors to propose and use innovative solutions in projects, innovations unknown to the STA. Whereas the BIM initiative takes its departure from a known innovation, which the STA wants industry actors to adopt. This difference has given rise to two separate client strategies for stimulating innovation and highlights two different roles client organizations can enact to stimulate innovation in transportation infrastructure. Findings suggest that the difference between the two innovation strategies has given rise to intra-organizational tension when they are applied simultaneously.

CONCLUSION

The two initiatives presented in this paper reveal two examples of how a public client organization has worked strategically to influence and stimulate innovation in the transportation infrastructure industry. The two strategies deployed by the client are either to: give more responsibilities to suppliers in order to enable suppliers to propose innovative solutions; or to demand the use of a specific innovation, thereby ensuring its use. The differences between the innovation strategies have led to organizational tension as it has been difficult to apply them simultaneously, especially when referring to the same innovation. However, the findings display how the two innovation strategies relate to very different types of innovations. Either the innovation is unknown and the innovation process is initiated by the supplier, or there is a specific, in the studied case a systemic innovation, which is requested by the client. Because of the difference in innovation sought, the strategies do not have to hinder each other. The ‘supplier-led’ innovation strategy can be applied in order to establish an environment where industry actors are able to find the best solution to the client's performance-based specifications, taking advantage of the fragmented nature of the construction industry and the competitive environment it brings; whereas in case of a ‘client-led’ innovation strategy, the client can influence the industry in a specific direction, enhance collaboration between actors to ensure change in a sought after direction. However, as the findings shows how ‘supplier-led’ innovation limits the actions in the ‘client-led’ innovation strategy, this paper argues for a more flexible approach towards the role of the client in stimulating innovation in transportation infrastructure and hence choice of innovation strategy. Instead of consistently choosing one, client organizations could make use of both innovation strategies depending on the type of innovation they seek to stimulate.

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MANAGING RISK AND UNCERTAINTY IN SUSTAINABLE CONSTRUCTION INNOVATION: THE ROLE OF THE PARTNERING CONTRACT

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Drawing upon actor-network theory and the related concepts framing/overflowing by Michel Callon, the present work aims to explore the role of the partnering contract in construction. The method used is a case study of the design and construction of an innovative cross-laminated timber campus building in Inland Norway. The contract unexpectedly became a conduit of overflow as it delimited the action space for joint exploration, undermined trust and collaboration, shaped and triggered guarding behaviors, self-interest, controversy and prolonged negotiations over construction design, responsibility and distribution of unexpected costs. This, in turn, spilled over and challenged the project's innovative sustainability ambition. The conclusion is that the partnering contract did not stay faithful to its expected collaborative and innovative role. When used in practice, the contract also played a more hybrid, surprising and unfaithful role because it added new unexpected uncertainties, risks and costs.

Keywords: partnering contract, trust, risk management, actor-network theory

INTRODUCTION

Partnering has been widely considered as a solution to poor project performance, with expected benefits for efficiency, quality and innovation. Yet, in practice it appears to be a mixed blessing. As Alderman and Ivory (2007) note, although partnering is supposed to be about sharing benefits from joint collaboration, it can also be a “smokescreen” for doing business as usual” (392). In practice, partnering is not without paradoxes, and the construction industry appears to have more than its fair share of mixed experiences (Wood and Ellis, 2005; Bygballe, Jahre and Swärd, 2010; Gadde and Dubois, 2010). Cheung, Ng, Wong and Suen (2003) identified the main problem as the client's unwillingness “to fully commit to the partnering agreement” (255). Partnering is a trust-based contractual relationship, as also pointed out by Wamuziri and Seywright (2005). The authors are also considering risk sharing in such collaborative arrangements, and mention client's use of formal risk register in the bidding process. Larya and Hughes (2008) note a proliferation of such formal analytical risk management models for assessing contractors' risks in pricing bids.

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Yet, the authors also note that these models are rarely used and calls for more ethnographic research into the actual practice of risk management and with what effects for the construction project. According to the authors' own empirical investigations, a range of issues might be at play such as tensions between underestimated costs ex-ante and true costs ex-post, and further issues regarding costing/pricing and trust between client and contractor. The literatures recognize trust building and risk sharing as important aspects of the partnering arrangement (Crespin-Mazet, Havenvid and Linné, 2015; Cheung *et al.*, 2003) and as an important factor in achieving project goals regarding cost efficiency and quality. Although the extant literature report from several cases about partnering in construction, it appears to be relatively few studies that consider the risk management practices as the events of the construction project unfold and the contracting partners interact. How the partnering arrangement translates into management and sharing of risks and benefits is not very well researched. This raises a more general question about the role and usefulness of the partnering contract. More specifically, our research question is: what role does the partnering contract play during a construction project in managing risks and in facilitating or hindering innovation, trust and collaboration?

To address this question we have investigated a case, Evenstad Campus in Hedmark County, Norway. The project used a partnering contract (called 'samspillskontrakt' in Norwegian). The project ambition was high in terms of innovation, i.e. to accomplish "the world's most sustainable building". The project is also knowledge intensive, i.e. being involved in the research effort "Center on Zero Emission Neighborhoods in Smart Cities - ZEN Centers".

The Concepts of Risk, Uncertainty and Trust

The terms risk and uncertainty are often used interchangeably in everyday language, but there is also a debate among scholars regarding their theoretical connotations and whether the two terms should be distinguished from each other or not. Already in 1921, Frank Knight conceptualized the difference between risk and uncertainty by arguing that the former could be calculated while the latter could not. Callon *et al.*, (2009) considered risk as a subset of the broader concept of uncertainty, which concerns the more fundamental condition that we know that we do not know. Both define risk as the factors one can identify and estimate in advance and; a likelihood of occurrence. In short, it means that risks are the factors we know and can make calculations about. Uncertainty, on the other hand, is, accordingly, all outcomes that occur as unexpected in the sense that actors have failed either to calculate the probability of an occurrence or that the outcome itself has not been identified ex ante because it is not known. It also means that uncertainty holds potentially both negative and positive outcomes, a point also emphasized by Chapman and Ward (2011).

The role of the contract as a distributor of risk between two parties is illustrated, inter alia, by the Principal Agent theory and work on transaction costs economics (e.g. Williamson, 1981). The approach is normative, with the aim of finding the optimal contract given the current situation and actors' propensity to act opportunistic. The normative assumption here is that human actors cannot be trusted and that contracts must be designed to mitigate their opportunistic behavior by including appropriate controls and schemes for distributing rewards, risks and sanctions in order to reduce uncertainty and 'getting the risks right' (Flyvbjerg, 2006). According to this conceptualization, uncertainty is but another word for risk. However, risk and uncertainty can also be conceptualized and approached under the assumption that

uncertainty is an expected outcome and a consequence of risk management. Callon (1998 and 2009) builds a theoretical framework for this kind of analysis based on the Actor Network Theory (ANT). The ANT approach is not normative, but descriptive and analytic since it provides a socio-technical lens to analyze how the contract can play other and more dynamic roles in addition to the normative and controlling role proposed by standard economics. In the present work we describe and analyze an innovative building project and consider the role of the partnering contract - as a non-human actor/actant - which, through its design frame and affects the interactions of the developer/procurer and the contractor in ways that are perceived as unexpected by them. The client, supplier or sub-supplier may go bankrupt, or a third unexpected stakeholder may protest against the construction project and file a formal legal complaint. While the list of the entities (both humans and nonhumans) that are included in the contract is finite, the list of the excluded entities and events will always remain infinite and incomplete due to lack of knowledge and foresight. The notion of overflowing suggests that attempts to make a complete list of all contingencies and events is bound to fail due to this fundamental uncertainty. Generally, additional important actants to be accounted for could, in our case, be the construction site, the weather, the physical-material elements of the building construction, the drawings, calculations and models that together constitute the project. The ANT approach is relational and does not assume that people have fixed identities with a given set of expectations and interests. Rather, the assumption is that actors' identities are more dynamic and considered as an outcome that is shaped in interaction with non-human entities, such as the partnering contract. It is thus an open empirical question if the contract, in addition to represent human actors' expectations, interests, and responsibilities at the time of contract signing, can also play more active and unexpected roles as the contracting parties interact and the events of the construction project unfolds.

Callon's (1998) notions of framing and overflowing enable us to analyze these dynamics. Callon considers the contract as a socio-technical framing device, i.e., it draws a boundary around actors' interactions by defining through textual inscriptions their roles and responsibilities, their identity for short. Like all framing devices the written contract is imperfect. It cannot take everything and everybody into account. Nevertheless, the notion of framing also suggests that people calculate and mobilize their knowledge and foresight, for example when writing up contracts with price/cost estimations, roles and obligations. As a risk management tool, the contract attempt to regulate the interactions between the contracting parties and to "contain" risk by making them explicit and manageable. Yet, such attempts to install control and predictability will be followed by unexpected events and interactions, which transgresses the boundary of the contract and overflow to the context of the interaction. As suggested, an important element of this context is the written contract. The contract and its inscribed assumptions about price/cost, roles and obligations is challenged by overflowing, for example as unexpected costs and design challenges morph into controversial issues regarding risk assessment and distribution that threatens to undermine actors' trust in each other and the partnering arrangement.

Callon's notion of reframing further denotes the possibility that hitherto uncontained overflows can be taken into account if actors negotiate a new contract. Thus, according to Callon (re)framing and overflowing are not separate processes and phenomenon, but are related and ongoing. In contrast to economics more conventional notion of an externality, Callon considers overflowing to be the norm.

Drawing upon Callon (1998, 2009), Themsen and Skærbæk (2018), Harty *et al.*, (2014) argued that risk management tools can help to create risk and uncertainty between the actors instead of reducing these. In construction management research, several contributions have noted the proliferation of formal risk management tools or models (see Larya and Hughes, 2008, for a comprehensive review), including the contract as a risk management tool. This research points to a need for ethnographic approaches to inquire further into what people are actually doing as they try to figure out the risks and price for a construction contract. It appears to be room for further research into the complex dynamic relation between the contract and price ex-ante and the emergence of new and unexpected risks and uncertainties during a construction project. More specifically, and going along with our ANT approach, it appears to be room for more ethnographic case-based research on what the contract does and its eventual dynamic role in managing risk and uncertainty during an innovative construction project. As regards our case, differing opinions between the public procurer and the private entrepreneur clearly emerged. The controversies concerns supposed water damages inflicted on the innovative massive wood constructions elements, elements that was novel to both key actors in the partnering contract. Framing and overflowing in this case concerns the role of the partnering contract in shaping actions and events, including negotiations between the client and construction management over the target price and risk distribution between the two contracting parties.

METHOD

When researching our case we use ANT and Latour's (1987) 'rules of method' (258) to follow the actors and the unfolding chain of actions and controversies. The ANT approach is processual, case-based and inspired by ethnography and anthropological methods. Translated to our research, we have conducted visits and direct observations on the construction site since spring 2015 during the groundwork and assembly of the building. We have also conducted direct observations during a meeting at the construction management office on the construction site and participated on site during the celebration of the finished building. In order to reconstruct the chain of events and the controversies that emerged after the signing of the partnering contract, we supplemented with document studies and semi-structured interviews with key actors. The collected documents are planning documents from the early phases of developing concepts and project proposals, reports from client advisors prior to project competition, competition brief and contract standards, meeting protocols and a report from the client and its advisors about project outcomes. Semi-structured interviews were conducted with key actors while they were still working with the project and negotiating with each other. Interviews include project- and construction management, the client and user representative at Campus Evenstad, the project owner- and facility management at Statsbygg. In addition, we interviewed the management at Tre Torget, a private-public funded industry research association and a consultant affiliated with "Tredriveren in Hedmark", which are regional key actors within a national network promoting innovation in wood construction. For the purpose of this paper, the focus is on two unexpected and controversial issues that emerged during 2016 and that challenged the partnering agreement. Both controversies concerns moisture in the wood construction material and is accounted for in the vignettes below.

First Case Vignette: Negotiating Re-Design of the Outer Wall

Construction Management (CM) was appointed in December 2015, soon after the contract with the large public client, Statsbygg, had been signed. Previously, the concept and feasibility study had made the case for extensive use of massive wood. Subsequent refinements by the architect and client advisors resulted in a design of a two floors office building, with massive wood prefabricated panels including both the inner and outer walls. The wall panels would be sufficient to carry the weight of the building construction. Together with packed wood fibers in between, the wall's sandwich design would also be able to isolate and regulate temperature and humidity levels, to the benefit users' indoor climate. In addition, and importantly to the project ambition, the massive wood construction would also benefit the outdoor climate, because, it would contain the greenhouse gas CO₂ while also providing an energy efficient solution due to its material properties in regulating the indoor climate.

These material properties are translated and inscribed into the wall construction design, only to be subjected to further and intense discussion, just after CM was appointed for the job. The project 'clock' started ticking once the client and contractor signed the contract. According to the partnering contract, CM was in principle left with discretion to figure out the best design solution for the client, this then in contrast to a conventional design-build contract. In practice, however, the CM's design discretion was framed by the partnering contract in several ways. There was a time for proposing changes, but only within the timeframe of the contract. Delays was associated with a fine. So the time for change in project plan and design was limited. Still further, with the discretion to propose changes followed also a responsibility. If changes proposed and implemented turned out bad during the first 5 years of operations (another but related timeframe), the client could invoke guarantees and liability clauses. If CM for that or some other reason proposed no further design changes, the client could still invoke guarantees and liability clauses later on if CM failed to recognize the need for such changes during the construction project. In either way, due to these inscriptions, CM's roles was framed by the partnering contract - to propose change or no change became an on-going responsibility, dilemma and concern.

Within the project team different views soon emerged among advisors regarding the massive wood wall sandwich design. Proponents of the design, the chief architect and a technical advisor on wood construction, both with many years of experience with wood, and even massive wood constructions, maintained that the wood wall design was feasible and sustainable; economically, socially and environmentally. By contrast, other advisors, among them, specialists in heat, mechanical ventilation, electricity, energy efficiency and construction engineering raised concerns about the indoor climate. The key argument was that the proposed design, due to its novelty, could prove prone to water leakage and the accumulation of too high moisture levels in the walls. This, in turn, could damage the construction and generate risks in the form of a microclimate for fungi and spores, with further unwanted ramifications for the indoor climate for end-users.

The debate intensified across the members of the advisor group, and caught up in between was a client and a construction company that had little or no experience with such massive and innovative wood construction designs. The situation could grow into an impasse and potentially put a halt to project progress. Yet, the partnering contract stipulated that progress had to be made. It appears that the conflict could not

be resolved through further project meetings and discussions. In a joint agreement with members of the project team, the CM and the client therefore decided to put the design to a test in the laboratory of a well-reputed Norwegian consultancy firm within construction materials and design. As noted by Callon (1998) external expertise and scientific instruments are often called upon to settle controversy. In January 2016 a physical mockup of a wall element with a full size window fitted was tested in the laboratory. The mockup was exposed to water and measurements of moisture were taken along with observations of the movements of water on the mockup. Pictures were taken to document the test. According to the expertise from the consultancy firm, the design posed a risk due to water seeping in between elements in the wall, implying increased risks for accumulation of moisture and damaged construction.

CM and the client could now either choose to accept the risk and move on according to the joint agreement in the partnering contract, or decide to re-do the design. From the point of view of CM, the project was interesting because it featured this innovative sandwich design based on massive wood. Yet, it would also put a high risk on the part of the contractor if they stayed faithful to that design - if it turned out to be a problem with the indoor climate during the first 5 years of use. The client was clearly also interested in this novel massive wood design since they included such deliberations in their competition brief. However, as owner and facility manager of the building, they were also interested in providing a good indoor climate for their tenants and users. During the negotiations between CM and the client, it became clear to both parties that neither of them were willing to accept the risk and uncertainty implicated in this design option. It was decided to re-do the design by opting for a more simple and “safe” solution that replaced the outer massive wood element with ordinary thin wood panels.

The new design appeared to look like the massive wood panel, but due to its thinness, the outer wall would perform differently. The capacity of the outer walls to contain CO₂ would be reduced along with the building’s sustainability performance vis-à-vis its external environment. But then again, the laboratory test proved decisive in closing this debate about the design options. It appears that the closure implies a stronger focus on reducing risks inside the building, especially concerning the indoor climate. By reframing the contract according to the thinner wall design, a new negotiated boundary between the building’s outside and its ‘safer’ inside environment is settled. Simultaneously, the new boundary became an unexpected conduit of CO₂ overflowing, generating new uncertainties and risks in relation to the building’s outside environment, ‘the world’ in short. However, it also appears that the stronger focus on the inside environment also paved the way for further design issues regarding the overall design concept for the heating, ventilation and air-conditioning (HVAC). What was originally a quite simple mechanical concept of indoor climate based on natural ventilation (opening windows) turned into a more complex mechanical design concept requiring more energy to operate. The project plan and the contract’s target price needed revisions due to these design changes. CM and the client sat down to renegotiate a new and higher target price. The lower cost of thinner outer walls could not offset the extra time and costs for test and changes to the construction- and HVAC design, additional planning and assembly work on site.

Second Case Vignette: Negotiating Re-Doing of the Floors

In the summer of 2016, in the middle of the construction phase, comprising the erection of the frame and inner walls of massive wood panels, the construction crew

also installed oriented stranded floor boards (OSB). Just after the installation an unusual heavy rainfall occurred. The mounted floor slabs were under water for about 2 days as the contractor struggled with pumping out and draining the water. After the crew erected the roof, CM and the crew initiated a drying process. They made careful and repeated moisture level measurements of the supporting floor structure in order to ensure that the drying progressed satisfactory. It took some time, because the floor slabs made up about half of the total floor area of 1300 square meter of floor surface.

The client's representative arrived at the building site for regular meetings and inspections during the construction process. When arriving in the aftermath of the 'rain-and-floor' incident the client expressed concerns over the quality of the floors. Through an ocular inspection on site, the client pointed out that the floors was discolored, with further complex ramifications for the collaborative spirit between the partners. The client considered that this OSB floor was damaged and that the OSB floor could create issues with sponges and bad indoor climate. They could also prove to be too weak to carry the overlaying floor. This overlaying floor was a particularly durable and expensive oak floor consisting of short rods glued together from the fiber direction. Thus, according to the client representative, the underlying OSB floor was damaged and a clear case of a construction management error.

The construction manager, in turn, pointed out that the discoloration created by the water standing on the OSB floor could in no way affect the quality of the further construction; it was not a problem to lay the overlaying oak floor; nor could this incident affect the indoor environment negatively by creating a microclimate for the spreading of mold spores. Measurements of the moisture level confirmed that it was below the technical threshold value implicated by the contract and quality standards. However, at the subsequent building meeting, the client representative maintained the view that the discolored floor was an unacceptable deviance from quality standard and a construction error and demanded the contractor to replace the floor structure completely. CM then made the assessment that it was not meaningful to refuse this requirement since the client would otherwise report the resulting damage as a general construction defect after the completion of the construction. Thus, the decision to replace the floor material was taken by the client, unilaterally. In practice it took considerable time to re-do several hundred square meter of floors. Materials and the restoration costs for the entire operation was approximately 5 million NOK, or more than 10% of the contract sum. Once again, the project plan was up for negotiation due to unexpected costs and demands related to moisture and water on wood construction elements. Although CM and the client representative sat down, from CM's point of view, to renegotiate a new and higher target price, the client did not accept this. The cost of tearing out the already mounted floor construction elements, buying the new material and reinstalling that in the building, all these extra costs had, according to the client, to be carried by the contractor.

The post-project evaluation report (Statsbygg, 2017) used the benefit of hindsight to allude to the project team's lack of knowledge and failure to reduce risk and uncertainty. For example, regarding the wall design, it was noted that "Testing of new solutions should take place in the development phase, the pre-project phase, in order to reduce risk and uncertainty with regards to quality, progression and economy." (65 Translated from Norwegian).

DISCUSSION

The case vignettes show examples of controversy related to water and moisture in wood. It appears that wood containing moisture can become both a benefit and upside risk in regulating a good indoor climate and a liability if it grows mold spores. These micro observations of the dynamic tensions between upside and downside risks also makes them useful in furthering our discussion of the role of the partnering contract in managing innovation and risks in construction. Larya and Hughes (2008) called for more empirical research into actual risk management practices and Wamuziri and Seywright (2005) pointed to the partnering contract and target price as a way to share risks. The notion of risk and uncertainty reduction is integral to the partnering contract as it inscribes roles and obligations for the client and the construction firm by specifying in writing a shared risk and incentive scheme vis-a-vis the target price. The parties will share 50/50 of savings below the target price and budget or the extra costs above. The two parties are supposed to be, “in the same boat”; Since it is not an ordinary design-and-build contract with a fixed price the innovative ambition is higher and translates into a target price that can be renegotiated during the project by using the contract’s ‘change request’ mechanism. However, for this mechanism to be mobilized and have effect, it requires a joint agreement about setting a new target price, as it also turned out in our first case vignette. Costing and the new higher target price is thus a negotiated settlement of an emergent set of unexpected issues and concerns with the wall design.

That reframing was possible to negotiate after the wall design controversy reached a closure due to the new knowledge produced in the laboratory test. The costs and risks for the construction work and the indoor climate could be re-estimated and a new agreement could be reached. However, this revised contract and context of the partnering project appears to be focused on the downside risks; the new knowledge obtained from the test was not used to negotiate further resources to continue the exploration of the novel design, but used as a way to stop these explorations. The downside risks for the indoor climate appears to count more than the upside risks. Wood and Ellis (2005, 324) notes the emergence of “hush realities” further into the project processes, which tends to reduce the initial optimism in the partnering arrangement. Our case vignettes seems to indicate a similar trajectory. As the subsequent rain-and-floor incident also shows, new uncertainties emerge and prevails further into the construction processes when parties are judging on site the quality and performance of the OSB floor; what might appear to be a quite basic and simple construction element. However, this incident also shows that there is little left of the notion of a partnering contract when the key parties are negotiating the meaning and significance of the incident for further project and construction work. It appears, that the partnering contract can be used, not only as a device to negotiate and share unexpected costs and downside risk, as in the case of the wall design issue, but that it can also be used as a device for constructing quality error and allocate downside risk, as the floor issue illustrate. This finding supplement Wood and Ellis (2005) in drawing attention to the unexpected role of the partnering contract in undermining optimism and trust and in triggering guarding behaviors, self-interest and controversy. Finally yet importantly, the contract along with other planning documents such as time schedules and design- and feasibility studies, can also frame project evaluation and be used to allocate success and failure ex-post (Statsbygg 2017). However, as argued by Kreiner (2014) the realism alluded to by Statsbygg (2017) when pressing for more upfront planning could actually undermine the optimistic spirit that animates

project parties to carry it through the unexpected challenges and events. If and when the optimism is undermined, the project can run an increased risk of failure, including a failure to innovate, learn and produce new knowledge. We contribute to this discussion by drawing attention to the ambiguous and dynamic role of the contract as a framing device and mechanism for both supporting and undermining optimism, innovation, trust and collaboration. When in use, the partnering contract appears to play several such more or less hybrid roles. This then in contrast to Gadde and Dubois' (2010) typology of relationships which posit that partnering in construction "cannot evolve" (p.258) since mutual orientation and adaptations are avoided. While our second vignette would agree with their claim, our first vignette does not, because it involved mutual adaptations and a joint agreement of a new target price. Trust breaks down during the events captured by the two vignettes, and the contract play a role in both supporting and undermine trust and collaboration. While Cheung *et al.*, (2003) note that trust is always a dynamic and dependent variable our case analysis of the dynamic and hybrid role of the contract also adds to the explanation of why this is so. While Bygballe *et al.*, (2010) suggest the need to consider relations outside the project and its dyadic relationship between contracting partners, our findings suggest that this social 'dyadic' relation is better conceptualized with an ANT lens as a complex and dynamic unfolding socio-technical network in which the contract also plays important roles. There is a need for further studies of the roles of the contract.

CONCLUSIONS

Our conclusion is that the partnering contract can play unexpected dynamic and hybrid roles. The 'change request' mechanism implies that the contract is inscribed with uncertainty as a prevailing condition, which appears to be useful in innovative projects with extraordinary demands for new knowledge. But it is also inscribed with guarantees in the form of liability clauses. What makes a practical difference is how project stakeholders then use or do not use the elements inscribed into the contract. Instead of attempting to eliminate uncertainty and risk by using the contract as a conventional risk management tool, it might be more useful for stakeholders if they could use the contract as a device for knowledge production and in doing so cultivate the ambition and imagination of an upside risk to partnering and innovation in sustainable construction.

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RHETORICAL STRATEGIES TO DIFFUSE SOCIAL PROCUREMENT IN CONSTRUCTION

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Social procurement - in particular employment requirements aimed to create employment opportunities for disadvantaged unemployed people like immigrants or the disabled - are increasingly implemented in Swedish construction procurement. Social procurement is novel in Sweden, and actors who work with implementing employment requirements try to spread these practices throughout the sector. Building on interviews with 21 actors working with social procurement, this paper investigates rhetorical strategies for diffusing a social procurement practice in the construction sector. Applying the Aristotelian types of arguments, ethos, logos and pathos, when investigating the rhetoric used by proponents of social procurement, the findings show that they use a wide range of rhetorical strategies that emphasize the character of the proponents and their arguments, that explicate the rationality of social procurement, and that appeal to the emotions of potential supporters. The findings contribute to research on social procurement by identifying discourse related to social procurement, as well as rhetorical strategies proponents of social procurement use in attempts to diffuse social procurement practice throughout the Swedish construction sector. These rhetorical strategies may potentially increase legitimation of social procurement. For managers who aim to diffuse social procurement in the sector, the findings provide an overview of a number of different types of arguments that can be used in order to argue for social procurement and its benefits.

Keywords: employment requirements, rhetoric, social procurement, Sweden

INTRODUCTION

Recent years have seen developments such as mass migration and increasing poverty, inequality gaps, and fiscal constraints (Barraket *et al.*, 2016). These challenges have led governments as well as public and private organizations to look at their procurement activities in a different light. Today, the procurement process is increasingly seen as a strategic tool for achieving social value in addition to the actual object of procurement, which can be referred to as social procurement (Barraket *et al.*, 2016). In Sweden, social procurement has been directed towards creating employment opportunities for people living in social exclusion. These people are often unemployed, poorly educated, and live in segregated neighbourhoods in housing that may need refurbishment (c.f. Brännström 2004: 2516, Edling 2015). The idea is that unemployed people will receive employment, and the construction industry,

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which is facing a severe lack of workers, will have access to a new pool of possible workers (Enochsson and Andersson 2016; Bennewitz 2017).

Social procurement, and specifically the use of employment requirements (i.e. procurement criteria for creating employment opportunities for disadvantaged unemployed people like immigrants, youths, or the disabled) is novel in Sweden. Although there are many drivers for using social procurement considering the severe issues of social exclusion Sweden is facing, social procurement is not “business as usual” (see Sutherland *et al.*, 2015) in the Swedish construction industry, and no cohesive industry-wide practice is yet in place (Sävfenberg 2017; Petersen and Kadefors 2018). There are high ambitions surrounding social procurement, but due to the limited diffusion, actors who work with employment requirements spend considerable time and effort arguing for the benefits of social procurement (Petersen 2018). Although the EU procurement directives and the Swedish Public Procurement Act allow for social procurement, these regulations do not require organizations to conduct social procurements. This suggests a need for other tools to spread social procurement practices, where rhetorical strategies may be one such tool. This paper aims to examine the arguments used by actors who wish to diffuse and subsequently legitimize social procurement practices. Such an examination would add valuable insight into a novel procurement practice that is scarcely examined both empirically and theoretically (Barraket *et al.*, 2016; Loosemore 2016).

Social Procurement and Changing Institutional Logics

Although the construction sector has historically been slow to adopt new sustainable concepts (Ruparathna and Hewage 2015), the sector has been targeted as suitable for social procurement (Almahmoud and Doloï 2015; Sutherland *et al.*, 2015). In Sweden, social procurement has not become a fully legitimized practice in the construction sector, while social procurement has become “business as usual” in the construction sector in other countries (Sutherland *et al.*, 2015) and is becoming a distinct domain of practice (Barraket *et al.*, 2016). When looking to international experiences of using social procurement and employment requirements, scholars have found that many actors within the construction sector are positive towards social procurement (Erridge 2007; Zuo *et al.*, 2012). Previous studies have shown that social procurement inspires deeper collaboration, knowledge sharing and building competences throughout the supply chain, not least due to the complexity of social procurement (Sutherland *et al.*, 2015; Barraket *et al.*, 2016).

At the same time, one major perception (and possible misconception) among actors in the construction sector is that social procurement is expensive and yields less value for money than traditional procurement (Eadie and Rafferty 2014; Loosemore 2016; Walker and Brammer, 2009; Zuo *et al.*, 2012). In the UK, in Erridge's (2007) interview and document study of a pilot project in Northern Ireland and in Eadie and Rafferty's (2014) survey study of construction contractors, the authors found that contractors see employment requirements as costly as they entail training for the unemployed, and that contractors required additional monetary incentives in order to accept the employment requirements. Erridge (2007) also found that contractors were concerned that the unemployed would displace ordinary workers. In general, there is a lack of knowledge about social procurement (Walker and Brammer 2009; Zuo *et al.*, 2012), and the perception of social procurement and its pros and cons varies. For social procurement to become an established and legitimate practice in the construction sector, sceptical actors in the sector must be persuaded of its benefits.

Institutions and institutional fields, like the construction sector, are infused with various logics, which can be seen as “material practices and symbolic constructions” that influence actors, their behaviour, and their perceptions of the world (Friedland and Alford 1991: 248). Legitimacy for social procurement may be difficult to achieve, as it embeds different institutional logics than traditional procurement (Petersen, 2018). Firstly, social procurement, unlike traditional procurement, does not solely focus on features directly related to the object of the procurement, the building, but also focuses on something not directly connected to the object, employment opportunities. Secondly, traditional procurement focuses on price and quality, and easy-to measure price-related criteria, while social procurement focuses on creating social value rather than monetary value, through fuzzy, hard-to-pinpoint criteria. Thirdly, social procurement requires new competencies and cooperative practices with “new” organizations like employment agencies. Lastly, in social procurement the role and influence of the client is extended as clients can steer who their contractors should hire. Therefore, instead of the traditional loosely connected roles that characterize construction (Kadefors 1995; Dubois and Gadde 2002), contractors and other suppliers must now contend with clients having a say in their personnel politics. Social procurement thus comes with a new set of institutional logics that must be accepted in the institutional field of construction (Petersen 2018). Institutional arrangements and their degree of legitimacy change as an effect of shifts in institutional logics. Institutional logics may be changed through e.g. the emergence of new technology or legislation, as well as through “the strategic use of persuasive language” (Suddaby and Greenwood 2005:35; Brown *et al.*, 2012). The following sections discuss the connection between persuasive rhetoric and legitimacy creation by applying the Aristotelian types of arguments of ethos, logos and pathos.

Persuasive Discourse

Considering the ambition in Sweden to increase the use of social procurement, the persuasive discourse used by actors trying to diffuse social procurement throughout the sector is important. Green (2004) argues that novel practices are diffused and later institutionalized when the arguments supporting the practice become taken-for-granted. Also, Suddaby (2010) and Brown *et al.*, (2012) claimed that the study of language and rhetoric is a promising area of future studies, especially in terms of studying how language is purposively used to persuade others when promoting new practices or when attempting to change institutional logics. Therefore, by applying a perspective that focuses on language and discourse to better understand change and institutionalization processes, the practices for diffusing and subsequently legitimizing social procurement may be better understood. In a study by Suddaby and Greenwood (2005) they conducted a content analysis of the rhetoric in transcribed witness statements surrounding the merger of an accounting firm and legal firm. They showed how institutional entrepreneurs enacted change by manipulating institutional logics through the use of purposive rhetoric, by first exposing contradictions within institutional logics, and then by connecting certain features of these logics to wider, institutionalized cultural arrangements. To study the arguments for and against the change, the authors coded their data according to the main three types of persuasive rhetoric: ethos, logos and pathos. Higgins and Walker (2012) used the same three rhetorical types (also called Pisteis), which originally were formed by Aristotle, to analyse the rhetoric of social and environmental reports. Their interpretation and presentation of the three categories are used in this paper. Higgins and Walker (2012) describe ethos as related to the character, and thereby credibility of the speaker, who

through techniques such as similitude, deference, self-criticism, consistency, and expertise tries to persuade others. Logos is related to reason, or the appearance of rationality, where the speaker refers to logic, data, and evidence as a rhetorical technique. Lastly, pathos inspires emotive responses from the audience and is related to the identification with the audience or others, through referring to cultural references such as under-privilege, well-being, hopes and aspirations, and sympathy. This paper draws inspiration from Suddaby and Greenwood's (2005) and Higgins and Walker's (2012) approach in its theoretical examination.

METHOD

In order to examine the argumentative rhetoric used to spread and legitimize social procurement, 21 actors (in 17 interviews) involved in using and diffusing social procurement and employment requirements were interviewed between May 2016 and February 2017. The reasons for choosing these particular individuals are firstly that they are the actors who have any considerable experience with and knowledge of social procurement. These actors are prominent in the Swedish construction sector as the people who "set the agenda" of social procurement. Secondly, these individuals are the actors who show considerable interest in social procurement, and are those that have been proactive and diligent in using and spreading employment requirements. The interviewees are mostly based throughout the southern half of Sweden, and represent a multitude of different organizations in the construction sector: clients, contractors and architects, and support organisations that provides guidance and support in procurement or recruitment processes. There is an emphasis on interviewing clients as they choose the contractual criteria. However, as clients are not the only actors in the sector that are interested in spreading social procurement, additional types of actors were included in the interviewee sampling. The interviewees were identified through industry press, websites, and seminars. Snowballing (see Flick, 2014; Bryman and Bell, 2015) was also used, where new interviewees were often identified through referrals from previous interviewees, who know many actors in the sector who might be persons of interest for the study. The interviewees are presented in Table 1 and will henceforth be referred to with their work title and individual code.

Table 1: Overview of interviewees

Organisation	Types of organisations	Work titles/positions of interviewees	Individual codes
Client (C)	Public and private housing companies, public and private commercial property companies, local premises office	CEO, procurement manager, procurement officer, CSR manager, sustainability manager, process leader for employment requirements, head of development, development strategist for social issues	C1-13
Contractor/ Architect (CA)	Construction contractors, architecture firm	Sustainability manager, project leader, project manager, development strategist for social issues, business developer	CA1-5
Support Organisation (SO)	Public procurement company, Employment Agency	Project leader, employment officer	SO1-3

The semi-structured interviews (Kvale 2007) lasted between 45 minutes and 3 hours and allowed for elaboration from the interviewees in order to capture topics they found particularly pertinent to discuss. This interview flexibility was important considering the novelty and research scarcity of social procurement (Edmondson and McManus 2007). The interviews focused on topics such as the interviewees'

perspectives on and experiences with employment requirements, their daily work practices, and the pros and cons of employment requirements.

For the data analysis, the interviews were recorded and transcribed verbatim. Excerpts that were promotional in nature, meaning that they can be characterized as persuasive and argumentative for the benefits of social procurement, were extracted. These excerpts were then coded according to the three types of arguments: ethos, logos and pathos. This allowed for seeing patterns in the interviewees' rhetoric. The three types of arguments may be simultaneously represented in the same excerpt. In those cases, the category that is most prominently emphasized labels the excerpt.

FINDINGS

The choice of using the types of argument of ethos, logos and pathos was because they are the basis for studies on rhetoric. With a focus on the role of language in institutionalization processes, and scarce knowledge about social procurement in general, using this well-established theoretical lens is judged to be a reasonable first step to investigate the role of language for diffusing and legitimizing social procurement in the construction sector.

Ethos

In the first category of rhetoric, the interviewees talk about their personal role and the role the organization they represent. These arguments are centred around (1) explicit consistency, (2) self-criticism, and (3) responsible use of power.

Firstly, the interviewees use consistency to strengthen their character and persuasive argumentation. It is difficult to say much about the interviewees' implicit consistency, in terms of them restating the same point of view over and over in different situations. However, what is clear is their explicit consistency, in terms of talking about their long-term approach to social procurement, that they do not see social procurement as a fad and will continue to work diligently with using and spreading social procurement. A business developer (CA4) said: "We will continue to drive social sustainability, and we see it as a recurring thing. So, for as long as there are reasons to do it we will continue". Similarly, development manager (C2) explained: "If I say that employment requirements benefit our property values... and ask if [our contractors] want in on the deal or not, they understand that we are not backing down. We show that this is something we will do this year, in ten years, in twenty years, and that message is important to get out there". This explicit consistency signals the seriousness of the speaker to potential supporters. Either in terms of making the arguments seem more believable, or in the sense that it is not worth working against this new procurement practice, as the organization is not backing down anyway.

Secondly, in an effort of self-reflection, the interviewees do criticize themselves, their organizations, and the sector at large for being part of the problem social procurement aims to solve. A CSR manager (C9) talks about walking the talk: "We need to take on many interns ourselves, because we can't place requirements on others, but we must also contribute and be a part of that". Others criticise the construction sector and the way the work is organized, especially in terms of the sector's project-focus and the short-term contracts in procurement: "Employment requirements are a very short-term solution (...) in the sense that they only last for the duration of the contract" (development manager C2), and "the lack of long-term perspectives is a weakness" (sustainability manager CA5)".

Lastly, the interviewees often refer to themselves and their role in society. This rhetoric has aspects of *logos* and *pathos*, as the rationale is that with great power comes great responsibility. In that sense it would be illogical (*logos*) and unfair (*pathos*) not to use that power to influence procurement practices and developments in wider society. A national sustainability manager (CA1) talked about the targeted neighbourhoods and explained that: “There is high unemployment, low level of education, low solvency, [and] low tax incomes. Shouldn’t we ensure that we work with these people? [...] That’s the type of measure we need. We must look at the social exclusion issues and match that [with jobs]”. A development manager (C2) agreed: “We are a public housing company, so we have [public values] in our mission. We have a social responsibility in the neighbourhoods where we have properties. So it's part of our mission to talk about social procurement internally, as well as externally”. By continually referring to their mission, power, influence and stance in society and in the sector, their character may be strengthened as this emphasizes them as market leaders who drive change, and who make that change seem legitimate.

Logos

A *logos*-based rhetoric centres around making social procurement logical and the rational choice for how to organize the procurement process. The interviewees use a *logos*-based rhetoric focused on two different topics, where the interviewees argue for (1) the logical use of resources, and (2) the win-win situation. Many of the interviewees emphasize the untapped resource that is the unemployed, and that this is a pool of potential employees that should be explored. This is especially pertinent as there is a severe lack of capacity in the construction sector, both in terms of construction trade workers and engineers. A project manager (CA3) claimed that: “there is a possibility with employment requirements [...] because there are many who come to Sweden who are well-educated. We’ve seen that [...] they have knowledge we should take care of”. A national sustainability manager (CA1) further explained: “[Social procurement] is not about us looking like we’re nice, because [social procurement] is an absolute necessity. If we don’t recruit a bunch of good people very soon we will have huge problems [...]. We are implementing social procurement for selfish reasons, because we want to find skilled men and women that want to work for us [...] We need good people long-term that mirror our society”. This means that not only is it wasteful to let skilled people remain unemployed, but it can also be bad for business. There is thus an argumentation that points to social procurement being good for business, as it can create a more diverse workforce and access valuable competences among workers who previously would be difficult to identify. This leads into the second topic of *logos*-based arguments.

The interviewees, no matter if they represent clients or contractors or other suppliers, have a clear commercial agenda behind social procurement. Many expressed that unless they can make money out of this initiative, they will no longer pursue it. The interviewees emphasize the win/win situation of social procurement, where society and the unemployed benefit, as well as businesses. A CEO (C11) explained his perspective: “The truly good business deals are profitable, and manage to create value for the clients, and for society”. A CSR manager (C9) explained that the commercial vs. social value combination is important also for public organizations: “We also have to make profits [...] although that’s not our main driver. But we can’t make bad deals and let the property value decrease. Property values don't decrease just because people are unemployed, but [social exclusion, employment and property value] are interdependent”. Also, for contractors, such combinations are becoming necessary in

order to meet stakeholder demands: “We have internal and external drivers, and our new business model is called ‘profit with value’, which means that the profit we make should create additional value in wider society. This is very high on the agenda, and that’s because we genuinely believe that this is what we should and must do. Because we see that society wants it, the clients want it, and employees want it” (development manager CA2). The notion is that everybody wins with social procurement, and therefore social procurement is the most rational procurement practice.

Pathos

To use a pathos-based rhetoric could seem particularly appropriate considering the fact that social procurement aims to create social value and employment requirements aim to help people move from social exclusion to social inclusion. Many of the interviewees say that eliciting emotive responses in others and nurturing these feelings internally in the organization is vital, and they say that they themselves like their work because of their emotional engagement. A process leader (C6) explained it as: “When I say that this is about building societies, then I just can’t back down, then I’m like a union for these people”. The interviewees try to elicit emotive responses, by (1) personalizing the unemployed, and by (2) referring to their under-privilege, partly by referring specifically to the 2015 refugee crisis.

In one of Sweden’s largest cities, one woman in particular has been made the face and living example of social procurement. The example of how her life, and the life of her family, had improved after she received employment through social procurement was retold from several interviewees working in that city (but in different organizations). There had been promotional articles written about her and pamphlets given out at various events. A project manager (SO1) told the story as: “We have [this woman]. She came to Sweden when she was 14 years old [...] and she dreamed about being an accountant. So she went to college for three years in a city three hours away. So she commuted between [her home] and this city for three years, and had to leave her daughter at day-care really early, and then she took the train there and back every day. She was unemployed for a year and applied for 100 jobs but was never called for an interview. The year after it was the same story, she found nothing [...]. But then she got a temporary job through social procurement [...] and today she is permanently employed. Can you imagine that she used to be on welfare? [...] When she got her permanent employment she even negotiated a higher salary. Can you believe it, what a journey!”. These stories of individuals who have turned their life around thanks to social procurement not only focus on them as individuals, but often include anecdotes about their family, thereby personalizing the people social procurement has targeted.

The rhetoric also includes reference to the disadvantage and under-privilege of the unemployed. Often this is in terms of how social procurement presents an opportunity for these people to change their life, which they otherwise would have difficulty doing (due to their under-privilege): “We can show that for the people we engage in, for them we create opportunities and they get some power over their own life” (process leader C6). The internships and temporary employments disadvantaged people can receive through social procurement can thus provide them with work experience they would not have access to otherwise. The same process leader (C6) also explained his ambition to handle the large inflow of refugees: “We’re going to introduce refugees to the Swedish society here, and then we’re going to introduce them to the labour market. If we get those two parts to work together it will be the best refugee integration ever! We create somewhere for them to live, and then we create the

opportunities for their first real job here”. Opportunity seems to be the operative word when emotively arguing for the unemployed, their under-privilege, and the role of social procurement, and the refugee crisis in particular is a rhetorical topic many throughout the sector use to legitimate the need for social procurement.

DISCUSSION

Looking to Aristotle’s three rhetorical strategies for persuasion used by Suddaby and Greenwood (2005) and Higgins and Walker (2012), the findings indicate arguments falling under all of these three types. Firstly, the interviewees refer extensively to their role in the sector and in society, both in terms that it is their responsibility to promote social procurement and lead change, but also that they will continue to do so no matter what other stakeholders might think. This approach could seem overbearing, but the interviewees seem to balance this potentially obtrusive approach, by also being self-critical of their organizations and of the sector.

Secondly, the findings also corroborate Suddaby and Greenwood’s (2005) notion of logos-based arguments’ play on established institutional logics, in this case the rationality of profit maximization and goal-orientation. The interviewees might not have concrete figures backing up their claims, but the results are framed as so obvious and logical that there is proof of the benefit of social procurement. This is achieved when the interviewees emphasize both the socio-economic and commercial benefits of using social procurement, thereby framing social procurement as the rational development of procurement. The interviewees simultaneously used value-laden arguments, like the importance of helping those in need and because this is the right thing to do. Thereby, the findings adds to Suddaby and Greenwood’s (2005) conclusion by indicating that the same proponents used tensions between values and commercialism to their advantage simultaneously, rather than proponents and opponents just using such tensions against each other.

Lastly, the interviewees’ pathos-based arguments aim to create sympathy, not only for the individual unemployed or the refugees, but also for their families and community. They also connect to cultural references by talking about the under-privilege of the unemployed and the refugees, and how social procurement may provide the opportunity for them to achieve their aspirations, hopes and dreams. A national sustainability manager (CA1) concisely exemplified the argumentative rhetoric underlying social procurement by saying that: “[With social procurement] we would have more taxpayers and less depression”. This quote represents two of the argumentative types simultaneously: the logic of having more taxpayers (logos) and the emotional appeals by referencing depression (pathos). As such, different types of arguments are used by the same proponents, and sometimes even at the same time.

When connecting the argumentative rhetoric with institutional logics, and taking Suddaby and Greenwood’s (2005) claims into account, it is difficult to say if the proponents of social procurement are trying to expose contradictions within institutional logics to then connect certain features of these logics to wider, institutionalized cultural arrangements. However, the findings indicate that proponents emphasize certain features of social procurement, in particular the socio-economic and commercial business opportunities of social procurement. These arguments tap into a discourse that is well-established in the construction sector, which has traditionally focused more on tangible profit-related criteria. The findings cannot say when different arguments are used over others. It may however be so that

logos-based arguments pointing to evidence of e.g. the profit opportunities of social procurement might increase when these can be better calculated than today.

CONCLUSION

The findings illustrate how proponents of social procurement use a wide range of rhetorical strategies that emphasize the character of the proponents and thereby the legitimacy of their arguments, that explicate the rationality of social procurement, and that appeal to the emotions of potential supporters. These findings contribute to research on social procurement by identifying discourse related to social procurement, and how social procurement may be legitimized in the construction sector. The argumentative rhetoric underlying social procurement might be particularly important in Sweden. As there are no regulations that can coerce engagement in social procurement, actors in the construction sector must be discursively persuasive in order to enact this change. However, it is difficult to say if the rhetorical strategies have been effective in legitimizing social procurement, as social procurement is not institutionalized in the Swedish construction sector today, although this process seems to be underway (Petersen and Kadefors 2018). Rhetoric, and the actors using the rhetoric, is likely only one tool among many others, like legislation, for legitimizing social procurement and to battle social exclusion.

For managers who aim to diffuse social procurement throughout the Swedish construction sector, the findings provide an overview of different types of arguments that can be used and combined in order to argue for social procurement and its benefits, and thereby to persuade sceptics of social procurement. Future studies could delve deeper into the substance of and interaction between different sets of rhetoric of proponents and opponents of social procurement, or the rhetoric of proponents proposing different sub-practices within the wider social procurement practice (for example using internships vs. temporary employment contracts). This should then include interviewing a wider range of actors, such as union representatives, authorities, and engineering consultants, whose exclusion is a limitation of this paper.

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A CASE BASED COMPARISON OF THE EFFICIENCY AND INNOVATION POTENTIAL OF INTEGRATIVE AND COLLABORATIVE PROCUREMENT STRATEGIES

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The purpose of this paper is to investigate and compare in what ways different types of integrative and collaborative procurement strategies may enhance efficiency and innovation in public infrastructure projects. Further, implementation challenges are identified and discussed. Interview-based case studies were performed of ten infrastructure projects in Sweden and the Netherlands. The projects involve four types of collaborative procurement strategies - collaborative Design-Build (DB) contracts, Early Contractor Involvement (ECI) agreements, Design-Build-Maintain (DBM) contracts and Design-Build-Finance-Maintain (DBFM) contracts. The findings indicate that the duration of the collaboration is fundamental in setting the limits for innovation and that early involvement as well as long-term commitments open up for more innovation. Naturally, the potential for increased efficiency is higher than for innovation and also occurs in collaborations with limited duration. These integrated project approaches, however, still appear to be in an early stage of learning. For a public repeat client to realise the full potential of a new strategy, it is important to have a long-term perspective and capabilities to analyse and learn from the experiences.

Keywords: public infrastructure, organizational learning, supply chain collaboration

INTRODUCTION

Due to the inter-organizational nature of construction projects and their inherent complexity, innovation in the construction industry often requires knowledge integration and collaboration across numerous actors and their activities (Harty, 2005; Kähkönen, 2015; Rose and Manley, 2012). The typical short-term and arms-length relationships within the industry furthermore result in disruptive learning curves, which are detrimental for efficiency (Eriksson, 2013). Many reports have therefore

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recognized that inter-organizational collaboration is a core mechanism for improving efficiency and innovation (e.g. WEF, 2016).

Traditional procurement procedures involve competitive tendering based on detailed and strict contracts and subsequent control and surveillance. Recent studies, however, advocate that complex infrastructure projects need new types of project management practices, promoting flexible management of change by collaborative teams rather than ex ante planning and control (Gil, 2009; Gransberg *et al.*, 2013; Koppenjan *et al.*, 2011). Early engagement of contractors in the design stage may also improve efficiency through improved constructability and reduction of delivery time due to parallel design and construction processes (Lenferink *et al.*, 2013). Some non-traditional strategies focus on client-contractor collaboration while others emphasize supply chain collaboration and integration by performance-based delivery models that may also comprise maintenance and financing. Although such procurement strategies are not new to some countries and industry segments, infrastructure construction clients in many European countries have been slow to adopt such non-traditional practices.

The purpose of this paper is to investigate and compare how different types of integrative and collaborative procurement strategies may enhance the opportunities and incentives for improved efficiency and innovation in infrastructure projects. Furthermore, challenges and perceived barriers to implement these strategies are identified and discussed. The paper is based on case studies of ten recent and ongoing infrastructure projects in Sweden and the Netherlands with the final aim to provide a learning perspective on integrative and collaborative procurement strategies for public client organisations.

THEORETICAL FRAMEWORK

Following the seminal work of March (1991), the organizational learning literature typically distinguishes between two main learning modes: exploration and exploitation. Eriksson *et al.*, (2017a) emphasize that explorative learning involves a distant search for and assimilation of, new knowledge and technologies to enhance creativity and to achieve innovation and radical development of new solutions. Exploitative learning, instead, is based on local search for familiar knowledge and technologies to deepen the current knowledge set and achieve efficiency through incremental development and continuous improvements of existing solutions (Eriksson *et al.*, 2017a). Due to their inherent differences, these two learning modes are difficult to combine and manage together, especially in organizational settings with scarce resources such as project organizations (Gupta *et al.*, 2006).

Construction projects are often complex and uncertain endeavours that require concrete problem solving and explorative learning to manage innovation and adaptation challenges. In addition, the nature of innovations and technology development in construction entails that numerous interdependent components and sub-systems must be coordinated (Harty, 2005). Hence, project actors need to collaborate in joint development processes. Knowledge is often context specific, which makes it difficult to transfer across projects due to varying personal, professional and organizational interests (Bresnen *et al.*, 2003).

However, prior research has indicated that in projects both short-term efficiency based on exploitation and more radical innovation based on exploration can be facilitated by inter-organizational collaboration (Eriksson, 2013; Eriksson *et al.*, 2017a). Based on

the work of Eriksson and Hane (2014) and Eriksson *et al.*, (2017b) four core procurement strategy components can be distinguished: 1) the delivery system and the nature of the contractor involvement, 2) the collaboration model, 3) the contractor selection procedures and 4) the reward system. The components may be combined in different ways in order to achieve a governance structure that fits project characteristics.

Integrative collaborative delivery models that are used most in the European context are Design-Build (DB), Early Contractor Involvement (ECI), Design-Build-Maintain (DBM) and Design-Build-Finance-Maintain (DBFM). While the traditional Design-Bid-Build (DBB) contracts integrate the client and designer competences, the basic idea of DB contracts is that there is no separation between design and construction that hampers constructability. The contractor then has more freedom to develop technical solutions that improve time and cost efficiency (Eriksson and Hane, 2014). However, neither DB nor DBB contracts promote collaboration between the client and the contractors since they separate, allocate and clarify the actors' different responsibilities in order to make the contracts more transparent from the client perspective (Eriksson *et al.*, 2017a).

An ECI contract engages the contractor earlier than a DB contract normally would and especially suits situations in which the uncertainty is too high to calculate a price in the tendering stage and where the client sees important benefits in involving the contractor in very early design stages to integrate design and production knowledge (Lenferink *et al.*, 2013). DB contracts may also be integrated with maintenance services or private finances. Such integrated DBM or DBFM contracts are associated with other business models of infrastructure projects, but also with improved efficiency and innovation (e.g. Roumboutsos and Saussier, 2014; Verweij, 2015).

Collaboration can be considered as a multi-dimensional concept that can be divided into four dimensions: Scope, Depth, Duration and Intensity (Eriksson, 2015). Collaboration scope involves the nature and number of companies involved in the integrated supply chain (Fabbe-Costes and Jahre, 2007). In construction projects, it refers to which organizations are involved in and jointly perform the integrative activities and technologies, for example clients, suppliers, contractors and consultants (Eriksson, 2015). Collaboration depth refers to the integration of different types of professionals and functions at different hierarchal levels within each partner organization (Eriksson, 2015).

The duration dimension is dependent on the length of the time period during which the partners will collaborate and jointly utilize integrative activities and technologies, which could include integration across sub-sequent projects and/or project stages (Eriksson, 2015). Hence, collaboration duration is strongly linked to the delivery system which decides in what stages of a project the contractor will be involved. The intensity dimension measures the degree or strength of integration, which is dependent on the extent to which integrative activities and technologies are utilized (Eriksson, 2015; Fabbe-Costes and Jahre, 2007).

Prior research on partnering arrangements emphasizes the importance of intense or strong collaboration, which is heavily affected by the implemented collaboration model (e.g. Bayliss *et al.*, 2004; Eriksson, 2015). An important element of collaborative procurement strategies is to utilize a collaboration model that includes several integrative activities and technologies. Examples of integrative activities and technologies are: co-location in a joint project office (Bresnen and Marshall, 2002;

Gil, 2009), joint IT-tools (Eriksson, 2015), formulation of joint objectives and continuous follow-up meetings (Bayliss *et al.*, 2004; Eriksson, 2015) and team-building activities (Martinsuo and Ahola, 2010). integrative activities and technologies strengthen the socialization of partners so that they can establish a collaborative climate that serves as a foundation for joint development efforts.

Contractor selection can be based on lowest bid competitive tendering which relies on the idea that a large amount of bidders who compete on the basis of price will ensure that the client can minimize their investment costs for the project. This selection model may work satisfactorily in rather simple and straightforward projects with low uncertainty, where (i) the competences and experiences of the contractors are of little importance and (ii) the bid price will remain close to the end price due to lack of changes. A strategy that is based on pre-qualification of a lower number of capable contractors and subsequent bid evaluation that also takes into account softer criteria (e.g. organization, experience, reference projects, etc.) may enhance collaboration (Sporrong and Kadefors, 2014; Eriksson *et al.*, 2017b). Partner selection may also promote joint innovation work because the client can select a contractor that is capable and willing to engage in such joint development (Volker, 2012).

With regard to the reward system, fixed price payment have been most common in both DB and DBB contracts when the client wants to ensure that the lowest price is obtained through competitive tendering (Eriksson *et al.*, 2017b). However, this reward system is a poor basis for client-contractor collaboration as the client has no incentive to support the contractor in cost saving development work and the contractor has incentives to lower the quality of the end product if it saves costs (Eriksson and Hane, 2014). Incentive-based payment can enhance project actors' motivation for joint innovation work and is therefore considered suitable when contractors are procured early and involved in the design stage (Rose and Manley, 2012).

Research Approach

The paper draws on empirical data collected through 44 interviews in 10 infrastructure projects on four types of collaborative procurement strategies in Sweden and the Netherlands. Data was collected in the context of the ProcSIBE programme, a Swedish research initiative on procurement for sustainable innovation. This also includes Dutch-Swedish knowledge exchange. Accordingly, we have studied two Swedish DB projects, two Swedish ECI projects, three Swedish DBM projects and three Dutch DBFM projects. The DBM and DBFM project were selected because they currently are in the maintenance phase and have started 8 to 15 years ago. The DB and ECI projects were selected because of their explicit focus on integration and collaboration. They were still in progress at the time of data collection. All projects were pilots or belonged to the early versions of the delivery and contract models. The DB projects, procured by the Swedish Transport Administration (STA), were studied during the construction phase. DB 1 can be considered as a conventional road project worth around 21 MEUR, whereas DB 2 is a sub-project in a mega railway project estimated to 190 MEUR. In both projects procurement focused on price with an open bid invitation and evaluation based upon lowest price. They include a reward system based on fixed price. In both projects the contractor was procured after a pre-design phase in which a large part of all permits for the stretch had been applied and approved.

For the Early Contractor Involvement two railway projects were studied in Phase 1 of a two-stage approach. Both were procured by the STA as parts of the same complex

urban mega project and estimated to 300 and 430 MEUR respectively. In the ECI model, the design was developed in Phase 1 in collaboration between the parties, along with a jointly agreed target cost. A DB construction contract was then signed, based on the target cost and including a gainshare/painshare component. The contractors were procured based on the proposed contractor's fee, but also soft parameters were evaluated, such as collaboration skills, experiences and technical skills.

The three Swedish DBM projects (two highways of 58 MEUR resp. 130 MEUR and one road of 130 MEUR) were also procured by the STA. They were studied in the maintenance phase so the impact of integrating several phases would be visible. After a restricted tender procedure with pre-qualification and an evaluation based on price, the contracts were awarded to different groups of contractors for a period of 18 to 24 years. In all DBM projects the reward system is based upon fixed price agreement with yearly payments for maintenance.

Two of the DBFM projects (a highway of 135 MEUR procured in a competitive dialogue and a tunnel of 700 MEUR procured in a restricted procedure with pre-qualification) were contracted for a period of 20 to 30 years by Rijkswaterstaat, the governmental agency responsible for the major infrastructure facilities in the Netherlands. The third project, a provincial road of 120 MEUR, was commissioned by Rijkswaterstaat in collaboration with a Dutch province by applying a competitive dialogue. In all three cases, contract management was organised by systematic auditing on quality levels. The reward system was based on fixed prices with incentives for early delivery and yearly performance based maintenance payments.

The empirical data collection was primarily based on 2 to 7 interviews per project with respondents in managerial positions (e.g. director, project manager, contract manager, stakeholder manager) representing the main parties (client, consultant and contractor) in the 10 cases. Also project documents, such as organization schemes, contracts and tendering documents were investigated. In some projects, written reports, observations and case descriptions were available. This information was utilized to triangulate the interview findings. The analytic framework that underpins this study is based on the assumption that the four procurement strategy components - delivery system, collaboration model, contractor selection, reward system - relate to the four dimensions of collaboration of scope, depth, duration, intensity, which in turn influence project performance in terms of efficiency and innovation. We largely present the findings on efficiency and innovation potential per procurement strategy.

FINDINGS

Efficiency potential

With regard to efficiency, we found that in both DB projects the client initiated a basic collaboration model in the early phases. The models entailed some collaborative tools, such as joint project office, formulation of joint objectives and regular collaboration meetings. The co-location of the client and main contractor facilitated informal communication and collaboration among them in both DB projects. This broader scope of collaboration had positive effects on the efficiency of the projects, mostly by enabling faster joint-decision-making and clearer communication. The joint project office also contributed to depth since, especially in DB 1, the construction process has seldom been stopped; minor problems were quickly solved on a low hierarchical level whereas larger ones were brought up to executive level. In

both DB projects working tightly and intensively (in the joint project office) created a commitment in which it is everyone's duty to actually contribute to the best interest of the project. However, we also found that the extensive collaborative activities must be put in relation to the contract sum. DB 1 for example, was almost considered to be too small for this type of extensive efforts.

From the ECI projects we learned that in terms of duration, early involvement of contractor enabled constructability in design. The two-stage approach allowed contractor to be involved before all permits were obtained. Further, no technical solutions or cost estimations were required in the tenders, which meant that tendering costs were low, about 10% of those for a comparable DB project. The projects had high ambitions regarding, scope, depth and intensity. There was an aim to include all relevant parties and not only managerial levels. Co-location was mandatory, partnering facilitators were engaged and extensive collaborative activities were planned. In ECI 1, these activities were much appreciated and co-location enabled informal communication and faster joint decision-making.

Still, both ECI projects experienced significant challenges in agreeing on a target cost before entering Phase 2. The gainshare/painshare component was seen more as a risk than an opportunity by contractors and created an incentive for them to inflate the target cost. This caused client distrust especially in ECI 2, where influential individuals with traditional attitudes initially held key positions on both sides. In the end, Phase 1 was delayed by more than 9 months for both projects. When the contract was eventually signed and some managers moved to other projects, relations in ECI 2 quickly improved.

We found that the prolonged duration based on a rather early involvement of the contractors has high time-saving potential since the integration of design and production makes parallel processes possible. For example, in DBFM 1 the tender resulted in an offer of the contractor that gained 11 months from to the initial planning. Findings from the DBM and DBFM projects illustrate that the long-term responsibilities during operations and maintenance also affect the contractors' priorities regarding quality. To some extent, the maintenance responsibility make contractors invest in materials and technical solutions with higher quality, although they may initially be somewhat more expensive, if they result in lower life-cycle costs during maintenance.

Findings from DBFM 1 and DBFM 3 indicate that the inclusion of the private funder may result in an economically more sound tender strategy and solid technical solutions with lower risks. To avoid unnecessary risks, the private funder strongly steers on quality control and assessment of the viability of chosen solutions. Furthermore, the private funder's focus on revenues will put pressure on keeping the time schedule and encouraging early delivery of construction work. The sooner the construction is finished and the traffic can be released, the sooner the private funder can start earning money.

On the other hand, the DBM and DBFM cases also showed that collaboration between the design and construction actors and the maintenance actors was challenging to achieve. Accordingly, the increased depth of collaboration was not reaching its potential, which affected the maintainability negatively. For all DBFM cases, the project organization included at least a dozen different parties, which makes transaction costs in the procurement phase high. During the execution of the contract, approval for significant changes (e.g. the implementation of an innovation) needs to

be found among several layers of responsible officers - which takes time. Accordingly, the complex organizational set-up of DBFM projects seems to act as a double-edged sword; it results in slower decision-making, but the decisions taken may be of high quality. Long-term collaborations also create challenges in relation to the ambiguities in contractual agreements since they affect the collective memory of the organization. Decisions and discussions made 15 years ago are hard to remember and most people will not be there during the whole contract. Hence, it is important to get the documentation right when decisions are taken, in order to prevent ambiguities and conflicts in later maintenance stages.

Innovation potential

Whereas the intensity of collaboration in both DB projects contributed to efficiency, none of the projects can however be considered as innovative. The fixed price contract and the design responsibilities seemed to have deterred the contractor from making uncertain innovation efforts. The collaboration may have enhanced some innovation efforts that require the presence of different actors and competences. These innovations mainly related to product quality. Because of the longer duration of the warranty period (10 years), it was for example desirable for all actors to decrease the risk of major maintenance work that resulted in e.g. higher quality of the asphalt in DB 1.

In the ECI-model, there is a higher potential for innovation. In ECI 2, a large design change (the elimination of a bridge) was suggested which saved a substantial amount of money and time, which would not have been possible if the contractor was involved at a later stage. However, the lack of incentives for innovation in Phase 1 was seen as a problem and several changes have been made in subsequent ECI projects to better incentivize both efficiency and innovation in this phase. Also, the sharing ratio was adjusted from 50/50 to 80/20 to make contractors less risk-averse.

In other cases as well, we found that an increased scope of collaboration may enhance some innovation efforts. In DBM 1, the intense collaboration between the client, the consultants and the contractor served as a main driver and enabler for innovation. In DBM 2 the contractor developed both product and process innovations that were beneficial for both the client and the contractor. In DBFM 3 an innovative asphalt development was realized and a similar innovation was seen in DBM 3 where the asphalt on the bridges was substituted for concrete. For the DBFM 2 project, a new way of handling the traffic on the adjacent lane was used by the contractor. Also wider asphalt machines were developed to be able to lay both lanes at the same time and avoid the edge between the lanes, making the road more durable.

Hence, findings also indicate that the early involvement of contractors may not be sufficient to facilitate more radical and large innovations. Too many restrictions are already set during the initial planning and permit processes that are conducted before involvement of contractors. In the DBFM projects, the increased quality control and the risk averse perspective of the private funder left minimum room for radical innovation. In these projects, the broader scope of collaboration resulted in fewer radical innovations but improved verification of the innovations that were selected and implemented. Contrasting findings from DBM 2 and DBFM 3 indicate the importance of client priorities towards innovation. An ongoing discussion regarding a change to LED lights in DBFM 3 shows that the contractor has no incentive to change existing techniques due to financial reasons, while the client desires this change for environmental reasons. Contrastingly, in DBM 2, the contractor awaited the

development of LED and implemented the latest technology in order to fulfil client requirements and reduce the energy costs during the operation and maintenance phase.

DISCUSSION AND CONCLUSIONS

Overall, the findings of our study indicate that the duration of the collaboration is fundamental in setting the limits for innovation and that early involvement as well as long-term commitments open up for more innovation. Naturally, the potential for increased efficiency is higher than for innovation and in addition occurs in collaborations with limited duration.

In all collaborative strategies, early involvement of the contractor improved constructability and reduced delivery time due to parallel processes. In the ECI contracts, early involvement also significantly reduced tendering costs. For maintenance responsibility, our findings align with previous studies suggesting that DBFM contracts encourage stronger focus on quality and LCC. This is because the contractor has strong incentives to reduce maintenance costs arising from poor quality and inferior technical solutions (Rose and Manley, 2012; Lenferink *et al.*, 2013). We further found that the involvement of private funder can result in selection of more robust and verified material and technical solutions and that collaboration with design consultants could enhance development efforts. Private investors increase focus on revenues, put pressure on keeping the time schedule and encourage early delivery of project. The scope, depth and intensity of the collaboration were also important in enhancing efficiency and innovation. In line with prior research (Barnes *et al.*, 2007), we found that collaboration at many different hierarchical levels resulted in improved and quicker decision-making in daily work. Co-location was especially powerful and appreciated. The involvement of design consultants and key sub-contractors in collaboration was valuable in all projects.

It is clear that collaboration among different roles and hierarchical levels, long maintenance responsibilities and early involvement of contractors all carry great potential. Decision-makers also seem to generally have high aims regarding collaboration and integration. This, however, appears to be difficult to fully achieve in practice. Our cases have highlighted several organizational, contractual and cultural limitations and barriers. First, legal restrictions from initial planning processes limits possibilities for innovation. Sometimes, corridors permit only one solution. In this respect, there are often less opportunities for design innovation in horizontal infrastructure projects than in vertical building construction projects. Furthermore, lack of time for joint design and development efforts can be a major barrier, both to collaboration and to innovation. When time pressure is too high, contractors will stick to their existing solutions to avoid time consuming and risky development work. Other hidden costs include that long-term maintenance contracts increase the need for documentation, due to lack of organizational memory and also the complexity of the organisation, which can delay decision processes and raise internal conflicts. Also, it should be acknowledged that improving collaboration intensity by an extensive collaboration model costs more time and money. Thus, there is a delicate balance between positive outcomes and expenses, which has to be considered before deciding on a collaboration model that fits the individual project.

Finally, our findings highlight that the impact of contractual incentives on efficiency and innovation is complex and that there are frequently contradictory effects that may be hard to assess. Some models for early involvement result in increased costs for tendering for the contractor, especially if a design is proposed and competitive

dialogue is used. Long maintenance responsibilities encourage efficiency, but could deter radical innovation due to risk for malfunctions and costlier maintenance. The involvement of private funders could also hamper more radical innovation that entails larger risk. Long term maintenance contracts are very difficult to price ex ante, which is the reason why contractors need to add risk premiums to their tenders. The longer the duration, the more difficult to price and the larger the risk premiums. The results of our study further suggest that target cost contracts, intended to share risks and create incentives for contractors to be innovative and reduce costs, in effect may counteract collaboration.

With regard to organizational learning this study identified vital potential improvements of efficiency and innovation as a result of the chosen procurement strategies. The fact that none of the projects studied were part of a long-term contract spanning over a series of projects seems to have hampered efficiency in terms of inter-project exploitative learning. Misalignments occurred, for example, in the level of specification in the DB-contacts, setting target costs in the ECI contracts, integrating maintenance knowledge in the DBM and DBFM contracts and risk aversion of private investors in the DBFM contract. Thus, for a public repeat client to realise the full potential of a new strategy, it is important to have a long-term perspective and capabilities to analyse and learn from these experiences. However, due to the challenges in reaping all the potential benefits of collaboration, actors need to continuously improve their processes, routines and capabilities for managing the projects. These activities seem to leave little room for organizational learning and could hinder further implementation of integrative and collaborative procurement strategies in infrastructure practice.

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**WALKING THE TALK:
MOVING BEYOND
WORDS**

GETTING THE MOST OUT OF A COLLABORATIVE RESEARCH PROJECT: CROSS INDUSTRY DESIGN FOR A HOLISTIC VIEW AND INCREASED LEARNING

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Lately, collaborative research has gained recognition. The balance between scientific rigour and practical relevance is a continuing issue within construction management research. The purpose of this paper is to describe a cross-industry and cross-disciplinary approach to co-creation of knowledge through a collaborative research approach. A collaborative research project on the topic communication regarding customer specific demands is presented using a model with two interacting cycles for knowledge creation. Two construction companies, a housing company with off-site manufacturing and a small subcontractor manufacturing street doors and front doors, are participating. Four other companies within mechanical manufacture, telecom and consultancy are involved. To engage the companies, the project emphasizes activities not adding any contribution to academic production. Networking, industrial education, publications in trade journals, participation in trade fairs etc. might be essential to convince the industry of the practical relevance. The findings prove that applied research does not need to be isolated to specific industries or disciplines, as the collected data are applicable to the different participating companies' despite of their differences.

Keywords: collaborative research, communication, cross-industry, cross-disciplinary

INTRODUCTION

Lately, collaborative research has gained recognition. For the Nordic countries, governmentally directed research funding requires a collaborative approach. To achieve significant results, this kind of projects are often designed homogeneously, by putting focus on a single industry or discipline. The presumption is that problems are isolated to specific industries or disciplines, such as the construction trade.

According to Neve *et al.*, (2017), the construction industry is falling behind the performance of other industries in terms of quality and efficiency. A common reference to support the description is Winch (2003), who states that the construction industry is a 'backward' industry failing to be innovative compared to other sectors. Further, Dubois and Gadde (2002a) argue that short-term goals are prioritized over

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innovations. The prevailing culture and an inherent ability to change are put forward as explanations (SOU, 2002).

However, Löwstedt and Räisänen claim that it is a myth that "the construction industry is conservative and slow to change" (Löwstedt and Räisänen, 2012, 2014) putting forward the complexity and nature of construction as explanations for the moderate pace forward. Winch (2003) points out that the auto industry, often put forward as an exemplar, is not doing any better in terms of productivity, than the construction sector. Moreover, innovation in construction is rather driven from client dissatisfaction (Winch, 2003).

To thoroughly scrutinize a multifaceted problem, a multi-disciplinary approach is suggested, arching over multiple industrial practices. This aligns with "the Medici effect" (Johansson, 2004) stating that true inventions and breakthroughs are never the result of incremental improvements within single disciplines.

For construction management research, the balance between scientific rigour and practical relevance is a continuing issue. To balance these two domains, Ellström (2007) suggests a model with two interacting cycles to create knowledge. Aligned with the model proposed by Ellström, Voordijk and Adriaanse (2016) have investigated engaged scholarship, where the basic assumption is that academic and professional knowledge represent different, but related domains. Van de Ven (2007, 9) defines engaged scholarship as 'a participative form of research for obtaining the different perspectives of key stakeholders (researchers, users, clients, sponsors, and practitioners) in studying complex problems'. Voordijk and Adriaanse (2016) concludes that practice research, design research and action research are presupposed to each other. Thus, collaboration becomes an integral part. Further, Kokkonen (2017) argues that "collaboration as a phenomenon is multidimensional and therefore research has vaguely applied the concept". Further, with support from McCaffrey *et al.*, (1995), Kokkonen (2017) stresses that participation works as a mechanism for collaboration. Participation can absorb complexity and consequently work as a management tool (Ashmos *et al.*, 2002; Kokkonen, 2017).

Corsaro *et al.*, (2012) have scrutinized heterogeneity in innovation networks and identified six factors of having impact; (1) goals; (2) knowledge base; (3) capability and competence; (4) perceptions; (5) power and positions, and (6) culture. Still, the interplay between the actors' features and how it impacts innovation outcomes must be further investigated.

The purpose of this paper is to describe a cross-industry and cross disciplinary approach to co-creation of knowledge through a collaborative research approach. A collaborative research project on the topic communication regarding customer specific demands is presented. The project includes two construction companies, a housing company with off-site manufacturing and a small subcontractor manufacturing street doors and front doors. There are also four other companies in the project within mechanical manufacture, telecom and consultancy. Previous collaborative research projects have resulted in clear and measurable results for the participating (and recurring) companies indicating increased learning, better communication and understanding of the actual problem or unit of analysis. The experience has been used in the design of the current project.

METHODOLOGY

Research Approach

This paper focuses on describing a cross-industry and cross disciplinary approach to co-creation of knowledge through a collaborative research approach. To fulfil the purpose of the paper, a multi-method approach is adopted. First, a conceptual model describing a conceptual research approach is presented. The purpose of analytical conceptual research is to add new insights into traditional problems, through logical relationship building. Those studies usually employ case study examples to illustrate these conceptualizations (Wacker, 1998, 373, 378). Thus, an empirical illustration is provided for the approach. In line with Lacoste and Johnsen (2015); Piekkari *et al.*, (2010) we have thus used ‘tacit knowledge’ gained through immersion in the field to guide our retrospective analysis of previous and current research approaches.

Collaborative Research Design

The research design presented stems from lessons learned of the KKHÖG projects KOPeration (Dnr 20080537) 2009-2013, KOPtimera (Dnr 20130150) 2014-2016 [henceforth referred to ‘the KOP-projects’] and The Whispering Game (Dnr 20160326) 2017-2020 (on-going). The research design has been incrementally refined throughout the projects by continuous feedback (evaluation surveys for both academic and industrial researchers at the closure of every workshop that have been summarized and discussed at the subsequent steering group meeting) and continuous improvements. The research objective and research design for all three projects have been jointly formulated with the industry (Bäckstrand and Lennartsson, 2016; Wikner and Bäckstrand, 2008; Wikner *et al.*, 2013) and the final report for the two completed projects (Wikner and Bäckstrand, 2013; Wikner *et al.*, 2017) constitutes a summary of actual results for each participating company. In summary, these three projects can be regarded as extensive engaged scholarship (van de Ven, 2007), also referred to as longitudinal immersion, that according to Wells and Nieuwenhuis (2017, 48) is defined as:

... the situation in which the accumulative insights generated through knowledge acquisition in multiple diverse research settings, criticality and reflexivity are repeatedly tested against multiple aspects of practice through sequential and overlapping engagements with businesses, regulators, non-governmental organizations, consultancies in the quest for applied impact on [the intended industry].

Description of the Empirical Illustration - the Whispering Game

Competitiveness is dependent on customer satisfaction and delivery of required products. A challenge in manufacturing is to be, both efficient and contribute to high effectiveness, i.e. customer satisfaction (Heikkila, 2002). Also, the manufacturers need to be responsive to comply with changing customer demands. In recent years, a multitude of manufacturers has experienced an increased demand for customized products. Some of these customizations can be satisfied by a mass-customization or ‘assemble-to-order’ (ATO) strategy. However, not all products can be ATO, some product customizations have impact on the product design. Hence, the products must be engineered-to-order (ETO), rather than trying to standardize or modularize the product mix, the project focus at management of the current situation with increased demand for customizations in a more efficient way. Gosling and Naim (2009) identified construction as a sector dominated by firms employing an ETO strategy, and by the addition of four more ETO-oriented companies the project is suitable for the collaborative research approach. The clients' ability to manage information has

been reported in Levander *et al.*, (2011) with focus on uncertainty and equivocality and Engström and Stehn (2016) where the project logic is put forward as a barrier.

For manufacturing companies offering customized products, the customer requirements can be represented by ‘customer-order specific information’ (COSI) (Wortmann *et al.*, 1997, 72). To fulfil customer requirements, the focal actor needs to be able to capture the COSI from the customer, which is subsequently communicated clearly to the internal supply chain, i.e. among the various functions within the focal actor and also the external supply chain, i.e. the suppliers, see Figure 1.



Figure 1. The transfer of COSI in the Customer - Focal Actor - Supplier triad.

The Whispering Game project formulation (including definition of scope and project direction) was initiated 1.5 years before the launch. This rather long project formulation process has been important to fully grasp the business partners’ needs (Company A-F) and the project scope has been developed jointly by the industrial researchers and the academic researchers. The purpose of the project is to achieve customer satisfaction by developing a way of working that supports efficient COSI-transfer, both internally and externally.

Business Cases

Hard facts regarding the participating companies are presented in Table 1 to illustrate the heterogeneity and cross-industry setting of the project. Short descriptions of the participating companies.

Off-site housing (A): The Company offers single-family houses on the private market, built up from volumetric elements and produced off-site. The products belong to a standard series, but customisations are allowed.

Subcontractor (B): The Company offers doors and gates which are produced in a small artisanal workshop. Most orders are customised and clients arch from condo associations to large contractors.

Telecom (C): The Company belong to a large global group and offers services, software and infrastructure in information and communications technology for telecommunications operators.

Mechanical Manufacturer (D): Offers tailored solutions to other companies within the engineering industry.

Mechanical Manufacturer (E): Offers heat exchangers on the global market.

Consultancy (F): Independent consultancy firm residing in Scandinavia with clients within manufacturing, services, public sector and defence.

Table 1. Business case overview

	A	B	C	D	E	F
Customer	B2C	B2B/C	B2B	B2B	B2B	B2B
Turnover (MEUR)	44.8	3.3	19,876	21.0	44.5	173.4
No. of employees	198	22	100,735	121	123	1,439
No. of members in project	1	2	1	2	1	1

Academic Group

The academic group consists of five members with the following profiles. Hence, also the academic researchers represent heterogeneity and cross-disciplinary research interests.

- Project leader, Ph.D. - Primary competence in purchasing.
- Ph.D. - Competence in construction, off-site production and control.
- Ph.D. - Competence in interplay and learning in groups and organisations.
- Ph.D. Candidate, M.Sc. - focus on industrial technology and customisations.
- Ph.D. Candidate, M.Sc. - focus business and IT alignment, enterprise architecture and modelling

RESULTS AND DISCUSSION

The scientific approach of the research project is based on collaboration and co-creation of knowledge, where both the academic researchers and the industrial researchers take an active part in refining the formulated research objectives, and in developing new knowledge (The project participants from the business partners are referred to as ‘industrial researchers’ to emphasize that they are not passive bystanders that the academic researcher conduct research on). This is referred to as collaborative or interactive research (Ellström, 2007). In an interactive research process the academic and industrial researchers interact for joint learning but have different roles and different interests regarding the outcome of the research (Larsson, 2006). A common way of illustrating the joint knowledge creation through interactive research is the two interlocked learning cycles representing the practice system and the research system presented by Ellström (2007), see Figure 2. The iterative and interactive approach is the basis for the research, but contrary to the Ellström model, data collection and data analysis is carried out by both the academic and the industrial researchers.

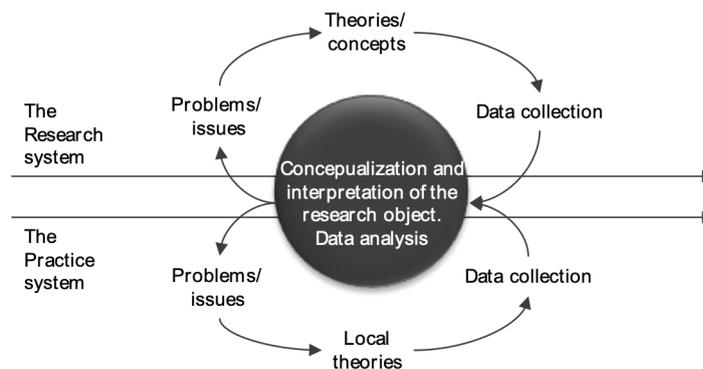


Figure 2: A model of knowledge creation through interactive research, based on Ellström (2007).

The project work is organized around recurring workshops, where the industrial researchers interact with each other and the academic researchers (this is the point of joint conceptualization and interpretation in the Ellström model). The workshops are ambulating among the business partners and the academic institution and is also an opportunity for observations including all researchers. During the former KOP-projects, the workshops have been found to be rewarding and the companies discovered that their problems were much alike, although they operated in different industries and manufactured different products (in terms of value, size, lead-time, and

level of customization etc.). The workshops also played a significant role regarding data analysis and conclusions.

Each workshop is associated with a work package containing data collection, data analysis and conclusions. Each work package covers four months of parallel activities, see Figure 3. From the project application, each Research Question (RQ) is processed in one or more work packages depending on the extent of the RQ. The work package is initiated by a planning-focused steering group meeting where a “homework” for next workshop is agreed, as well as the way of working. Since the same unit of analysis is investigated at all companies, this can be compared to a multiple case study with holistic design according to Yin (2014, 50).

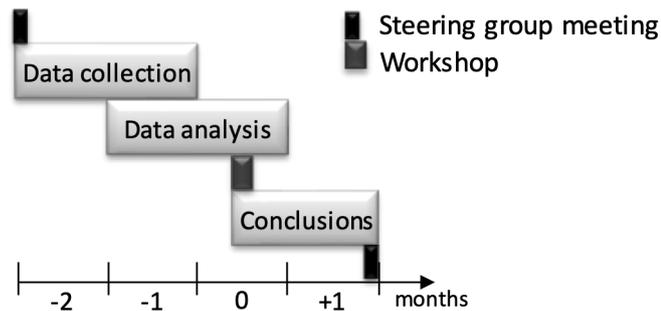


Figure 3. The generic work package associated with each workshop

The steering group meeting is followed by a two-month period of data collection and initial data analysis. This stage can be carried out as work meetings (where the academic and industrial researchers spend time at the other’s site) or individual work by the industrial researchers (together with their co-workers at the respective business partners). Parallel, the academic researchers are conducting literature studies or analytical conceptualizations (Wacker, 2008). The results from the homework are presented at the workshop and joint data analysis is carried out (e.g. cross-case analyses) and the formation of conclusions commences during the workshop.

The workshop is succeeded by a month of conclusions or implementation and testing. The work package ends with a follow-up steering group meeting where lessons learned are gathered and the result from the workshop evaluation is summarized. Based on the results the next work package is planned for, both in terms of WHAT to do and HOW to do it. Thus, each work package is associated with a deliverable. Accordingly, even though illustrated in a sequential manner in Figure 3, a set of work packages can be seen as an iterative cycle where the steering group meeting both close the work package and initiates a new cycle, which can be compared to the action-reflection cycle (Coghlan and Brannick, 2010; McNiff and Whitehead, 2011). This means that data collection, data analysis, and conclusions are performed continuously during the research project, although there are some sequential steps associated to each workshop. The activity plan for the project includes 3-4 workshops per year (in total 10 workshops over a three-year time span), depending on the needs of the academic and industrial researchers, see Figure 4.

The deliverable from the initial work package is an established “as is” base to find a desired “to be” scenario on and to measure project improvements towards. The final workshop is dedicated to fulfilling the purpose of the project. The intermediate work packages focus on the deliverables stated for each project.

There are also two workshops planned not associated with a work package, the initial kick-off and the closing conference. The initial kick-off focuses on establishing a

Table 2. Overview of the general planning for each workshop

Day 1	Day 2
Gathering, informal greetings	Joint analysis
Company visit/tour	Theoretical input
Joint lunch	Formulation of homework
Presentation of homework by companies	Summary and evaluation of WS
Joint dinner	Joint lunch

Results - Collaboration

A serendipitous result of having the workshops planned lunch-lunch (or longer) is that by including dinner and leisure time together, all project participants get to know each other and build trust each other, which has created an open and trusting work environment where also "sensitive data" such as weaknesses and poor decisions can be shared and discussed. From a research point of view this has been very beneficial since core issues rather than superficial problems can be addressed, thus adding to the relevance of the research.

Robustness of the Approach

In the paper, the heterogeneity of the approach has been promoted as positive. Of course, it is possible to point to limitations when managing a group of both organisations and people representing a variety of domains and backgrounds. Also, as for any collaboration effort including a significant number of individuals and/or organisations, there might be disturbances if anyone leaves or a new contender enters. There may also be concerns regarding the data quality gathered from the prescribed homework assignments that have been distributed to the industrial researchers with less formal academic training.

However, the iterative approach presented (Figure 2-4), which also arcs over consecutive research projects (including recurring companies), prove that the approach is solid and that the long-term perspective builds a culture, that conversely to some of the cultural manifestations in construction, has a positive influence. The approach nurtures participation which is also observed by Kokkonen (2017). Also, as for any projects of course the project scope and definition is crucial for commitment of the participating partners, both industrial and academic.

CONCLUSIONS

The purpose of this paper was to describe a cross-industry and cross disciplinary approach to co-creation of knowledge through a collaborative research approach, which has been done. To be successful with such heterogeneous set-up, the project execution has to be solid and well-planned. To engage the companies, the project emphasizes activities which are not adding any immediate contribution to academic production. Networking, industrial education, publications in trade journals, participation in trade fairs etc. might be essential in order to convince the industry of the practical relevance of both previous and future projects. The approach is supported by the argumentation from Kokkonen (2017) and importance of participation as a mechanism for collaboration.

The findings align with the results from Voordijk and Adriaanse (2016) regarding engaged scholarship that practice research, design research and action research are presupposed to each other, in the sense that applied research does not necessarily need

to be isolated to specific industries or disciplines, as the collected data are applicable to the different participating companies' despite of their differences.

From the supposition that the approach has succeeded to build trust among the participating companies, it would be interesting to investigate the impact factors proposed by Corsaro *et al.*, (2012) within the frame of the project.

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THE ACQUISITION OF KNOWLEDGE AND EXPERTISE IN CONSTRUCTION: UNDERSTANDING CONSTRUCTION PROFESSIONALS

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Education programs these days especially in Construction Management have been designed and updated to response to market and stakeholder needs. However, there still exists a need for educators to understand how construction practitioners develop their expertise. Understanding the development of expertise is essential for providers of university education and training to enable them to develop programs to establish on which new professionals can better develop their appropriate expertise. This paper builds on earlier research and further explores how expertise develops in construction professionals. It also explores the similarities and differences in development of that expertise in construction practitioners from the perspective of knowledge from various regions, which includes Thailand, Australia and Ireland, through the use of interviews with active and experienced construction professionals. To understand how construction practitioners' gain and use knowledge in their career can offer further extension to theorising about expertise in construction and through active application of this knowledge in courses and programs in AEC, enabling productive communication between industry and academia. AEC graduates in the future will need to be highly technical, adaptable, collaborative, good communicators and lifelong learners. The goal of creating those experiences that address these competences provides the modern academic with many challenges and those in industry have much to contribute to making this challenge more focused and appropriate.

Keywords: expertise, practice, knowledge, discourse, construction

INTRODUCTION

Previous research undertaken in Australia and Thailand has shown construction expertise derives both systematically and often for some professionals in an ad hoc manner from various forms of knowledge, either or both from authoritative and non-authoritative knowledge sources (Kanjanabootra and Corbitt 2016; Kanjanabootra 2017; Jordan, 2014). These forms of knowledge are constrained deliberately and politically by accreditation bodies, government authorities and by the market. However, our understanding of the development of expertise in Construction Managers (CMs) is still too limited to develop more comprehensive theory and apply that universally to the discipline. Education programs these days especially in CM have been designed and updated to respond to market and stakeholder needs. However, there still exists a need for education providers to understand how

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construction practitioners develop their expertise (Scott 2016). Understanding the development of expertise is essential for providers of university education and training to enable them to develop programs to establish the foundations on which new professionals can better develop their appropriate expertise. This paper explores the similarities and differences in development of that expertise in construction practitioners from the perspective of knowledge from various regions, which includes Thailand, Australia and Ireland, through the use of interviews with active and experienced construction professionals. The intention of this paper is not simply about how construction professionals acquire explicit or/and tacit knowledge, rather the research question asks how do professional accreditation bodies shape and control how construction professionals acquire initial knowledge and how does that impact their life-long learning and their expertise development?

Reviewing the Literature - The Challenge

The challenge in understanding construction professional knowledge and expertise acquisition and development is that at a superficial level it appears to be systematic. However, in reality this process is rather convoluted and complex from the beginning of the process. We argue that by studying the process of expertise development in CMs and then theorizing the process, a more universal, less complicated and less complex process will emerge, enabling universities to enable course improvement and enabling industry to provide better channels for knowledge acquisition and expertise improvement. At an informal level this could provide students with the capacity to enable lifelong learning. Expertise development is argued to be a lifelong process and can be seen from the perspective of processual understandings of expertise (Wood, 2002). However, such a non-structured perspective assumes all readers can differentiate the various structures that are necessarily part of knowledge and expertise acquisition as these structures are socially imposed, as university courses, professional development courses etc. The processual perspective is useful which looking at the history of the processes but needs to enable reflection on these structures which are formally recognised. Since our intent is to develop some theorization and therefore offer possible solutions, it is essential to be able to see not only the entire process, but the parts of that process. In doing this we believe that we can begin to unravel complexity, rather than desiring less complexity (Langley, 2013).

It is generally accepted that most occupations expertise development have similar patterns which start with initial training in formalised and structured education systems such as university or vocational training (Elvira *et al.*, 2016; Tynjälä 2008). Everything else then can be added on in professional practice via a 'learning on the job' basis (Edum-Fotwe and McCaffer 2000). In fact, expertise development process is far more complicated than just two isolated chunks of learning as mentioned, especially in the AEC industry where there are vast numbers of stakeholders involved. The result is that every stakeholder from a specific discipline domain need their graduates to be trained in a certain way with a specific set of competencies before entering the industry (Callanan and McCarthy 2003; Jackson 2016). Then specific practice discourses in each profession in the AEC shape and control how practitioners develop their life-long expertise development.

Initial Training Challenges

There are specific complications with how education providers such as universities and vocational institutions design their degree structure and how each course is designed to meet a complex set of graduate attributes set by various accreditation

bodies (Altbach and Knight 2007). Some degree programs have to comply with multiple accreditation bodies (Becerik-Gerber *et al.*, 2011). This means that the degree structures have to be designed to accommodate all of the graduate attributes that each accreditation requires. The challenge is that the degree will be packed with large amount of attributes, more than one student wants/needs. The university degree has a specific time frame (4 years, 8 semesters). Typical university degrees are full of practical courses with little space for non-technical courses, which some argue are essential for life and for the workplace context (Gambrill and Gibbs 2017). Hughes and Hughes (2013) showed that the expanding jurisdiction of professional institutions and their inability to address changing practices are somewhat responsible for eroding professional judgement.

Practice Challenges

Findings from earlier work (Kanjanabootra and Corbitt 2016; Kanjanabootra 2017) show that approximately 10-15% of knowledge used in professional practice is gained from an initial degree or training. Then practitioners gain the rest of their knowledge from doing their day-to-day job. New graduates have to acquire significant job specific, practical knowledge when they start their first job. Because each organization has different training practices in their firms as this training have been tied up with practice and tasks, this creates a discrepancy between professionals in development of their expertise (Boud and Hager 2012). Accreditation bodies or registered professional associations offer substantial Continuing Professional Development (CPD) courses for professionals in work contexts. Multiple professional associations also offer the programs/ courses in a non-systematic, and non-integrated way, but which are also controlled and very politicized. To understand how construction practitioners', gain and use knowledge in their career can offer further extension to theorising about expertise in construction and through active application of this knowledge in courses and programs in AEC. AEC graduates in the future will need to be highly technical, adaptable, collaborative, good communicators and lifelong learners. The goal of creating educational experiences that address these competences provides the modern academic with many challenges and those in industry have much to contribute to making this challenge more focused and appropriate.

The Cycle of Practice

At a theoretical level the Tynjälä's Model (2008) and the application of that model by Elvira *et al.*, (2016) reflect the essential role that integration of the three elements of expert knowledge (conceptual/ theoretical knowledge; practical/experiential knowledge and self-regulatory knowledge) play in the development of expertise.

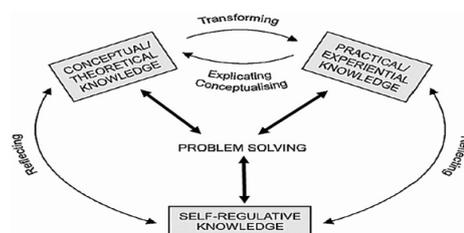


Figure 1: Generalised Model of Expertise Development (Elvira *et al.*, 2016, based on Tynjälä (2008))

Previous research (Kanjanabootra and Corbitt 2016 and Kanjanabootra 2017) has shown that the cyclic process proposed by Tynjälä was not as complete, resolving

through focus on the elements of Practical/Experiential Knowledge and Self-Regulative Knowledge and that ‘reflecting’ was constrained by the economic imperatives of project controls and was subsequently inconsistent and often weak.

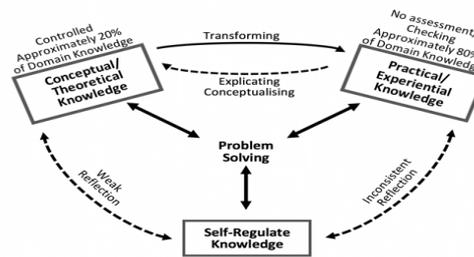


Figure 2: Expertise Development in Construction (based on Kanjanabootra and Corbitt 2016)

For the early career graduate professional, the nature of knowledge and expertise development surrounds gaining practical/ experiential knowledge through the application of learnt conceptual/theoretical knowledge where an advancement to self-regulated knowledge achieved by way of exposure to real tasks and objective mentoring. In particular, the significance that education has in contributing to both knowledge and professional practice is an important factor that impacts on expertise and knowledge development. This differs from Professional Body Frameworks which are functionalist and specific, detailing knowledge as skills and capabilities, almost always without seeing their interconnectedness. The codification of any discipline refers to what it knows through codes of practice, bodies of knowledge and the production of journals and other reading matter. Kuhn (1967) argues that disciplines are defined by paradigms through ‘models of thought’. As the CM discipline is a relatively young discipline, consensus has not been fully achieved. Langford and Hughes (2009) however, have argued that CM meets the three criteria and therefore can assert itself as a discipline.

We have used an alternative perspective to underpin this research. Hibbert (2013) describes the increasing routinization and instrumentalised contexts of professional practice where educators disseminate information, reproduce routine and students or practitioners receive training. Flyvbjerg *et al.*, (2012), Kanjanabootra (2016) and Antonacopoulou (2010a, 2010b) argue that learner reflection is needed so that skills and practice can be evaluated and then shared. In this way they argue, knowledge grows and collaboration of knowledge emerges. This is part of seeing how expertise develops in students initially and then in practitioners within the socially formed structures evident within the profession. At a conceptual level this involves the transfer of knowledge to problem solving as shown in Fig 2 above. To provide a framework to consider both this acquisition and transfer process, the research uses the approach of Kanjanabootra and Corbitt (2016) focusing on three elements related to expertise development in construction, the existential (who am I and what kind of person do I want to be as a practitioner?); the relational (how do I as a practitioner relate to others and to the world around me?); and praxis (understanding the self-conscious, questioning expertise development as both past actions and future possibilities).

RESEARCH APPROACH

This research aims to gain a better understanding of how the architecture, engineering and construction (AEC) sector understands and conceptualises Discipline knowledge and expertise. As this research is exploratory (Fellows and Liu 2015) seeking insights

about expertise development in construction managers, the research methodology employs techniques to both gather and then analyse rich data (Geertz 1973) with the intent of further theorization. The research reports the narratives offered by the construction managers’ own objectivity and their narratives reflect their learning and expertise development. Vygotsky (1978, 1986) argued that learning is a reflection of socially mediation informed by its social, historical, and cultural contexts and that learning is self-reflected in the narratives or stories respondents tell in the research process. Contextual analysis enables the meaning and inner workings of our main variable of interest to be better illuminated (Collins *et al.*, 1999). George *et al.*, (2015) also argue that context functions outwards, by encouraging researchers to examine a broader range of relationships that may influence outcomes of interest, in this case expertise development in construction managers. Only through the respondent themselves telling their story can a ‘richer’ understanding of how construction managers learn and develop their expertise be gained. This methodology was used here to elicit the types and forms of knowledge that informed the practice and subsequent development of expertise of the construction managers, seeking to further add to what Addis *et al.*, (2016), Chan (2016), Sage (2016), Kokkonen and Alin (2016), Mogendorff (2016), Scott (2016), Newton (2016) and Kanjanabootra and Corbitt (2016) have already proposed about expertise development in construction.

Each conversation between participant and researcher was recorded. The interviews were transcribed and then analysed using an iterative analysis trying to determine themes. The structured interviews generally took about 45 minutes each. All the interviews were audio recorded where permission was granted by the interviewees. Otherwise, notes were taken, as were during discussions and meetings. The qualitative data (e.g. the notes and transcripts of interviews) was analysed using the ‘content analysis’ method, i.e. following the logic of identifying the codes, themes and patterns. Use of NVivo and then thematic coding assisted in identification of themes in the interview data as they related both to knowledge and learning, and to expertise (Fereday and Muir-Cochrane 2006).

Table 1: Professional Background of Participants

	Australia	Thailand	Ireland
Construction Management	5	4	4
Quantity Surveyor	4	-	2
Architect	1	2	1
Engineer	3	6	1

ANALYSIS OF RESEARCH - FINDINGS

Outside the scope of knowledge graduates acquire formally and in the structured context of a degree, the graduates have to rely on both knowledge sharing via informal teaching from more senior practitioners, from peer interactions and from exposure to new products and processes from the commercial sector. Professional relationships with a more senior supervisor will determine what they can learn, and how much they can learn through job or tasks allocation. The research respondents highlighted instances where knowledge was withheld, either deliberately or through allocation of mundane, repetitive tasks, seemingly disengaged from acquiring new knowledge, hence expertise development can happen in a very slow manner. Graduates can learn new knowledge through the tasks that they are allocated to do and work under close supervision of more senior staff.

This learning process for construction professionals over time is determined, according to the construction professionals, by the types and amount of tasks that are allocated in construction projects. This is a complex situation because if the difficulty of the allocated tasks does not match their knowledge level, they might take longer time to execute those tasks. In the case of the QS professional at the end of this two year learning period, graduates also have to be nominated by a specific grade of AIQS member who has the responsibility to evaluate whether they have adequate competencies to be registered as a professional or not (AIQS, 2017). This, it can be argued, represents a continuity of authoritative knowledge through a professional discourse, but relies on the unstructured, almost serendipitous acquisition of less formal knowledge through knowledge transfer and knowledge sharing in the workplace. Newton (2016) argues that knowledge through ‘declarative and deliberate practice and knowledge’ are integral to expertise development in construction. The construction professionals interviewed in this research exemplify that knowledge transfer and knowledge sharing in the workplace are at times either or both declarative and/or deliberate, both being essential to the development of expertise.

The respondents’ data also highlighted individual instances where new professional knowledge can develop through process modification with the introduction of innovations. However, the QS interviewees consistently noted that the Quantity Surveyor role does not really enable innovation to take place as their role is defined in a very explicit way. While in the engineering profession new knowledge derives mostly from either new products or a modification of existing processes, by trial and error to improve designs or processes. This modification of existing processes often comes in a form of new constraints that are project specific. This resulting new knowledge, the engineering respondents noted, develops through the process of finding on-site solutions to address new project constraints.

The respondents highlighted what, it can be argued, exemplifies the effect of a discourse of benign knowledge sharing within what Bernstein calls his horizontal discourse. This benign knowledge sharing can happen through the introduction of technologies such as BIM in the construction workplace. There is substantial evidence for viewing the constraints of this type of supervision, and the demands for professional development career points (CPDS) discussed above, to represent parameters to learning, constraining the development of repertoires of skills/knowledge into formal structure perspectives. That discourse determines what has to be known to maintain professional practice as a career develops. In essence, it can be argued, these may form constraints on the development of an individual’s expertise as an example supporting the argument of Sage (2016) that knowledge acquired through technologies can shape, develop and constrain human construction expertise. This process of knowledge sharing and transfer is also indicative of the Authors argument that expertise development is not only constrained by the politics of control, but also by the incremental acquisition of knowledge.

The respondents consistently raised another issue related to the incompleteness of skills sets in the initial set of knowledge accrued in their vocational and degree learning. There was an often cited expectation that the initial knowledge given needed more attention to understanding the importance of lifelong learning and the ability to reflect on ‘your own performance’. These findings reflect another professional argument made by Nash *et al.*, (2016) that student pharmacists must have their competency standards, lifelong learning and self-assessment skills embedded into their university curriculum to ensure a strong foundation for practice. This, it can be

argued, recognises the importance of understanding not only the value of authoritative knowledge, Bernstein's hierarchical structured knowledge, and the corresponding importance of developing that knowledge through informal learning, professional development and through peer practice. This latter process represents a view that expertise emerges as both Bernstein's 'common-sense' knowledge and supports Chan's (2016) argument about the dynamic nature of expertise being in a state of constant flux, influenced, it can be argued by the constraints of attempts at control through professional politics (Sage 2016), and by demonstration of relevance to construction work (Mogendorff 2016).

DISCUSSION

The comparison of previous studies in Australia and Thailand to additional data from research in Ireland shows that there are some similarities and extension about how AEC practitioners develop their expertise. One of the key affirmations is that in the construction industry learning appears to be tied together with practice. "Learning by doing" is a concept that appears to be universally adopted across regions as learning and practicing are complementary. Practice enables practitioners (graduates) to apply conceptual/theoretical knowledge that they have learnt, in doing so also provides platforms for them to learn more and develop and expand their expertise. Challenging or difficult projects are also a good platform to provide better learning processes. The data suggests that if graduates have to face difficult projects early in their career they face a series of steep learning curves and this challenges their competency and stimulates the need for expertise development. This means that the expertise development process can be/is for many, a life-long process. However, this process is not the same for everyone. This also means that it is difficult to *get all* practitioners in the same profession to be on the same pace in their knowledge.

Another issue found in this on-going research is that self-reflection skills appear to be weak in many graduates. Some interviewees mentioned that there were some forms of feedback provided during learning and this they believed had a positive impact on those graduate's ability to develop their self-reflective skills. We would argue is while the provision of feedback during learning process is essential, students also need to develop their own self-reflection skill. This self-reflection is an essential link that helps graduates connect conceptual/theoretical knowledge, with practical/experience knowledge and enable them to self-regulate knowledge elements (Elvira *et al.*, 2016).

Evidence in the construction professional interviews done so far in this research supports a view that expertise development goes beyond the professional understanding of the existential - the who am I and what kind of person do I want to be as a practitioner; the relational - how do I as a practitioner relate to others and to the world around me?; and praxis - understanding the self-conscious questioning expertise development as both past actions and future possibilities. That existential, relational and praxis in construction is subject to restrictions in knowledge acquisition and learning imposed as structured dialogue by professional and accreditation associations. Those parameters are often designed and implemented to protect as well as control, however in whichever way they can be seen as inhibitors to the development of expertise through knowledge acquisition along an informal and unstructured discourse that fosters learning through observation and innovation.

Dewey (1938) in his work focused on the importance of experiential learning and was a true advocate of learning through practice. It should be noted that in some respects the phrase 'learning by doing' as referred to by some of the interviewees cannot be

considered as out of place. Certainly those participants in the research who have mentored graduates emphasised the importance of providing the opportunity for new recruits to learn on the job. For instance, to pick up just one example from the discourse with one interviewee:

The goal of vocational education should not be that of providing the students with a great amount of knowledge but rather it should consist in making the situation where they able to acquire a lot of knowledge. Our function in practice is to create the opportunity for them to apply that knowledge.

It could be plausibly argued that, although Dewey may have been the first to use the phrase, those experienced professionals involved in the AEC sector today understand the meaning originating from the novelty of his philosophy and, in particular, of his ideas about experience and knowledge. Mentoring of new graduates, a practice advocated by many of the respondents, requires a tremendous amount of time for a successful approach. Aside from the time commitment is the commitment toward understanding the idiosyncrasies of each other's knowledge within the discipline. As the AEC sector is so fragmented successfully trying 'to facilitate learning of collaboration across disciplines', the respondents made reference to the requirement of a willingness of mentors to collaborate across those disciplines. While the evidence shared is positive and as mentioned earlier, the research ongoing, for the purposes of generalisability the information collected on the outcomes achievement is not at a point where it can be used for such purposes. The authors intend to focus further research in these areas. The more recent phase of the research supports and confirms the position that expertise development emerges from the dynamic state of knowledge accumulation, transfer and sharing already identified from the earlier work of Kanjanabootra (2017). The research is showing that using knowledge, both authoritative and non-authoritative (formal or less formal) offers potential linkages across the existing theorisations of expertise (Addis *et al.*, 2016).

CONCLUSIONS

The changing, constantly evolving nature of the 21st century BE, both in theory and practice, requires new ways of approaching and understanding our urban surroundings. This in turn demands of academics in education that they reassess their attitudes to what they do and how it is done; that assumptions and titles are challenged, in order to remain at the forefront of BE teaching, training and research in CM. What is imperative is that the AEC professionals and leaders of the future get access to quality educational experiences. Going forward as this research project is in the early phases, the authors plan to critically look at the professional bodies' frameworks, such as UK SPEC and the Australian / Irish and Thai professional body relationships and focus on the call for industry contribution from such frameworks to theorizing construction knowledge and expertise.

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GENERAL TRACK

TOWARDS AN INTEGRATED FRAMEWORK OF BIG DATA CAPABILITIES IN THE CONSTRUCTION INDUSTRY: A SYSTEMATIC LITERATURE REVIEW

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Generation of data in the construction industry is increasing exponentially, becoming bigger and varied due to the use of sophisticated devices. This is necessitated by the call for automating the construction process. Getting valuable insights from data has taken the centre-stage of digitalization in the business world, through big data applications. Big data describes the application of advanced technologies to mine insights from datasets to solve problems. Studies have recommended the benefits of big data in the construction industry, though scanty, but cognizance is not given to what it takes for the industry to realize to the fullest, the benefits of big data. This study identified big data capabilities across different disciplines required in the construction industry through a systematic literature review. Four major big data capabilities thus organizational strategy, data, technology and people were identified from literature through qualitative synthesis. The research was limited to peer reviewed articles indexed in Web of Science and Scopus. The findings together with antecedents of innovation from the Schumpeter's theory of innovation led to conceptualization of a process framework for big data capabilities in the construction industry. The framework consists of antecedents to innovation, big data capabilities and outcomes. The study addressed the gap of big data capabilities deficit in the construction industry. Practically, the framework can serve as a guide for construction organizations interested in adopting big data in their operations.

Keywords: big data, capabilities, construction, innovation, systematic literature review

INTRODUCTION

Data on construction projects are compiled as progress reports to brief stakeholders on project performance (Omran, 2016). Subsequently, the report informs decisions about the direction of, or changes on the project. Mostly, minute datasets are captured in the report due to reporting templates and inability of stakeholders to process data. Unused datasets becomes idle, occupy space and add-up to waste, though, insight from these datasets can be mined for making well-informed decisions. Generation of data is on the rise due to the use of sophisticated IT devices like sensors, surveillance devices and drones (KPMG International, 2016; Han and Golparvar-Fard, 2017). Currently, data is essential in decision-making and improving processes. Those benefits have

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made data an inevitable resource in firms, necessitating the introduction of Big Data (BD) in the field of data management. In simple terms, BD is the application of sophisticated information technologies to gain valuable insights from large datasets (*volume*), generated at a faster rate (*velocity*) and in different format (*variety*) (Manyika *et al.*, 2011).

BD is intended to enhance business improvement, provided firms are competent and capable to host and manage the BD technologies. Nonetheless, the scanty literature have revealed benefits of BD in construction, cognizance is not given to what it takes for the industry to realize to the fullest, the benefits of BD analytics. This study presents a systematic literature review (SLR) on BD capabilities across different disciplines required in the construction industry.

LITERATURE REVIEW

Schumpeter Theory of Innovation and Big Data

Joseph Schumpeter is one of the progenitors of innovation and economic growth theories. Schumpeter theory of Innovation (Schumpeter, 1934, 2013), business cycle (Schumpeter, 1939) and entrepreneurship (Schumpeter, 1939) are based in economic, political and historical settings. The business cycle theory suggests firms experience fluctuations such as depression and growth due to both internal and external drivers. Nevertheless, firms' ability to make changes to internal drivers through the theory of innovations can lead to economic growth due to the influence of a leader with entrepreneurial qualities. These theories focus on the life, economic growth and production function of business entities.

A change in the production function, either marginally or wholly can improve a firm's economic performance (Schumpeter, 1934). It may include altering the quantity of materials, new equipment, change in supply of commodities and adopting different managerial strategies. These changes are termed as innovation. Impliedly, innovation is adjusting operational routines with the purpose of improving efficiency. External and internal drivers can motivate organizations to change its production function, but Schumpeter theory of innovation considered internal factors. Because innovations are not a response to the external demands but the need for change in firms (Schumpeter, 1934). In perspective, these drivers are within the control of the firm and affects its production function. However, the authors believe external drivers also influence process change in firms. Example is Revit and AutoCAD from Information System (IS) discipline, which are external to the construction industry but impacted the design of construction projects. Also, the effectiveness of BD in other sectors can motivate the construction industry to revisit the poor handling of data. External factors are included to the theory based on the aforementioned reasons. Schumpeter theory of Innovation is used because BD application can improve construction processes and economic growth of firms through the use of data. Furthermore, the theory becomes instrumental in understanding the antecedent for BD applications in the construction industry.

Generally, the use of sophisticated devices and the inability of traditional data analytic technologies to process voluminous and variety of datasets are the main drivers for BD applications (Oracle Corporation, 2014). The construction industry is using sophisticated devices to generate voluminous datasets like videos and images, which traditional technologies are incapable of processing. The internal drivers for BD application in the construction industry include the demand for changes in data

management, use of sophisticated devices, innovations and the need for data-driven management of the construction process. The benefits of these changes are pushed down to customers (Schumpeter, 1934, 1939). Process improvement experienced in healthcare (Wang and Hajli, 2017) and business processes (Wamba *et al.*, 2017). As well as pressures from project environment as witnessed from BIM (Dainty *et al.*, 2017) can motivate the construction industry to explore BD application.

Dynamic Capabilities (DC) and Big Data

The datasets and BD technologies constitute BD application. Drivers for BD application were identified through the Schumpeter theory of innovation, albeit, it is essential to identify the capabilities required for its implementation. Eisenhardt and Martin (2000, p.1107) defined DC as

...the firm's processes that use resources - specifically the processes to integrate, reconfigure, gain and release resources - to match and even create market change...

The definition emphasized the aptness and ability of firms' to respond or make changes in the business environment. Gradually, the construction industry is becoming data driven, requiring firms to adopt processes capable of addressing data mismanagement. Capabilities are developed to enable firms to improve its processes to be competitive in the market (Wamba *et al.*, 2017). Processes, position and path are the essential elements in defining capabilities needed in firms (Teece *et al.*, 1997). Processes involve the integration of activities, learning and experimenting to know the best and quicker way of reconfiguring and executing tasks to meet the dynamism in the market. Position comprises of the processes and assets of the firm including technological, financial, institutional, firms' boundaries and the market. Path involves the past, present and future opportunities available to a firm by assessing the firm's competence and capabilities. Eisenhardt and Martin (2000, p.1106) made three observation of DC. Firstly, DC is adopting the "*best practices*" common amongst similar firms. Secondly, DC involves the manipulation of firms' resources to achieve new value. Thirdly, DC is developed in response to market dynamism. The firm's resources in that context are reorganized and reconfigured to respond to the changing environment (Gajendran *et al.*, 2014). For example, the business world is witnessing technological advancement like BD analytics which requires the manipulation of firm's resources or outsourcing to achieve data-driven management.

The combination of the essential elements of DC thus processes, position and path indicate that sources of data, BD infrastructure, BD analysis and the value from data are the basic capabilities derived from the definitions of BD. Discussing further the essential roles and relevance of the aforementioned components point to the capabilities required to exploit them. Amit and Schoemaker (1993) described capabilities as the ability of a firm to achieve its intended goals through judicious use of resources. Developing capabilities in firms tend to be inspired by demand from clients, paradigm shifts in the industry, external innovators and the firms desire to affect change by addressing challenges. Scholars from other disciplines have explored capabilities needed to run an effective and efficient BD (Mneney and Belle 2016) and BD analytics (Gunasekaran *et al.*, 2017). Different variables were considered in the various scholarly pieces albeit the authors believe all the variables can be subsumed into organizational strategy (Organization), BD infrastructure (Technology), Data and People (BD analyst). Through organizational capabilities, the BD analysts process the datasets using the big data technologies to produce knowledge. Meanwhile, these knowledge become irrelevant until management

experience is applied to understand, decode and interpret the knowledge in improving business value (Bradlow *et al.*, 2017). The decoded knowledge assist management in decision making, improving the competitive advantage and processes of firms (Wamba *et al.*, 2017). However, the relevance of these constructs in construction is still indeterminate and to get a better understanding we have adopted a SLR methodology to develop a theoretical framework.

RESEARCH METHODOLOGY

SLR is conducted to form the basis for new research, identify research gaps and provide summary evidence of existing scholarly works in a discipline (Santos and Da Silva, 2013). SLR is used in this study to identify BD capabilities in literature, which can be further explored in the construction industry. The research question (RQ) for the study is, *what are the capabilities required for the adoption and implementation of Big Data?* The key terms in the RQ became the search terms as shown in Figure 1. Scopus (362) and Web of Science (228) databases were searched. The time period span from the creation of the databases to 3rd January 2018. The downloaded citations and articles were managed and processed using Endnote X8. In all 590 articles were downloaded from the two databases as shown in Figure 1. The PRISMA flowchart (Figure 1) illustrates the processes involved in a systematic literature review to screen and select eligible articles for final extraction and analysis (Moher *et al.*, 2009).

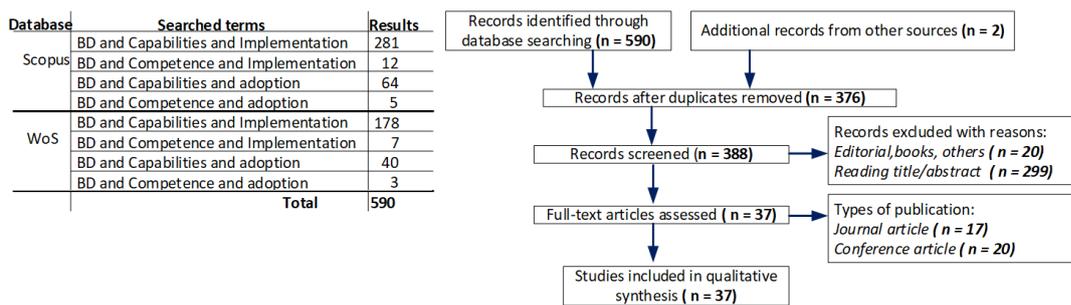


Figure 1 PRISMA flowchart and databases searched

Duplicates and articles not written in English were removed from the Endnote as well as editorials, books, book section. The included articles for qualitative synthesis were peer-reviewed conference and journal publication because high level research findings are disseminated through those medium. Articles on general Information systems and general reviews were excluded after reading the abstracts. Finally, thirty-seven (37) articles were further synthesized according to the classification - organization, data, technology and people - as indicated in earlier sections.

RESULTS AND DISCUSSION

Organizational strategy, data, technology and people were identified under the DC section of the study. The four capabilities were further decomposed after reviewing the thirty-seven articles (Table 1). Some of the selected 37 articles have not been included due to page restriction. The capabilities are discussed below:

Organizational strategy: Firms are required to respond to internal and external changes. The capacity of the firm to run the BD system is ingrained in its functions. Changes can happen in firms provided management shows its commitment (Table 1). For instance, top management commitment significantly influences the acceptance of BD predictive analytics in firms (Gunasekaran *et al.*, 2017). Apparently, it is easy to demand change but implementing change can fail abysmally due to individuals'

reluctance. Nevertheless the business agility and the culture of the firm can facilitate the rate of adoption or acceptance. Investing in the BD system cannot be ignored since it involves monetary commitment from firms. The combined efforts of investment, commitment, culture and business agility as well as external factors inform firms to sanction research and development goals, which subsequently leads to innovation in a firm or industry.

Table 1 Big Data capabilities

Capabilities	Decomposed capabilities	References
Data	Real time data devices (sensors)	Swan (2013); Intrieri <i>et al.</i> , (2017); Lee and Tso (2017)
	Availability data	Gupta and George (2016)
	Structured and unstructured	Leyens <i>et al.</i> , (2017)
	Data quality	Adrian <i>et al.</i> , (2017); Kim and Park (2017)
	Data standardization	Kim and Park (2017)
People	Managerial (Business) skills	Wamba <i>et al.</i> , (2017); Gupta and George (2016)
	Technical skills	Kim and Park (2017); Wamba <i>et al.</i> , (2017); Gupta and George (2016)
	Real time data processor	Liu <i>et al.</i> , (2014)
Technology	Big data infrastructure (Hadoop, fault detection etc.)	Mnoney and Van Belle (2016); Intrieri <i>et al.</i> , (2017); Moyne and Iskandar (2017); Wamba <i>et al.</i> , (2017); Bisson <i>et al.</i> , (2016);
	Scalability	Vargas-Perez and Saeed (2017); Ghiş <i>et al.</i> , (2013)
	Query capabilities	Borkar <i>et al.</i> , (2016); Istephan and Siadat (2016); Papakonstantinou (2016)
	Data mining techniques	Boehm <i>et al.</i> , (2016); Kopczynski <i>et al.</i> , (2017)
	Analytics capability (analytical, traceability, predictive)	Kim and Park (2017); Wang and Hajli (2017)
	Data privacy and security	Adrian <i>et al.</i> , (2017)
	Visual analytics	Jayasingh <i>et al.</i> , (2016)
Organization strategy	Management support	Hallman <i>et al.</i> , (2014); Chen <i>et al.</i> , (2015); Coleman <i>et al.</i> , (2016); Mnoney and Van Belle (2016); Kim and Park (2017)
	Financial resource	Adrian <i>et al.</i> , (2017); Kim and Park (2017)
	Data-driven culture	Gupta and George (2016); Kim and Park (2017)

Data: Processes in firms generate data. Overtly, identifying the what, how and where data can be found is a required BD capability. The first step in data capabilities -what - relates to the forms of data generated and gathered to solve an essential matter. Wenger and Sinha (2013) indicated that the data collected should conform to the firm's strategy. Tacitly, the data should be consistent with the expected outcome and possibly have a standard format, whilst there might be the possibility of having unstandardized data. For example, it is possible to have email communications not following a standardized format, unlike issuance of receipts on transactions. The second issue in data capabilities (*how*) deals with the manner of generating data. It is during this stage that data generating and capturing technologies (DGCT) takes the centre-stage. DGCT includes sensors, smart devices and unmanned aerial vehicles (Table 1). There is not much difference between *what* and *how*. It is important to note that these require firms' commitment to invest in DGCT. The last step critically looks at where data is generated in the firms' processes. For instance, Han and Golparvar-Fard (2017) used unmanned aerial vehicles to capture images and videos of

activities during construction. Succinctly, the business strategy towards the adaption of BD focuses on the firms’ processes which needs serious improvement. An example in the construction industry can be on the construction supply chain, because of the fragmentation of the construction industry which is believed to have a negative effects on the performance of the industry. Though, all the steps in these capabilities are equally relevant but the *where* to get the data, perhaps dictates the other steps.

Technology: the centrality of the BD buzz is using IT infrastructures, which have the capacity to handle volumes of data unlike the traditional ones. Different infrastructures are made available by developers of BD analytics, such as Apache and Hadoop Spark (Table 1). The adapted platform should commiserate and compatible with the data gathered. The technology capability comprises of the hardware and software to manage the datasets (Kim *et al.*, 2011). Wamba *et al.*, (2017) added that the BD technology have to be compatible to the firms’ operations. The ability to apply machine learning techniques to the datasets should be an essential feature of the technology. Examples include using both supervised and unsupervised machine learnings for the purposes of clustering and classifying both structured and unstructured data. The presentation of the knowledge generated through the data analysis process like visual analytics is also vital in having a robust technology (Jayasingh *et al.*, 2016).

People: The implementation of the BD is meaningless if there is no BD expert in the firm. The competencies of the analyst should include technical knowledge, technology management skills, business and relational knowledge (Table 1). This capability might be outsourced, however firms can have an in-house personnel with expertise in managing the BD technologies. The ability of the BD experts to understand the construction processes together with the BD knowledge is an added advantage.

The Integrated Big Data Capabilities Framework

Figure 2 illustrates a holistic framework comprising of drivers of innovation (Schumpeter), BD capabilities (DC), experience and expected outcome on BD analytics in the construction industry. BD applications are highly spoken of in the data management literature and among managers.

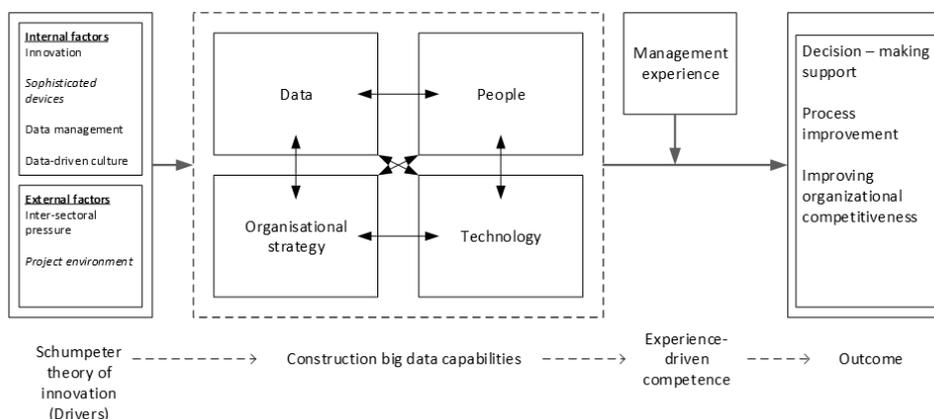


Figure 2 Integrated Big Data capabilities framework

There is a school of thought on whether or not, BD takes the role of managers in making strategic decisions. Bradlow *et al.*, (2017) argued that BD cannot replace the role of managers but a complimentary tool to assist managers. Further, the research

revealed that managers need to rely on theory to identify latent variables in spite of the overwhelming volume of data. This makes it easier for managers to seek for the essential insight needed in a time period rather than being “led astray” by the data.

Figure 2 proposed an integrated framework comprising of Schumpeter theory of innovation and BD capabilities discussed in an earlier section of this paper.

Schumpeter theory of innovation argues that innovation in organizations are motivated by two main drivers - internal and external - but the theory focused on only internal drivers of the firm, which leads to changes in the economics of an entity. The assumption of innovation includes the setting-up of new plant and equipment; new entity for a specific purpose; a leader to lead the change (Schumpeter (1939)); and new source of raw material supply changing the production function (Schumpeter (1934)). Importing ideas and products from one industry to the other - IT devices from IS to construction - is an innovation. The acceptance and success story of innovation encourage competitors to explore its usefulness. Technological advancement in the construction industry like BD contributes to changes in the managerial function of production in an economic entity. Albeit, the construction industry does not necessarily have to set up new entity to make changes as assumed by Schumpeter (1939).

The internal drivers - innovation, sophisticated devices, data management and data-driven management - are motivation for construction firms to use BD (Figure 2). Sophisticated Devices used in the automation of construction generate voluminous and varied real time and secondary datasets which are difficult to process using the traditional data analytic technologies. Moreover, the construction industry do not necessarily mine datasets for improving its processes but store these data as evidence for litigation purposes.

Having data-driven culture can motivate construction firms to use BD in predicting profit margins, overheads and contingency sums for project and alternative ways of reducing the duration and cost of projects. Externally, the impact of BD in other sectors to improve its processes becomes an incentive to use BD in construction.

The identification and strengthening of the four capabilities (Table 1) are expected to make construction firms proficient to use BD. Knowledge is produced after the BD experts process the generated datasets in the BD technologies. Knowledge becomes useless if it is not decoded and interpreted to solve organizational problems. Therefore the success of the BD also depends on management ability to comprehend the knowledge generated from the datasets. This informs the decision to introduce management experience as a critical factor in the theoretical framework above. The application of management experience on the produced knowledge can assist in decision making, improve construction processes and make organizations competitive.

CONCLUSION

Drivers and capabilities are two most important factors needed to adopt and implement BD application in the construction industry. The generation of exponential volume of data continue to edge firms to adopt advance data analytics like BD application to mine valuable insights to the benefits of the firm. The study identified four BD capabilities - data, technology, organizational strategy and people - from the perspective of dynamic capabilities through a SLR. These capabilities together with drivers of innovation (Schumpeter theory of innovation), experience and expected outcome of BD analytics led to the development of an integrated framework for big

data capabilities. This study has highlighted the gap of BD analytics capabilities deficit in the construction industry. Practically, the framework can serve as a guide for construction organizations interested in adopting big data in their operations.

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APPLYING RADIO FREQUENCY IDENTIFICATION TAGS TO IMPROVE PERSONNEL SAFETY IN DREDGING CONSTRUCTION

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Falling overboard, slips, trips and falls cause most of the workplace injuries that occur in the dredging construction. Some of the factors that contribute to these accidents include very congested work areas; oil, ice or snow-covered decks; worker fatigue; lack of visibility; and rough seas that result in shifting work platforms. Utilizing RFID technology has the potential to help reduce these on-board accidents. The objective of this research was to evaluate the effectiveness of radio frequency identification (RFID) tag technology in providing individual personnel safety monitoring on a dredge. Four experiments using passive RFID tags were conducted to test the hypothesis that the use of RFID would create a safer environment on a dredge by providing the dredge captain with real-time monitoring of the dredge crew. This real-time monitoring would provide an immediate notification to the bridge should a crewmember fall overboard or be in an unauthorized mechanical space when the dredge is in operation. This preliminary research compared several types of passive RFID tags to determine which one is the most effective for this application. During these evaluations, RFID tags were worn on lanyards and on the front of the hardhats of the workers. The RFID readers were located in four locations on the dredge. Based on performance testing, the most accurate combination of RFID tags and readers were Smartrac R6 RFID tags and the Far Field RFID reader which reported crew locations with 92% accuracy. Future research will focus improving accuracy and installing a complete RFID reader system on a dredge in order to perform operational testing. If this future operational testing proves to be sufficiently reliable, this technology has the potential to improve safety and reduce fatalities in the dredging industry and other related marine industries.

Keywords: abstract, safety, dredging, RFID

INTRODUCTION

The specialty construction sector, marine construction, is unfortunately plagued with accidents. Three hundred and five workers were killed on barges or during towing operations in the United States between the years of 1997 and 2006 (OSHA 2009). Many of these accidents (and other recordable workplace accidents) occur due to slips, trips and falls. Root causes of these slips, trips and fall can include rapidly changing direction when walking, slippery surfaces due to oil, snow and ice, fatigue, lack of visibility, and unsuitable footwear (OSHA 2009).

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Specifically, work on dredger vessels is particularly hazardous. Hopper dredgers use suction pumps to remove sediment from shipping channels. The sediment is pumped into an open hopper in the hull of the ship. When the hopper is full, the ship travels to a disposal area out to sea. Once it arrives, the hull of the dredger opens like a clamshell allowing the sediment to be dumped into the disposal area. It is imperative that the dredger captain knows the location of all crewmembers during this operation to insure no one becomes caught between the moving machinery or cast overboard when the hull opens. Other hazards include falling overboard during dredging operations or falling into the dredger hopper and becoming trapped in the sediment as it is pumped on board.

Radio frequency identification is a method of communication that utilizes embedded radio waves and location-range imaging to provide non-contact automatic identification and location services. The construction industry is currently utilizing Radio Frequency Identification (RFID) tags to track material and equipment movements on civil and commercial jobsites. Marine construction contractors see the value of this technology, and RFID tagging is currently being tested for use in tracking material and equipment both on deck and underwater. However, the use of RFID tagging to track personnel in the dredging industry is non-existent. The balance of this paper describes an exploratory research study completed to discern (1) the effectiveness of tracking workers in a marine construction setting with RFID tags, (2) how placement of RFID tags on personnel (meaning the location of the RFID tag itself on the person) effects tracking capabilities, and (3) what currently available commercial RFID equipment is most effective in a marine construction setting. A brief literature review regarding RFID technology is provided, along with the methodology for the study. Conclusions are discussed, along with limitations of the study and future research avenues.

LITERATURE REVIEW

Information has been said to be the most critical resource in the post-industrial age, as labour was in the agricultural age, and capital was in the industrial age (Donyavi and Flanagan 2011). Radio-frequency identification (RFID) is defined as a branch of automatic identification (auto ID) technologies in which radio frequencies are used to capture and transmit data (Jaselskis *et al.*, 1995, Jaselskis and El-Misalami 2003). RFID systems consist of tags, antennae, readers, application software, and computing hardware. RFID tags consist of an integrated circuit with memory (i.e. a microprocessor chip) and can either be battery operated (i.e. active) or non-battery operated (i.e. passive) (Taneja *et al.*, 2011.) The chip has a specific identity that is broadcast to a reader operating on the same frequency (Ngai *et al.*, 2007.) The basic process includes the transceiver sending out radio frequencies to the tags within a given area (or a grid of specified areas), and the tags sending a signal back to the transceiver. Antenna are used for communication between the tags and the readers, to which design and placement of the antenna is a crucial part of determining the coverage zone, range, and accuracy of communication (Ngai *et al.*, 2007.) A line of sight between the receiver and the RFID chip is not required for communication, which is the driving force for the usage of this technology over bar coding systems (Omari *et al.*, 2009, Taneja *et al.*, 2011, Awolusi *et al.*, 2018). RFID technology is the most commonly used system for proximity detection of material, equipment, and workers (Awolusi *et al.*, 2018).

The number of academic research studies into RFID implementation in construction have grown substantially over the past 20-plus years. Ngai *et al.*, (2007) reviewed 85 academic articles published between 1995 and 2005, two of which were related to construction. Li *et al.*, (2016) expanded on this work, reviewing 75 articles published between 2005 and 2014, all dealing with real-time location tracking (RTLS) in the construction sector. One abundant RFID research topic has been the location tracking of materials and tools on construction jobsites and production facilities, including ready-mixed concrete production and delivery (Jaselskis *et al.*, 1995, Moon *et al.*, 2017), float glass production (Gil and Kahn 2004), precast concrete component tracking in supplier storage yards (Ergen *et al.*, 2006), tool tracking via an intelligent toolbox (iBox) (Goedert *et al.*, 2009), material, and equipment installation progress (Omari and Moselhi 2009), indoor management of construction materials (Kim *et al.*, 2011), material movement by tower cranes (Li *et al.*, 2013), and residential prefabricated panels (Altaf *et al.*, 2017).

As stated by Kanan *et al.*, (2018), “even though labourers are trained to stay away of potential dangers, there are still many types of risks that can occur within only a few minutes of carelessness.” RFID systems can be structured to work together on site to reduce the safety issues that may occur due to human error or lack of proper safety training (Donyavi and Flanagan 2011, Marks and Teizer, 2013), providing real-time information visibility and traceability for construction firms (Lu *et al.*, 2010). Enhancing worker safety with the use of RFID has garnered much attention is worker safety, including general worker location tracking onsite (Song *et al.*, 2006, Montaser and Moselhi 2014, Fang *et al.*, 2016, Awolusi *et al.*, 2018), the alleviation of worker back-over accidents around heavy equipment (Chae and Yoshida 2010, Kanan *et al.*, 2018), worker personal protective equipment (PPE) usage (Kelm *et al.*, 2011), worker location tracking on underground works (Ding *et al.*, 2013), tracking of “near-miss” accidents (Wu *et al.*, 2010), and tracking of “struck by falling object” accidents (Wu *et al.*, 2012).

According to Li and Becerik-Gerber (2011), “academia has achieved remarkable accomplishments in RFID research, but the solutions must be better integrated with the industry to transform the academic development into industry productivity.” This sentiment is echoed by several other researchers (Donyavi and Flanagan 2011, Ngai *et al.*, 2007, Zhou *et al.*, 2013). Li *et al.*, (2016) found that of the RTLS publications reviewed, nearly half of the research was experimental in nature without implementation on actual construction projects.

Moreover, Fang *et al.*, (2016) state that RFID integration into the construction process faces implementation challenges, including (1) poor system scalability for full-scale implementation on arbitrary sites, (2) heavy infrastructure on site for data processing and visualization, (3) lack of effective strategy for visualizing location information, and (4) limited capability for sharing location data of construction resources across remote users.

In summary, RFID is a highly researched and relevant technology in the construction field. Research into RFID implementation to improve worker safety on construction sites has been completed with promising results, but there is a research gap regarding RFID implementation to improve worker safety in marine construction settings. Lastly, RFID research that informs and involves industry is somewhat lacking, but highly regarded and suggested.

METHODOLOGY

The research methodology consisted of 3 steps to meet the research objectives:

- Outfit an active marine construction dredging vessel with RFID transceivers from different commercial suppliers
- Outfit construction personnel (i.e. crew members of the dredging vessel) with passive RFID tags (passive tags chosen due to their pervasiveness in the construction industry) from different commercial suppliers
- Collect data on construction personnel movement around the ship utilizing the RFID equipment

The research team chose to test the effectiveness of two RFID receivers: the Impinj Mini-Guardrail ILT, and the Impinj RHP Far Field RFID, and two RFID tags, the Omni-ID ADEPT 650P RFID Tag, and the Smartrac R6 Dogbone RFID Tag. The Omni Adept tag was connected to a lanyard and hung from the crew members necks (as shown in Figure 1), and the Smartrac R6 Dogbone RFID tag was attached to the crew member's hard hats (as shown in Figure 2).



Figure 1: Omni-ID ADEPT 650P RFID Tag



Figure 2: Smartrac R6 Dogbone RFID Tag

The research team also chose four separate locations on the dredging vessel: (1) On-boarding/off-boarding entrance to the dredge, (2) the staircase leading up to the bridge, (3) catwalk next to the dredge hopper, and (4) the entrance to the stern engine room, shown below in Figure 3. The entry staircase test location was selected since this is the point of entry/exit onto the dredger. This would be an obvious location to

install a passive RFID reader should the system be implemented on an operational basis in the future. The bridge staircase location was selected because it was relatively unobstructed. This provided a good comparison to the more congested areas on the dredger. The catwalk next to the dredger hopper is a very narrow, congested area. Since this area is congested with a large amount of metal machinery, the thought was that this would offer a good test to determine if the passive RFID signal would be adversely affected by interference from the electrical systems and density of the large metal objects in this location. The last location, the entrance to the stern engine room was selected based on the dredger captain's suggestion. He stated that knowing if personnel are in the engine room is a critical safety concern during operation and maintenance of the dredger.

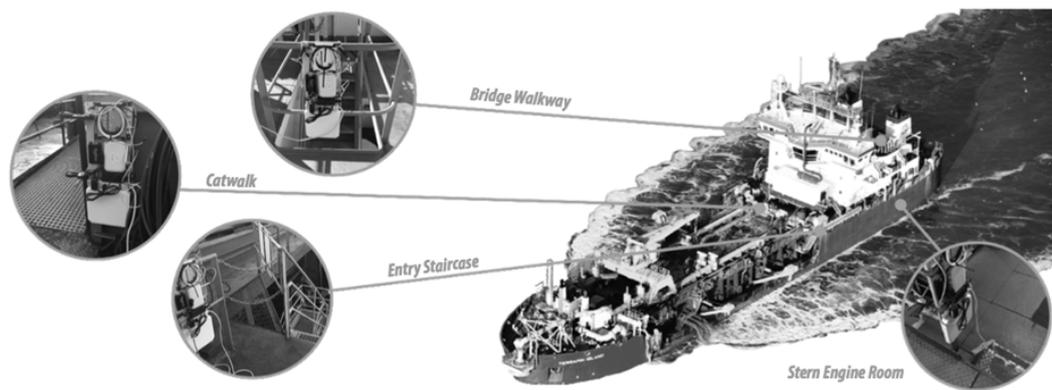


Figure 3: Location of RFID Readers

Five crew members were outfitted with both of the RFID tags. Each of the five crewmembers walked past each of the transceivers, the combinations of which are provided in Table 1. At each of the test four locations, five crewmembers wore a passive tag and walked passed one of the two readers. The five crew members were selected at random but varied in height from between 5'-6" and 6'-2". The number of crew members participating in the evaluations were limited to five due to availability. However, as can be seen below, each evaluation was conducted multiple times in order to obtain sufficient data. For each combination of tags and reader, the crewmember walked by four separate times. The exception to this methodology was at the engine where only four crewmembers participated in the testing. Therefore, 80 readings were taken at each location except the engine room where only 64 readings were taken. For the first two passes, the RFID readers were attached to their hardhats. For the remaining two passes, the readers were attached to lanyards.

Data collection of the test results were recorded using the Impinj Speedway Revolution R420 UHF RFID Reader Evaluation Kit (4 port) and recorded on a laptop in order to analyse the results.

RESULTS

The researchers conducted their experiment on a dredging vessel, the *Terrapin Island*, in the Savannah, Georgia harbour on the east coast of the United States. The experiment was conducted over two days in October of 2016. Table 2 contains the overall results for the four RFID reader/RFID tag combinations evaluated. A reading was considered to be "successful" if the RFID transceiver recorded the crew member's RFID tag as the passed the transceiver. As shown, the most accurate combination of RFID tags and readers was the Smartrac R6 tags and Far Field reader

at 92% accuracy. The least successful combination was the Smartrac R6 tags and the Mini Guard reader at 0% accurate readings.

Table 1: Combination of tags and readers at locations

Location	Equipment	Test #1	Test #2	Test #3	Test #4
Dredge Entrance	RFID tag	Omni-ID	Omni-ID	Smartrac R6	Smartrac R6
	Tag reader	Far Field	Mini-Guardrail	Far Field	Mini-Guardrail
Bridge Stairway	RFID tag	Omni-ID	Omni-ID	Smartrac R6	Smartrac R6
	Tag reader	Far Field	Mini-Guardrail	Far Field	Mini-Guardrail
Catwalk	RFID tag	Omni-ID	Omni-ID	Smartrac R6	Smartrac R6
	Tag reader	Far Field	Mini-Guardrail	Far Field	Mini-Guardrail
Engine Room	RFID tag	Omni-ID	Omni-ID	Smartrac R6	Smartrac R6
	Tag reader	Far Field	Mini-Guardrail	Far Field	Mini-Guardrail

Table 2: Summary of test results for each equipment combination

RFID Reader/RFID Tag Combination	Percent Successful Readings
Omni-ID/Mini-Guardrail	76%
Omni-ID/Far Field	67%
Smartrac R6/Mini-Guardrail	0%
Smartrac R6/Far Field	92%

Table 3 summarizes the test data for each equipment combination based on where the crewmembers wore the RFID readers. As shown, the location of the RFID tags on the crewmember’s hardhats provided successful readings greater than 80 percent for three of the four RFID transceiver/tag combinations, while the lanyard location only provided successful readings greater than 80 percent with one of the combinations.

Table 3: Summary of test results for placement of RFID reader

RFID Reader/RFID Tag Combination	Location on Crewmember	Percent Successful Readings
Omni-ID/Mini-Guardrail	Hardhat	97%
	Lanyard	53%
Omni-ID/Far Field	Hardhat	84%
	Lanyard	39%
Smartrac R6/Mini-Guardrail	Hardhat	0%
	Lanyard	0%
Smartrac R6/Far Field	Hardhat	92%
	Lanyard	92%

ANALYSIS

Research objective (1): Discern the effectiveness of tracking workers in a marine construction setting with RFID tags

The research results showed that the use of RFID tags to track worker movement on an active dredging vessel is effective. Overall, the equipment tested provided accurate readings of crew member movements in various positions on the ship. These results show that RFID technology could be utilized by marine construction contractors as a safety measure to track the movements of personnel, and warn them when entering areas of potential danger on an active dredging vessel.

Research objective (2): How does placement of RFID tags on personnel (meaning the location of the RFID tag itself on the person) effect tracking capabilities

The most successful location for wearing the RFID readers was on the crewmember's hardhats, as opposed to the lanyards, in this experiment. That being said, the researchers observed six items that may have been a factor in these results:

1. Omni-ID tags, worn as lanyards, would move behind and be blocked by the crewmember's jackets or safety vest.

The crewmember's hands or arms sometimes blocked Omni-ID tags, worn as lanyards, as they passed the readers.

On occasion, two crewmembers walked by the reader at the same time, wearing the Omni-ID tags. During the experiment, one person blocked the other person's tag and prevented it from being read.

The distance from the location of the Smartrac R6 sticker, worn on the hardhat of the crewmembers, to the Mini Guardrail reader, was too far to create a reading.

The Dredge Entrance Stairway, contained large amounts of steel that, on occasion, impeded the Mini Guardrail reader from picking up both the Omni-ID tags and the Smartrac R6 tags.

During two tests at the Catwalk, two of the five tags were not read while using the combination of Omni-ID tags and the Far Field readers. The cause for this error could not be determined. It is assumed an equipment technology error occurred. The definite cause remains unknown.

The testing indicated the best place for the RFID tags to be worn was on crewmembers' hardhats since this minimized the possibility of the interference from clothing, arms, other crewmembers, etc. However, it should be noted that wearing the RFID tags on hardhats is not as secure as wearing the tags on lanyards since crewmembers are not required to wear chin straps on their hardhats. Therefore, if hardhats fall off or are taken off, the ability to track crewmember locations will be lost and may result in the issuance of a false alarm. This potential problem can be mitigated by requiring the crew to use chinstraps when wearing their hardhats.

It should also be noted that the crewmembers who were test subjects had numerous questions how this technology might be used in the future. It was evident from the nature of their questions they were concerned about the captain having real-time data concerning their locations. In other words, they were concerned about "big brother watching". If this technology were to be implemented in the future, a key component of implementation would be crew education to assure them that the system would be used to enhance their safety.

Research objective (3): What currently available commercial RFID equipment is most effective in a marine construction setting

Overall, the most effective equipment combination when all tests were considered was the Smartrac R6 tags and the Far Field reader with a success rate of 92%. However, this equipment combination was surpassed by the Omni-ID tag and Mini-Guardrail reader combination when the tags were worn on hardhats. The equipment combination of Smartrac R6 tags and Mini-Guardrail reader proved to be ineffective. This equipment combination was tested prior to deployment in the field and appeared to work. However, as noted in the field observations, this combination had insufficient range to register any readings.

CONCLUSIONS

RFID technology has shown to be an effective tool for contractors to track material and equipment movement across a construction jobsite. The research described in this paper has shown that RFID technology may also provide benefit in the marine construction arena as a safety measure.

Much more research is needed to discern the true effectiveness of RFID technology as a safety measure beyond what was presented in the paper, as the experiments conducted by the researchers were only conducted on one vessel, over a short amount of time (i.e. two days), and with only five construction personnel. Future studies should be conducted over a longer period of time, and with more crewmembers participating. Only one type of RFID tag technology (i.e. passive) was tested by the researchers. Future research should also include the testing of semi-passive and active tags to discern if different technologies provide different results. Finally, future research should be conducted on different types of vessels and in differing weather conditions to determine how those factors may affect the use of the RFID equipment.

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REAL-TIME OBJECT DETECTION SYSTEM FOR BUILDING ENERGY CONSERVATION: AN IP CAMERA BASED SYSTEM

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In the contemporary world, there is a rapid introduction of automated and intelligent building systems. These technologies offer new and exciting opportunities to increase the connectivity of devices in built environments, particularly for energy conservation. Most of the developed building energy conservation systems are based on sensors, thus, the application of those systems is limited to small spaces due to maintainability issues. The reliability of these sensor-based systems is still argued as sensors are not capable enough for multi-person tracking and real-time object detection. Giving emphasis to these limitations, the current study introduces a real-time object detection, tracking and counting system for building energy conservation particularly, for HVAC and lighting based on IP CCTV cameras. An experimental research design was employed for the study. Initially, CCTV images from three objects: human heads, lighted vehicles, and non-lighted vehicles were collected from 12 offices. Subsequently, these objects were trained using the machine learning and the real-time object detection was performed using a Single Shot Detector model. The proposed system was developed using the Python programming language. The developed system comprised of three basic features namely, object detection, object tracking and counting, and HVAC and lighting control. This system enables real-time object classification for human heads, lighted vehicles, and non-lighted vehicles, therefore, reduces excessive energy consumed by air conditioning and lighting depending on the nature and movements of the objects. With the use of this system, facility managers can make built environments much comfortable for occupants while deducting excessive energy consumption and human effort taken to manage comfort levels of buildings.

Keywords: energy conservation, IP CCTV camera, detection, real-time tracking

INTRODUCTION

Energy consumed in buildings is a significant fraction of that consumed in all end-use sectors. Although percentages vary from country to country, buildings are responsible for about 30 to 45% of the global energy demand (Asimakopoulos *et al.*, 2012). For instance, buildings consume approximately 41% of total primary energy use by sector in the US (United States Department of Energy [USDOE] 2012) and particularly, 18% (17.4 out of 97.4 quadrillion Btu) from commercial buildings (USDOE 2012). Further, a significant share of energy is consumed by Heating, Ventilation and Air

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Conditioning (HAVC) systems (Sane *et al.*, 2006) and lighting (Yun *et al.*, 2012) systems in buildings. According to Perez-Lombard *et al.*, (2008), energy consumption from the HVAC system and lighting requirements in a typical building range between 45 to 55% and 20 to 35% from its operational energy consumption respectively.

Giving this dramatic increase in energy consumed by HVAC and lighting systems, the energy efficiency of system components for HVAC and lighting have improved considerably over the past 20 years (American Standard Inc. [ARI] 1999). In contrast to energy conversion equipment, less improvement has been achieved in optimum control in terms of energy efficiency distribution for conditioned air and peak load reduction potential. Therefore, advancements are also needed to improve the control systems and systems integration from a whole building perspective while meeting occupant comfort and performance requirements (National Energy Technology Laboratory [NETL] 2000).

Referring to lighting systems, daylighting strategies have been studied and proposed in order to reduce artificial lighting energy demands (Mardaljevic *et al.*, 2009; Yun *et al.*, 2011). Further, Yun *et al.*, (2010) study concludes that lighting controls in connection to daylighting can save lighting energy demands by 20 to 40%. In a different point of view, Lindelöf and Morel (2006) investigations on light switching patterns during working hours revealed that lights are 'ON' although daylight is enough to provide adequate illumination.

Despite these simple energy saving techniques, the world has taken a move towards advanced building energy management systems. Accordingly, the implementation of a combination of various technologies under the title of “Building Automation”, “Smart Buildings”, and/or “Building Management System (BMS)” are increased (Jan Bozorgi and Ghannad 2009). Since monitoring the accuracy of any controlling system in industrial, commercial, and residential environment separately requires time, energy and presence of manpower in the place, it is necessary to implement an integrated management system, which is able to display information and arrange all smart controlling systems in a short time. BMS as a unique and modern way to fulfil this need have been applied in most of the developed and developing countries and it has proven its abilities in the field of managing all kinds of smart controlling systems applying in industrial and non-industrial environments.

Different technologies are currently employed for BMS with different benefits and evaluations. Amongst, hard-wired networks have long been used in BMS (Dinh and Kim 2012). However, authors further posit that this approach is inflexible in design due to high cost and difficulty in renovations. Later, advances in Wireless Sensor Networks (WSN), including hardware, software and emergent standards have demonstrated the strength of WSNs. WSNs as a key solution are alternatives to a wired approach in the BMS field (Brambley *et al.*, 2005). WSNs are used in many kinds of application in BMS including HVAC, lighting, air quality and window controls, and security and safety systems, which use different types of sensors such as light sensors, gas sensors, movement, motion sensors and more. However, the WSNs for BMS is still challenged due to its interoperability, integration failures, overhead and low bandwidth problems of the constrained environment (Dinh and Kim 2012).

Besides, many pieces of research have been carried out on predictive controllers and real-time control models for building energy conservation over the years. For instance, Henze *et al.*, (2011) have been introduced a model-based predictive optimal control for active and passive building thermal storage inventory. The second

category of research uses also the predictive control but it introduces real-time control model in order to give more benefits contrary to Henze *et al.*, (2011). For example, Mishra *et al.*, (2013), Kimbley *et al.*, (2016), and Yuganandhine *et al.*, (2017) have been proposed automatic room light and fan controller with bidirectional visitor counter systems using IR sensors over the years. Furthermore, Kastner *et al.*, (2005) introduced a basic requirement, services and application model for BMS, and Ploennigs *et al.*, (2006) analysed a network in BMS and proposed an automated model. A fuzzy logic control is implemented for building illumination and temperature control in Lah *et al.*, (2005). A novel multi-agent control system for managing the comfort level of the building environment is proposed in the research of Dounis and Caraiscos (2009). From the literature, it is observed that most of the theoretically developed and practically implemented systems for building energy conservation especially for HVAC systems and lighting have been based on sensor technologies, which subject to practical limitations such as

Inflexibility in design: sensors are only capable of detecting objects within a limited space where the sensor is installed

No object classification: sensors are only capable in object detection but unable to classify objects (i.e. if an object moves across the infrared rays, the system just count it as an object without knowing whether it is a live object or not)

No real-time object tracking: unable to identify the exact location of a moving object

Expensive in implementation: building owners have to install an excessive number of sensors, which is costly. Therefore, not appropriate for large-scale buildings

Giving emphasis to these limitations, very recently, Akkaya *et al.*, (2015) have opined that CCTV systems as an improved way of object detection, tracking and counting in real-time for energy conservation in open building spaces despite the common goal of using CCTV systems for the prevention of crime and disorder by tracking and observation. However, this approach still has not been converted into a system design or implemented within buildings for the purpose of energy conservation. Unlocking this potential constitutes the motivation for this work. Occupant behaviour is a crucial factor in determining HVAC and lighting energy use in buildings (Masoso and Grobler 2010). With this motivation, this paper introduces a novel building energy conservation system based on real-time object detection, tracking and counting using IP-based CCTV cameras in order to tackle several of these needed advancements.

RESEARCH METHODS

The study employed an experimental research design to develop the proposed building energy conservation system. Initially, CCTV images of three selected objects including human heads, lighted vehicles, and non-lighted vehicles were collected from 12 office buildings (i.e. working areas and car parks). A sample image taken for the study is shown in Figure 1. The selection of 12 office buildings was based on the convenient sampling as the requirement is just to collect a possible amount of CCTV images within office premises. Then, a list of bounding boxes (xmin, ymin, xmax, ymax) were defined for all the objects within collected CCTV images in order to prepare the input .csv formatted file for the analysis. Next, the collection of coordinates defined CCTV images were divided into two as images taken for the object training (90%) and for the model testing (10%).



Figure 1: A sample CCTV image

Subsequently, these images were trained using the machine learning: TensorFlow framework integrated with the Single-Shot Multibox Detector (SSD) mobile net software to export the inference graph. Compared to other object detection methods such as Region-Based Fully Convolutional Networks (R-FCN), You Only Look Once (YOLO), and Deeply Supervised Object Detector (DSOD), SSD has much better accuracy and faster even with a smaller input image size (Liu *et al.*, 2016; Shen *et al.*, 2017). SSD is simply relative to methods that require object proposals as it completely eliminates proposal generation and subsequent pixel or feature resampling stages and encapsulates all computation in a single network (Liu *et al.*, 2016). The code is available at

http://download.tensorflow.org/models/object_detection/ssd_mobilenet_v1_coco_2017_11_17.tar.gz

The TensorFlow framework provides an iterative machine learning process until the user breaks the process once it resulted in the optimum inference graph considering the total loss value provided. The total loss represents the percentage of failure in object classification and localization with test data. Although there is no exact number or rule of thumb to determine the number of images required for the object training, TensorFlow framework itself determined the ideal number of images required depending on the total loss of test. Accordingly, the analysis resulted in a total loss lower than 1% with the use of 1000 CCTV images indicates that there is a greater accuracy in the inference graph developed. Therefore, it was taken as the optimum trained model for the object detection in this study.

The building energy conservation system is constructed using the Python programming language. And also, the system comprised of a number of components that every component has its own function integrated to each other for completing the whole system to functioning. The system further includes a MySQL Database in order to store configuration data relating to pre-defined building zones and customised standards for HVAC and lighting control.

Finally, the proposed system design was validated through few discussions held with seven experts in the fields of building operations and Information Technology (IT). This approach for software validation has been approved by Boehm (1984). In detail, three experts are Chief Engineers who possess more than twenty years of experience in building operations while the other is a Facility Manager whose experience is eight years. In addition, all three IT experts are Senior Software Engineers who have more than seven years of experience in the field of software development.

PROPOSED SYSTEM DESIGN

The system introduced for the building energy conservation in this study basically consists of 03 features. They are real-time object detection, object tracking and counting, and controlling of HVAC and lighting devices.

Real-Time Object Detection

The inference graph obtained through the object training process mentioned in the research methods was input to the proposed system design, which configured to the SSD. Hereafter, this SSD configured inference graph is called as the SSD model within the proposed system that provides the classification of objects for real-time CCTV stream images. The output provides a label and coordinates for each object together with its probability of being that particular object. A sample image derived by the real-time object detection function within the proposed system is shown in Figure 2 and 3.



Figure 2: A sample output of object detection (Humans)



Figure 3: A sample output of object detection (Lighted vehicle)

As shown in Figure 2 and 3, the SSD model has been perfectly functioned to classify the objects (i.e. human heads and lighted vehicle) in CCTV images taken from the CCTV video streams.

Real-Time Object Tracking and Counting

With the use of aforementioned SSD model, a number of objects from each category were calculated and determined the exact building location, where it is located at the very time. In order to proceed this, a MySQL Database was developed and it includes coordinates for each and every pre-defined zone. A sample diagram of the developed database is presented in Figure 4.

Zone Mapping	
PK	zone_id
	lb_coordinates
	lu_coordinates
	rb_coordinates
	ru_coordinates
	ea_zoneid
	su_zoneid
	we_zoneid
	nt_zoneid

Figure 4: Zone mapping table structure

As shown in the zone mapping table structure, each zone has four coordinates such as lb - left bottom, lu - left upper, rb - right bottom, and ru - right upper. These coordinates help to determine the exact zone of the detected object. Furthermore, it includes outer boundaries for each zone namely, ea - east, su - south, we - west, and nt - north.

Accordingly, Figure 5 shows a sample of an integrated image of two camera streams together with pre-defined zoning coordinates.



Figure 5: A sample of an integrated image of two camera streams

At the same time, the system counts the number of objects for each category for all zones.

HVAC and Lighting Controlling

As the next step, the developed system calculates percentages for the amount of HVAC and lighting requirements within each specific zone. For example, the number of lights to be turned on or/and the degree of air conditioning dampers to be opened for a given zone is calculated according to the number of objects detected and their behaviour. These calculations are based on the data stored in the developed database and Figure 6 shows the table structure of setup data for HVAC and lighting controls.

Zone HVAC and lighting initial setup		Lighting Setup for object	
PK	zone_id	PK	object_id
	minL_precentage		cuzoneL_precentage
	minHVAC_precentage		eazoneL_precentage
	minlp_humancount		suzoneL_precentage
	maxlp_humancount		wezoneL_precentage
	minhvac_humancount		ntzoneL_precentage
	maxhvac_humancount		svalidity_duration

Figure 6: Table structure of setup data for HVAC and lighting controls

The fields shown in the table structure of setup data for HVAC and lighting controls are defined as follows.

Zone id - unique identity for the zone

minL - minimum lighting percentage required for the zone

minHVAC - minimum degree of air conditioning damper to be opened for the zone

minlp_humancount - the minimum human count that minL should apply

maxlp_humancount - the maximum human count that 100% of lights to be turned on

minhvac_humancount - the minimum human count that minHVAC should apply

maxhvac_humancount - the maximum human count that 100% of AC required

Compared to HVAC, lighting behaves in a different way. Therefore, lighting percentage required for a zone should be mapped according to the detected object: human or lighted vehicle or non-lighted vehicle. As shown in Figure 6, there is a separate table structure for lighting setup for objects and fields of the given table are defined in below.

object_id - unique identity for the object

cuzoneL - lighting percentage for the object in the detected zone

eazoneL - lighting percentage for the east zone of the detected zone.

suzoneL - lighting percentage for the south zone of the detected zone.

wezoneL - lighting percentage for the west zone of the detected zone.

ntzoneL - lighting percentage for the north zone of the detected zone.

svalidity_duration - the period of time that the generated control signal to be kept

The control signals generated for each and every zone will be transferred to HVAC damper controllers (ATMEGA microcontroller) and lighting controller devices using the Wireless Transceiver Module. These controlling signals will provide the necessary level of illuminance and conditioned air to pre-defined zones based on the real-time object detection, tracking and counting. For example, an air conditioning damper installed within a zone will rotate as per the calculated percentage.

In addition to aforementioned explanations, a process chart illustrating the entire system procedure is presented in Figure 7. The validity of the proposed system design shown in Figure 7 has been evaluated via informal discussions held with experts in the fields of building operations and IT. Accordingly, four experts engage in buildings operations confirmed that the implementation of this system will meet user requirements and ultimately leads to reduce excessive energy consumed by HVAC and lighting systems installed in office buildings. Further, the credibility of the proposed system design is assessed by three experts in software development and confirmed that the system meets user requirements.

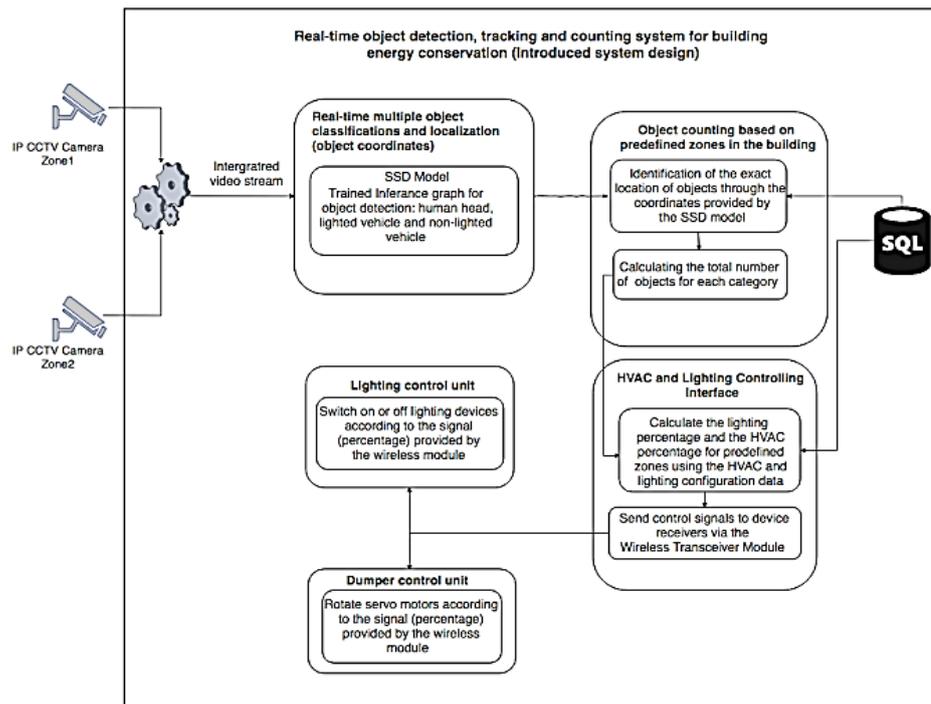


Figure 7: The process chart of the system design for building energy conservation

DISCUSSION AND CONCLUSIONS

This study introduces a novel system for building energy conservation through real-time object detection, tracking and counting using IP-based CCTV cameras. The objective function selected for the system designed in this study is the minimisation of building operating costs while optimising energy consumed by HVAC and lighting devices. Unlike previous systems developed by Mishra *et al.*, (2013), Kimbley *et al.*, (2016), and Yuganandhine *et al.*, (2017), this system enabling energy conservation by optimising the energy requires for both HVAC and lighting systems as those are dominant energy consuming end-users in buildings. Furthermore, the system is based on IP-based CCTV cameras, therefore, eliminates the limitations exists in currently using sensor-based systems. Very importantly, the developed system featured with the real-time object detection, classification, tracking and counting, which cannot be achieved via sensors. Simply, this system enabling changing the comfort levels of the building environments within few milliseconds.

Moreover, the cameras used for this system can be alternatively used for the security purposes as well thus, effective in cost aspects. In addition, the wireless network proposed for the system makes it convenient for the implementation and flexible in design. Refereeing to the advanced features used in this system, the system keeps the pre-defined minimum lighting and HVAC percentage as the default value for a given zone and then it is changed according to the signal provided by the wireless module depending on the real-time results of object detection, tracking and counting. This control signal will keep only for a pre-defined signal validity duration and once it expires it is back to the default minimum percentage. This feature leads to reduce an excessive amount of energy consumed by HVAC and lighting systems consequently, cause a significant reduction in the cost of building operations.

Despite having many improvements compared to the existing building energy conservation systems, the application of the developed system is limited to the open

spaces in buildings due to privacy features violated with the use of cameras. The system can be easily implemented to any place where IP CCTV cameras are in operation and this will be a steadfast system to track the real-time occupancy and energy consumption of buildings, which is a challenging task to Facility Managers. In addition, although the figures mainly show objects identified in office environments, this technology and system design will prove useful on construction sites and for construction management, particularly in the management of operatives, and plant and equipment.

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STRATEGIZING AS IDENTITY WORK: CREATING HEROES IN INTERNATIONAL CONTRACTING

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There has been little emphasis on the role of narratives in competitive strategy within the context of construction management research. This paper draws from the ‘narrative turn’ in organisation studies to explore strategizing activity through the lens of ‘identity work’. It is argued that identity construction is a process whereby individuals create temporal narratives for the purposes of legitimising themselves and their actions. Such processes refer to a continuous and temporal interaction between different levels whereby self-identities are formed by mobilizing resources from lived experience and accepted formalised narratives. The empirical analysis focuses on strategy narratives within the Turkish international contracting sector. Turkish firms are famed for their ability to work in challenging markets. Of particular interest is the way in which managers within Turkish contractors commonly ascribe to themselves a self-identity as heroes who constantly strive to overcome adversity. Such ongoing processes of identity work are seen to progressively shape not only the trajectory of individual contracting firms, but also the Turkish construction sector as a whole.

Keywords: narrative turn, identity work, strategizing, Turkish contractors

INTRODUCTION

“We can be heroes just for one day” (David Bowie, 1977)

Competitive strategy in international construction has long been an area of interest for construction management researchers. Much of the literature is informed by prescriptive practices such as Porter's diamond model or SWOT analysis (cf. Porter, 1985). Such studies tend to conceptualize competitive strategy on the level of organisations seeking to position themselves within a supposedly stable and predictable landscape (i.e. Ofori, 1994; Zhao *et al.*, 2009). More recently, the approach known as Strategy as Practice (SaP) has challenged these by emphasising the role of individual actors in the ‘doing of strategy’ (Whittington, 2006). The competitive strategy discussion in construction management has also increasingly shifted towards accentuating the socially constructed and discursive nature of competitive strategy (i.e. Green *et al.*, 2008; Kao *et al.*, 2009). However, as yet little attention has been given to understanding strategy as a form of ‘identity work’. The reported research argues that the doing of strategy takes place by means of the temporal narratives through which individuals seek to establish ‘subject positions’ both for themselves and their organizations (Fenton and Langley, 2011). On this basis, the paper conceptualises ‘identity work’ as a key strategy practice which is

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directly implicated in shaping the future trajectory of Turkish international contractors.

For the purposes of the current paper, identity work is seen as a continuously enacted process in which individuals interpret themselves within the intersection of their past experiences, present realities and future expectations (Ricoeur, 1991). This transient and fluid interpretation of identity construction implies that self-identities are continuously contested concepts rather than fixed constructs. In the enactment of such a process, individuals draw from numerous established, overlapping and interrelated narratives at the organizational or sectoral level (Coupland and Brown, 2012). They can also be seen to utilise literary plot structures to construct subject positions for themselves and others with whom they interact (Brown and Humphreys, 2003). These plot structures offer alternative ways to describe organisational events by infusing different meanings into the narrative elements. Drawing from the narrative approach to strategy and using the notions of epic plot, the current paper aims to understand the process of identity construction in the Turkish international contracting sector. The analysis is based on 31 face-to-face interviews with senior managers from Turkish firms. Of particular interest is the way in which the heroic self-identities of managers are formed by mobilizing resources from pre-existing formalized narratives. The findings illustrate the way that 'overcoming adversity' becomes an essential facet of self-identity of individual managers with direct implications for the future trajectory of Turkish construction sector as a whole.

Academic Narratives of Competitive Strategy

Strategy as a Property of Organizations

Much of the competitive strategy research in construction management is informed by notions of rationality and predictability. A recurring tendency is to identify the strategies which firms can adopt to enter different markets or otherwise increase their performances. An especially important point of reference is Porter's diamond model by which companies are assumed to analyse the external forces in the market place for the purposes of positioning themselves (cf. Porter, 1985). Ofori (1994) notably adopted this perspective to discuss performance improvement strategies for Singapore's construction industry. Öz (2001) also mobilized the diamond model as a means of analysing the sources of competitive advantage for Turkish international contractors. Such studies have undoubtedly been useful in terms of progressing the debate. However, they focus only on exogenous factors and tend to suggest trajectories of improvement based on assumptions of stability and predictability. Similarly, SWOT analysis has received wide acceptance as a means of determining the strengths and weaknesses of construction firms as positioned against an assumed static set of exogenous factors (Zhao *et al.*, 2009; Lee *et al.*, 2011). The limitation of these studies is that they tend to treat the external operating environment as a static objective reality which can be characterised on the basis of a pre-determined set of factors. More importantly, both approaches conceptualize competitive strategy as something that can be defined, measured and (allegedly) improved. However, such objectivist and acontextual perspectives are directly challenged by the recognition of the complexities of strategy making in practice (cf. Mintzberg, 1987). Of note is the emergence of the 'strategy process school' which accentuates the broader historical and political context within which 'strategy in flight' must be understood (cf. Pettigrew, 1997). However, even these approaches fail fully to recognise the shift toward seeing organizations in terms of their essential temporality (Tsoukas and Chia, 2002). To date, the construction management literature has tended to under-

emphasise the fluid, transient and ephemeral nature of strategy making (cf. Green *et al.*, 2008).

From Doing of Strategy to the Narrating of Strategy

Developed as an extension of the process school, the strategy-as-practice (SaP) Approach sees strategy as a socially situated activity (Whittington, 2006). It accentuates the continuously contested nature of strategy making by moving the focus of analysis to micro practices on individual level. As such, it shifts the discussion from strategy as an entity which is possessed towards a process of permanent enactment. However, discursive and narrative approaches to understanding strategy have only been recognised relatively recently (i.e. Fenton and Langley, 2011). Researchers who adopt more critical and discursive approaches to construction management tend to stress the dynamic and embedded nature of strategy making (Green *et al.*, 2008; Kao *et al.*, 2009). They conceptualise competitive strategy as an unfolding discourse which is in a constant flux and transformation. For them, the practices which are involved in strategy making can only be understood in retrospect, i.e. past practices are only labelled strategic for the purposes of making an argument about the future. Similarly, Löwstedt and Räisänen (2012) apply a narrative approach to understanding strategic change in a construction company by comparing formal and individual narratives. However, with this notable exception, the potential of narrative methods has remained relatively unexplored in the context of construction management research.

Strategizing as Identity Work

The 'narrative turn' accepts organisations as socially constructed, emergent and processual arenas (Tsoukas, 1994). Organizations, in this sense, become the arenas within which individuals develop, rehearse or test their narratives of self-identity. Hence identity construction depends upon a process whereby temporal narratives about the past are created for the purposes of legitimising actions (cf. Fenton and Langley, 2011). Such narratives hence become ways of ascribing meaning to ourselves and to our day-to-day practices. More importantly, the way that the individuals connect with the past is seen to carry through into the present thereby setting out a trajectory for the future. Identity work conflates with strategy making as both can be seen to be essentially concerned with constituting an overall sense of direction for ourselves (Oliver, 2015). However, as yet little attention has been given to the extent to which strategy can be understood as identity work that are incessantly contested through negotiation and re-construction. The available formalized narratives and managers' own collections of lived experience provide key resources. As argued by Brown (2015), identity work taking place in the present can only be understood with reference to both an-imagined past and a desired future. For example, Löwstedt and Räisänen (2014) suggest that identity work on the individual level draws more from a collective identity accepted on the sectoral level rather than the single firm.

Empirical Study: Creating Heroes

The essential starting point for the empirical study is that the narratives rehearsed by practitioners provide windows into the micro-processes of strategy making. Yet practitioners do not talk about strategy in a detached manner; they like talking about strategy because it boosts their sense of self-identity. It also enables them to project their sense of self-identity onto others. In such process, the choice of characters, turning points and the structure of the plot become the key activities of identity work

(Brown, 2015). It should further be noted that self-identity is not about the factual representation of what happened, it is how the meaning is infused through the devices used to construct narratives (Gabriel, 2000). There are a number of stereotypical plot structures -i.e. epic, tragic, and comic- derived from literature which can be used to conduct narrative analysis in organisational studies (Czarniawska, 2004). These can be adopted by managers for the purposes of defining the ‘subject positions’ which are of central importance in identity work. The empirical analysis described below draws from the tradition of narrative enquiry to explore the extent to which the narratives espoused by managers are structured around the notions of epic plot structure. The expectation is that narratives are structured around a ‘hero’ who conducts a noble journey towards a successful outcome. It might further be expected that such heroes would be depicted as displaying courage and dedication in overcoming predicaments and challenges along the way. Table 1 presents the elements of a typical epic plot structure which was used as an analytical device to interpret the empirical data. It is taken as axiomatic that all individual narratives formulate temporal subject positions through the mobilization of narrative elements. It is important to emphasise that such a perspective does not accentuate any objective reality or fact; it rather highlights the discursive nature of strategy and the way it is inexorably conflated with identity construction (i.e. Sveningsson and Alvesson, 2003).

Table 1: Characteristics of the epic plot

Narrative elements of epic plot	The narrative elements of the Turkish contractors narrative
Protagonist	Heroic owner-leaders and key senior managers
Other characters	Dedicated Turkish employees (helper), government (adversary), Western and Chinese competitors (villains)
Plot focus	Expansion into new markets and project types, adapting to the changing requirements of international contracting
Predicament	Oil price changes, political conflicts, finance, design and engineering capabilities
Fixed qualities	Courage, risk loving nature, dedication, self-motivation

It is argued that managers subjectively select facts from the past and order them into epic plot structures. Narratives about the past are hence shaped by an individual's vision for the future. Such narratives can further be understood as identity work whereby temporal identities are continuously tested and negotiated with different audiences. The described research explores such practices on an individual level. But it also pays specific attention to the collective identity narrative created on the sectoral level. Especially important is the epic history of Turkish contractors published by Turkish Contractors Association (TCA) as a 'memory book' (Tayanç, 2011). It describes the internationalization of Turkish contracting sector as an epic adventure whereby heroes overcome the adversaries of high-risk markets with great courage and dedication (Duman *et al.*, 2017). In Gabriel's (2000) Terminology, the TCA book can be understood as an attempt to create a sectoral 'mythology' to reinforce desired sectoral values. It is argued that the creation of such an epic narrative on the sectoral level serves a clear strategic purpose in projecting the idealised characteristics of Turkish contractors.

RESEARCH METHOD

The empirical study was based on 31 narrative interviews with senior managers from Turkish contracting companies. The interviews were conducted following a systematic analysis on the sectoral formal narrative of Turkish international

contractors (cf. Duman *et al.*, 2017). The previous analysis helped the researchers to understand the collective identity narrative of Turkish international contractors and to identify the individuals who might usefully be interviewed. The interviews were conducted on the basis of generic narrative generating questions (cf. Hopf, 2004). The managers were asked to interpret the development of their organisations within international markets. The use of narrative interviews allowed them articulate their own stories regarding competitiveness and strategy making freely. They were designed to access identity work 'in flight' at a particular point in time (cf. Sveningsson and Alvesson, 2003). The ways in which the interviewees create subject position themselves in respect of others is seen to be an important part of the relational aspects of identity (cf. Brown and Phua, 2011). The interviewer played an active role as a 'fellow-traveller' in the telling of the narratives by asking clarifying questions or making comments to encourage the managers to elucidate further (Gabriel, 2000). The data analysis started with developing codes according to the most repeated phrases and the concepts. The sectoral level narrative of TCA and the researchers' knowledge of the strategy literature informed this process. Subsequent cycles of the analysis focused on refining the initial codes and elaborating narrative elements of the epic plot structure.

FINDINGS: THE ANALYSIS OF NARRATIVE ELEMENTS

The individual narratives revealed strong commonalities with the epic sectoral narrative as presented by the TCA. Although different events and actors were stressed by different managers, the common tendency was to depict themselves as heroes of the international markets. The focus on the heroes' journey was described in terms of expanding into new markets, increasing penetration in current markets and moving up the value chain to deliver more complex projects. There was also a recurring emphasis on describing the role of other characters such as helpers, adversaries and villains. The difficulties which the heroes had to overcome were described in great detail, thereby echoing one of the key characteristics of an epic plot structure. However, there was also a strong consensus regarding the sector's heroic attributes of abiding courage, risk acceptance and dedication despite all challenges. Indeed, these features were consistently described as 'second nature' to Turkish construction managers. Taking pride in the job was seemingly of note, but the interviewees also at times gave indications of anger, despair and envy. The dominant epic plot structure therefore off and on contained elements of tragedy which can also be seen as key components of identity construction. The managers promoted themselves and their firms as symbolic of Turkish contractors' epic struggle for success. There was a notable consistency in emphasizing a collective identity as 'heroes of international contracting'.

Who is the hero? The contest between 'I' and 'the company'

The interviewees were keen to emphasize the key roles which they saw themselves as having played in the success of Turkish contractors. The narrative interviews hence provided windows into the processes by means of which managers constructed their own sense of self-identity. They also illustrated the ways in which the interviewees drew resources from pre-existing collective identities as enshrined within the formalised TCA narrative. While some managers cast themselves as the hero of the company, others attributed such roles to the owner-leaders or other senior managers. For example, a vice-president strongly emphasised himself as the hero of the firm:

I was experienced in [my previous organizations], in oil and gas and I came here now and I bring my expertise here. That is why we have got a project, oil and gas projects

now. We are doing a refinery now, doing power plants. I bring my experience here. So, experience means your network, your people, I know the people (Interviewee 2; 2017)

Above quotation emphasizes the perceived importance of individuals in shaping the trajectory of the organisation. While the managers from relatively younger companies tended to focus on their own individual identity, the managers from the first generation of Turkish contractors more often emphasized the collective identity. On those occasions when 'I' language turned to 'we', the company leaders were described as the visionary heroes who shaped the trajectory of the company. Hence the attribution of heroic role tended to be fluid rather than fixed. Some managers accredited the company leader with great respect and admiration, thereby expressing a sense of pride in being part of such firms. Others however conceptualized these strong leaders as barriers to the progression of their own 'modernising' vision for the firm. This continuous juxtaposition between the level of the individual and that of the collective is in itself an important aspect of identity work.

Other characters: Relational aspects of identity construction

The individual narratives were also often notable for the way in which the managers ascribed subject positions to other characters. Especially apparent was the collective identity assigned to Turkish employees -with no small sense of national pride. The self-motivated and flexible characteristics of the Turkish employees was repeatedly cited as a key helper. The argument was frequently made with reference to the employees available to Western contractors who were seen to be reluctant to move beyond their comfort zone. In contrast, Turkish employees were seen to be more willing to sacrifice their personal life to work in often harsh conditions:

We are very hardworking company... starting from bosses to every professional in the company... I remember at that time [several project deliveries in a year] we didn't do vacations; everything was postponed until the completion. Everyone without bothering anything, with the excuses from their families... DU: What is the motivation behind this? BU: I can proudly say at that time we felt this power to become a mega contractor from a small contractor, and each of us took part and felt that we are a part of something important, not for only to that country also for our own country (Interviewee 3, 2017).

The above quote is again representative of identity work, not only on the individual level, but also on the level of the organization. The emphasis on the dedication displayed by all involved was seen as an essential component of becoming a mega contractor. It is also indicative of a tendency to draw from supposedly national characteristics for the purposes of legitimisation. The common point of reference was the depiction of Turkish people as 'madly hardworking'. The extent to which this is true is not the issue. The important point is the way in which this collective self-identity is continually reinforced as being of vital importance to the continued success of Turkish international contractors.

The Turkish Government emerged as another key actor who was depicted on occasion having shaped the journey as a hero, but interestingly it was more often positioned as an adversary. The interviewees frequently emphasized that the Turkish government should lobby more strongly on behalf of the contracting sector. This was seen to relate not only to establishing networks in new markets, but also to providing more support in the development of the financial capabilities required to enable Turkish firm to compete more effectively with their counterparts. Other national governments were seen to be much more supportive than tended to be the case with the Turkish government. Of particular interest was a perceived lack of policy stability on the part of the Turkish government:

The developed countries like the US or UK have this overall long term strategies, we do not have, I mean when I say we, the Turkish government ... this mismanagement in the foreign affairs causes a lot more to the contractors, and also to Turkish economy. This is the lack of government. You know the crises with Russia, what it cost to the contractors, to tourism sector, you can imagine... (Interviewee 3, 2017).

The preceding quotation is suggestive that identity construction extends beyond describing the characteristics of the main characters to ascribing subject positions to others parties in the narrative. For most of the managers interviewed, the instability and unpredictability of the government is the key reason for recent reductions in the recorded annual international turnover of Turkish contractors.

The heroic journey of Turkish contractors was frequently described as a 'market war' against powerful Western and Chinese companies. When asked about the future prospects of Turkish contractors in international markets, several interviewees cited state-backed Chinese contractors as the key villains. The shared narratives often displayed aspects of envy in terms of the government support enjoyed by Chinese contractors. This was especially evident in respect of the African market:

For example, all the administrators I talked in Africa complains about the Chinese, they [Africans] think Chinese do not do good job, they do not do quality job, they break their promises but they [Africans] are still helpless [because China comes with money] ... (Interviewee 13, 2017)

The above quote is again indicative of identity work by labelling Chinese contractors as 'low quality', with a direct inference that Turkish contractors see themselves as champions of quality. Such explanations were often followed by the phrases such as 'the Turkish quality'. In contrast, Western contractors tended to be characterised by slow working practices, higher prices and duplicitous claim management practices. These statements again highlight Turkish firms as offering high quality with relatively low prices. The collective identity of Turkish contractors would seem to be especially strongly identified with high client satisfaction. Such labelling of others reflects the relational aspects of identity work in terms of depicting how Turkish contractors position themselves against their competitors (cf. Brown and Phua, 2011). Creating such a strong collective identity for Turkish contracting is arguably the very essence of strategy work.

The focus of the epic journey and the challenges faced on the way

Expansion into new markets and adapting to the changing demands of international contracting were repeatedly outlined as the current challenges faced by the heroes of Turkish contractors. The managers repeatedly positioned themselves as the 'masters of contracting' by emphasizing the experience gained in different markets across several decades. Such narratives tended to shift the focus of identity work from the individual level to the organizational level. Some narratives sought to address the issue on the sectoral level. Phrases such as 'the clients know that we can do the work on site' emerged as common points of reference. The extension of this to the sectoral level was 'Turks can deliver the project no matter what happens'. But more important than the targeted markets was the emphasis on moving upwards in the value chain from contracting to being able to undertake Engineering Procurement and Construction (EPC) Projects in specialized sectors, especially industrial and energy projects. There was a strong narrative that Turkish firms need to progress to the delivery of integrated construction services. The narratives were further strengthened by projecting international contracting in terms of league tables:

Turkish contractors are not too many in this league. I would say this is the first league that is a very specific field that not too many companies manage to enter that. [Why?] Because of client requirements, they say that to be eligible for such projects, you should have this much turn over, you should complete this type of projects, there are so many requirements, not only technical but also financial, but also past experience, so on. So that is a different level which international companies are playing with better margins, not too many Turkish companies there yet I believe (Interviewee 16, 2017).

The above quote is clearly indicative of identity work in seeking to persuade the firm to move upstream to EPC. An especially key message was the development of design, engineering and financial capabilities in addition to being 'masters of contracting'. This emerged as one of the strongly stressed points in both the individual and formal narratives. The same point was also emphasized by the TCA representative:

From now on, our firms started to remain in classical contractors' class. So, we know how to make a road project or dam project, but the projects are not to call a contractor to do the construction part, there is no job like this anymore. There is EPC, and now it is plus with finance (Interviewee 12, 2017).

The key message of the preceding quotation and several other similar ones is that Turkish firms must escape from the identity of being 'muddy boots contractors' or accept the tragedy of market lose. Similarly, the decrease in oil prices and increasing instability in key defined markets were also positioned as challenges to be overcome. But the interviewees were also keen to ascribe an identity to themselves as quick responders to such shifts:

...the oil prices dropped and global market narrowed... because of the aircraft crises with Russia...we are not allowed to enter in the bids...So, we decided to find another area... Another region, another country, another climate, so which we are not aware of. Of course we have some knowledge but I mean we have no experience, so what we did, we established our core team, heavily experienced in airport projects also we... imported others [managers] who have experienced in Gulf Region (Interviewee 13, 2017).

What is notable in the above quotation is the identity work emphasizing that when a crisis emerges in one market, the heroes can easily move to another. As such, the depiction of the Turkish people as courageous and dedicated to dealing with the challenges of chaotic markets was evident across several interviews. A similar reference was made to the prospective opportunities in Middle Eastern markets by stating that 'if there is peace in the Middle East, again, everybody will be scared to enter but we will be the pioneers'. There is hence an enduring optimism at work whereby each setback is presented as an opportunity.

CONCLUSIONS

This paper positions organizations as temporal, polyphonic social constructions in which individuals continuously rehearse and co-construct their self-identities. The empirical work has demonstrated how strategizing activity can be considered as identity work. Drawing from the 'narrative turn' in strategy research, the notion of an epic plot structure has been presented as an analytical tool. The research described provides an innovative interpretation of identity work in the Turkish international contracting sector. The empirical work highlights the tendency of Turkish managers to depict themselves as heroes of international contracting. Although the primary unit of analysis relates to individual level narratives, the empirical data also portrays the continuous juxtaposition between the individual level and that of the collective. The findings illustrate that the identity work occurs at the nexus where narratives on different levels continuously overlap and interact. Identities are never fixed and

stable, and the processes of identity construction are multi-faceted and constantly contested. Managers can be seen to draw from temporal narratives about the past to legitimize their strategic visions for the future. Hence strategy is not an observable material practice that can easily be accessed. However, new insights can be gained by viewing strategy through the lens of identity work. In essence, strategy becomes inseparable from the identity work with which individuals continuously engage. Practitioners like to talk about strategy; it bolsters their sense of self-identity. It also portrays their sense of self-identity to others. It is suggested that such processes are continuously enacted through narratives, and are hence best explored through narrative analysis.

The analysis demonstrates that the attribution of the heroic role shifts not only between interviews, but also on occasion within the course of a single interview. The notion of epic stories is of central importance to the described success of Turkish contractors. This is evident not only with the recited stories but also within the formalised narratives on the sectoral level. The clear depiction of the subject positions attributed to other characters illustrates the relational aspects of identity construction. By labelling various characters as helpers, adversaries and villains, the managers make sense of the roles others play in the epic story of Turkish contracting. Such narratives continuously conflate issues of strategy with issues of identity construction. A recurring emphasis on the courage, dedication and risk attitudes of the identified heroes further provides a set of strategic resources for the future. Especially important is the use of epic plot structure as a means of evoking feelings of pride and honour. As might be expected from identity narratives, the managers were skilled in crafting heroic role for themselves. The significance of such narratives does not lie in the facts, but in the meaning they create for others (Gabriel, 2000). Their purpose is to grab the attention and commitment of others, thereby paving the way for future actions. While the findings here are based on the case of Turkish contractors, the study is seen to contribute to the construction management literature in two ways. First, it extends strategy research in the field by conceptualizing the identity work as a strategic practice. Second, it extends the methodological debate by mobilizing the notions of literary plot structures to guide the empirical analysis.

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FORESEEING COUNTERMEASURES FOR CONSTRUCTION SAFETY VIOLATIONS IN SOUTH AFRICA

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Human failure (errors and violations) studies from the sub-Saharan African region are limited. While non-compliance (violation) is cited as a causal factor in reported incidents and accidents, countermeasures are lacking in how safety research is understood in the region. Through research methods that used a semi-structured questionnaire for face-to-face interviews, perceptions of site management and workers were collected. Routine violations outnumber other cited failure types in the study, where the violations and their causes are either unclear or are misunderstood by some people in the front line of construction worksites. Examples of reported violations by the interviewees include working on a site that allows “fist fights” and “racial slurs”. The lax attitudes of contractors, the ignorance (arrogance in certain instances) of workers, and the ineffective site inspectorate regime have made violations the norm on the visited projects. There is a clear case for measures that will tackle problems with rules found on the visited sites. Problems with rules on the sites are systemic, since they occur at both organisational and individual levels. For example, site management professionals and workers blamed each other for safety violations. Problems with rules have rendered induction and toolbox talks ineffective in the sampled projects. The paper thus argues for deployment of countermeasures that will improve risk perceptions of contractors and their workers, so that adequate understanding of safety violations and their consequences on construction sites is created. Use of countermeasures also requires a clear implementation strategy to avoid redundant decisions and actions, which will manifest if “problems with rules” are left unchecked.

Keywords: compliance, construction, safety, site work, violations

INTRODUCTION

Deliberate non-compliance is prevalent in poorly controlled workplaces. Several definitions of safety violations exist in the literature. Alper and Karsh (2009) commented on eight various definitions of violations. For the purposes of this paper, a safety violation is defined as a premeditated departure from rules, procedures, instructions, and regulations specified for efficient workplace operations. It is an intentional failure recorded when a worker deliberately does the wrong thing. In his seminal book ‘Human error’, Reason (1990) explained that violations are committed for many reasons. If the violation is deliberate, investigators must examine prior intention to cause harm. If prior intention to cause harm is established, such violation

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can be categorised as sabotage (malevolent). In contrast, if prior intention to cause harm cannot be established (non-malevolent), the violation should not be of great concern (Reason 1990). Reason (1990) made a further distinction, namely deliberate but non-malevolent non-compliance, which he categorised into ‘routine violations’ and ‘exceptional violations’. Another category of violations was distinguished, namely ‘situational violations’ (Reason 2008). Of these three types of violations, this paper addresses routine and situational violations that are common in construction incident reports.

Safety violations in the project environment, for example, often arise from systemic problems in the workplace (Lingard, Pink, Hayes, McDermott and Harley 2016). For example, when people assume different roles on a project site based on their health and safety (H&S) tendencies influenced by time and work pressures, level of experience, risk perceptions, and safety culture (Choudhry and Fang 2008; Oswald, Sherratt and Smith 2013), unsafe acts and conditions could eventuate. In South African construction, where there is a paucity of research literature that investigates deliberate violations without malevolence in worksites, factors such as the perceived benefit of violation, outlined by Reason (2008) in Table 1, have continued to harm people (Emuze and Smallwood 2012a, 2012b; Emuze, Van Eeden and Geminiani 2015). Contractors and their employees reportedly embark upon deliberate violations in the mentioned South African citations because of a perceived shortcut (easier way of working), perceived savings in time (and cost of labour), the need to meet tight deadlines, and the tendency to want to show that the industry is masculine. These short-sighted benefits are implemented after people weigh up the perceived cost and the perceived benefits of an act of violation and they come to the conclusion that the perceived benefits exceed the perceived cost. When people make such a decision, they are likely to violate rules and procedures (Battmann and Klumb 1993).

Table 1: Reason’s balance sheet for violation. Adapted from Reason (2008: 58)

Perceived benefits of violation	Perceived cost of violation
Easier way of working	Causes accidents
Saves time	Injury to self or others
More exciting	Damage to assets
Gets the job done	Costly to repair
Shows skill	Sanctions/punishment
Meets a deadline	Loss of job/promotion
Looks macho (masculine)	Disapproval of friends

In addition, the dominant narrative that violations are perpetrated by “bad” people, with the “bad apple theory” of Dekker (Dekker 2006) embedded in a workplace, may explain the paucity of studies on deliberate non-compliance and its causation in the industry. However, recent case studies on accidents in South Africa are bringing several issues around human failure into the research spotlight. For example, a building collapse that recorded two fatalities and 29 severe injuries in Durban, South Africa, provides evidence of deliberate non-compliance by the developer, the contractor, the engineer, and workers on the project (Emuze, Van Eeden and Geminiani 2015, 2017).

Media reports on more recent accidents equally attest to the need to conduct studies on safety violations in the South African context. In essence, this paper reports on a preliminary assessment of safety violations on several construction sites, so that countermeasures required for contextual support can be deliberated and examined. The next section of this paper presents a succinct explanation of the research method of the study. After the section, the results and interpretations of the study are used as the basis for a discussion on countermeasures required to halt the proliferation of safety violations on construction sites.

RESEARCH METHOD

To achieve the research goal, a phenomenological study was conducted using construction sites as the location of primary data collection. The use of an interpretive qualitative perspective assisted the study in the sense that data collection was done based on the social and contextual beliefs of the participants. The study thus conforms to the notion that qualitative research is a situated activity that locates the observer in the world (in the case of this study a construction site) (Denzin and Lincoln 2008).

The research consists of interpretive practices that make the world visible through interviews, conversations, photographs, recordings, or field notes (Denzin and Lincoln 2008). Interviews, conversations, and field notes were the only tools used in this reported study. The interviews were expedited using a semi-structured questionnaire protocol that elicited information from both site management and general workers. The interviewees were requested to respond to questions such as “What is your understanding of safety violations?”, “What are the root causes of violations?”, and “What violations have you encountered on-site?” All the interviews were face-to-face, and they were all tape-recorded and transcribed.

To promote stronger substantiation of constructs and working propositions, the study utilised multiple investigators to collect data from sites in three provinces of South Africa. Use of multiple investigators with the same instrument enhances the creative potential of the study, while ensuring convergence of observations from them to improve confidence in the results (Huberman and Miles 2002). As such, the author used three final-year Bachelor of Technology students registered for the research subject to collect the primary data, which was predominantly textual in nature.

The thematically analysed data serves the purpose of illuminating the phenomenon (safety violations) as lived experiences of the interviewees. According to Huberman and Miles (2002), an interpretation must illuminate or bring alive what has been studied. They go on to say that illumination occurs only when the interpretation is based on data that is collected from the world of lived experiences, as “unless ordinary people speak, we cannot interpret their experiences” (Huberman and Miles 2002: 362).

Tables 2 to 4 summarise the demographic and general information of the participants in the three South African provinces of Gauteng, the Free State, and the Eastern Cape. The tables show that both site management and general workers participated in the study. In the Gauteng province, 2 sites were visited. One of the sites was a pipe installation site, and the other site was a construction site for a two-storey office block. A semi-structured questionnaire was prepared to obtain responses from general workers through one-on-one interviews.

From the site where the two-storey office block was being constructed, 6 general workers participated in the study. From the pipe installation site, 9 general workers were selected by their managers to take part in the study. From this site, 7 site management-level professionals participated in the interviews. In total, the responses from general workers numbered 15, and the responses from site management were 7, in Gauteng. The occupations of the interviewees in the sites visited in Gauteng included machine operator, H&S officer, and others outlined in Table 2, and most of the participants had more than five years of construction industry experience.

Table 2: Gauteng interviewees' demographic and general information

Occupation	Site experience in years				Know it			Violation		
	0-5	5-10	10-30	>30	Yes	No	Unsure	Yes	No	Unsure
Machine operator		1					1			1
H&S officer	1	1	1		3			3		
Concrete hand			1			1		1		
Scaffolding erector		2			2			2		
Steel fixer				1			1	1		
Safety representative	1				1			1		
General worker	4	2			2	1	3	4	1	1
Storeman	1						1			1
Bricklayer	1						1			1
Quality control engineer			1		1			1		
Quantity surveyor			1		1			1		
Construction manager			1		1			1		
Environmental officer	1				1			1		
Foreman				1	1			1		
Sub total	9	6	5	2	13	2	7	17	1	4
Total				22				22		22

The fieldwork conducted in the province of the Eastern Cape was only able to collect data from professionals occupying site management positions in the sites visited, where unstructured observation access was granted in most cases (see Table 3). Apart from one interviewee, all the participants in the province had been in the industry for more than five years. In the Free State province, 10 interviews were conducted with 8 professionals and 2 general workers, who could not participate using the English language. With the use of an interpreter, an unstructured conversation was conducted with the general workers, as is indicated in Table 4.

Table 3: Eastern Cape interviewees' demographic and general information

Occupation	Site experience in years				Know it			Violation		
	0-5	5-10	10-30	>30	Yes	No	Unsure	Yes	No	Unsure
Quantity surveyor	1	1			1		1	1	1	
Construction manager		1	1		2			2		
H&S consultant		2	1		3			3		
Site manager		1				1				1
Sub total	1	5	2	0	6	1	1	6	1	1
Total				8				8		8

FINDINGS AND INTERPRETATIONS

Table 2 shows that seven of the interviewees in Gauteng were “unsure” of what constitutes a violation, but only four of them were also unsure of the causes of violations. The table also indicates that 17 of the interviewees had opinions regarding the causes of violations, but only 13 could explain a violation. There is consistency, with the general worker clearly saying he does not understand what constitutes a violation, and he does not know the causes of violations. By contrast, the one concrete worker who said he does not understand what constitutes a violation ended up saying that he knows the causes of violations. The contradiction between those that understand the phenomenon and the ones that confirm their knowledge of it suggests that there is a difference in the minds of the interviewee cohort, particularly among the general workers.

Table 4: Free State interviewees’ demographic and general information

Occupation	Site experience in years				Violation			Know causes		
	0-5	5-10	10-30	>30	Yes	No	Unsure	Yes	No	Unsure
Construction manager	1	2			3			2		1
Production manager	1				1			1		
Site agent			1		1			1		
Site foreman	2	1			3			2		1
General workers			2			2			2	
Sub total	4	3	3	0	8	2	0	6	2	2
Total				10			10			10

Table 3 indicates that a site manager, who should know construction regulations and the required H&S expectations on sites, contended that he did not understand what constitutes a violation, while a quantity surveyor was unsure of it. While the quantity surveyor did not know the causes of violations, the site manager was unsure of them.

Again, these two responses arouse curiosity regarding the knowledge and competencies of the concerned professionals. In sites visited in the Eastern Cape, however, there was consistency between those that confirmed their knowledge of what constitutes a violation and what causes violations. In the Free State province, the different occupations understood what is meant by a violation, although two of them were not sure of what causes violations (see Table 4). The two general workers that were interviewed said they did not understand what constitutes a violation, and they could not comment on their causes. In brief, the majority of the interviewees had experienced violations.

In the interviews, violations where both workers and management were agents were mentioned. The interviewees experienced different violations on their different sites, and the Gauteng interviewees who indicated that there were no violations on their site were not being truthful. The research investigator determined that the responses of these interviewees were not entirely true, because on one construction site that was visited for observation it was instructed to suspend work due to non-compliance over working conditions. This information was provided to the researcher by the site manager, but the construction manager from the same site did not disclose this information in the interview. The observation is deemed to represent a failure of being truthful on the part of the construction manager. The interpretations of how the

interviewees understood what constitutes a violation and the causes of violations are described below.

Theme 1: Understanding of what constitutes a violation

Over the years, violations have been linked to injuries and fatalities in the construction industry. Despite occupational health and safety (OHS) regulations and labour laws being in existence, the construction industry remains dangerous, with statistically alarming rates of fatalities and injuries. Of all the interviewees in Gauteng, only 13 understood what constituted a safety violation. The researchers had to explain to the general workers what the word “violation” was in the applicable vernacular language before they could answer the questionnaire, as some of them were unclear about it. Overall, most of the general workers were aware of what the basic requirements relating to a safe working area are. This speaks to the “yes” under the “Aware of causes of violations?” column in Table 2. The main source of their knowledge is the daily toolbox talks used to create awareness concerning a safe working area. Although some workers opined that their management always fail to provide appropriate personal protective equipment (PPE) when it is required, in the form of earplugs and dust masks, their site management colleagues were of the opinion that workers tend to commit violations because they fail to listen to and apply suggestions from toolbox talks. In the study, site management interviewees indicated that some general workers committed violations by coming to work under the influence of substances such as alcohol and drugs, which impair their alertness and concentration on worksites.

As mentioned earlier, translation into vernacular languages was necessary for the general workers to answer the questions, since it was evident that English was a language that was not fully understood by them. In this regard, one respondent articulated that the lack of education and information comprehension among the general workers has led to his experience of violations on construction sites. Therefore, inasmuch as there are toolbox talks daily, they may be futile if the recipients do not have full understanding of what is being communicated. Regarding factors that cause violations on-site, certain general workers noted that site factors such as an unsafe working environment and lack of communication result in violations on the construction site.

Another factor that stood out was communication between the workers. The communication factor was not about language comprehension. It was about the fact that the workers would not talk amongst themselves in an atmosphere of conflict or negative competition. The reported lack of communication can lead to conflicts and misunderstandings, which could produce safety violations. The interviewees also articulated that some violations are brought about by the workers not listening to instructions. They reasoned that this was because the workers think they know a lot based on the amount of experience they have had in the construction industry.

Theme 2: Causes of violations on worksites

From the feedback received it was shown that most workers had no knowledge of what a violation is, *let alone* the root causes of violations, and what constitutes a violation. A major conclusion derived from the general workers indicated that their lack of skills and training contributes to safety violations. In an interesting conversation with some unskilled workers on-site, their limited knowledge of violations stood out. The workers were generally left to carry out their daily tasks in whatever way they perceived was right. Taking an overview of the perceptions

expressed by both management and workers together, the shifting of blame over responsibilities that emanated from both sides is cause for concern. Apart from issues around skills and training, lack of adequate financial provision for H&S was also mentioned as a cause of violations.

Safety-related resources such as protect gears and clothing are an essential component of project financing. An issue mentioned by a manager related to cutting expenses to increase profitability over the duration of the project by any means possible. As a result, workers lacking PPE go to work on-site with marginal training. Violation is said to also occur due to productivity-based decisions and actions. For instance, interviewees opined that in efforts to push for greater production on-site, long working hours become the norm for contractors, who disregard regulations concerning working hours for the workforce. These long working hours are perceived as a violation, which triggers further violations. Long working hours leads to stress and impaired mental health, which could lead to accidents on sites. In particular, the study observed that working in confined areas without appropriate PPE is permitted on a site. This was a concern raised in the study. However, it appears that such conditions are deemed as workable site challenges by the interviewees and their employers due to a fixed low project budget.

At the organisational level, fatigue from working long hours without rest, a lack of H&S and work method knowledge, allowing workers to work without the required knowledge and skills, stress, provision of faulty machinery, lack of adequate training opportunities for workers, mandating the use of unsafe scaffolding, allowing the use of unsafe power tools, use of uneducated or uninformed persons on sites, failing to mitigate the effects of language barriers in communication in a multicultural workplace, unfair production pressures allowed by workers, mandating after-hours work without adequate technical and safety supervision, haphazard scheduling for toolbox talks, allowing disputes between contractors and workers to escalate, asking workers to work without the required PPE, such as helmets, earplugs, and dust masks, and not providing required signage as well as barricades for deep excavation are the causes of violations highlighted in the study.

At the individual level, the major causes mentioned by the interviewees include the lack of attention to toolbox talk details by workers, people who work on-site taking things for granted because they think they know it all, not wearing PPE because people refuse to listen to instructions, not following what has been said in inductions, jumping over trenches instead of going around them, climbing heights without a safety harness, negligence of supervisors on-site, and making racist comments. An interviewee said that “ignorance, arrogance, stubbornness and complete disregard for order” underpin most violations that he has encountered on sites. Another interviewee cited an incident where a white man called his fellow black worker “a monkey”, which he claimed was a recipe for violations on-site.

It is also important to highlight the view that when a case of misunderstanding and ill treatment occurs, workers tend to violate rules set by management on the site. As an illustration, two interviewees cited instances of “fist fights” on sites, and one such incident involved two ladies physically fighting each other on-site. A quote from an interviewee sums up the causes of violations at the individual level. The interviewee made several comments and summed them up by saying “[w]orkers fail to comply with regulations where there is no system used within the company forcing them to comply”.

DISCUSSION

Further results from the interviews show that toolbox talks once a week and inductions for workers and site visitors are ways in which participants have been tackling violations on their projects. However, these two measures have failed to stem the tide of violations among the interviewee cohort. Indeed, it appears that safety violations have managed to slip through in spite of inductions and toolbox talks. In other words, the industry in South Africa is in need of credible countermeasures directed at reduction and complete elimination of safety violations on the worksite.

The discussion in this section is an attempt to conceptualise countermeasures that are suitable for the identified violations in this study. The previous section of the paper alludes to the fact that most of the interviewees confirm that violations occur on their sites. The interviewees went on to cite various types of human failure. In particular, the interviewees commented on violations that are viewed as the norm in the industry. These routine violations involve rules and regulations that are ignored by workers and their employers (contractors).

The consensus regarding non-compliance with some of the rules is ineffectiveness of the inspectorate functions of the Department of Labour (DoL) in South Africa (Geminiani, Smallwood and Fee 2013; Geminiani and Smallwood 2008). The human failure-related toolkits from the Health and Safety Executive (HSE) in the United Kingdom (UK) suggest appropriate countermeasures for routine violations. For example, it is crucial to create responsible and effective supervision of work on-site, in addition to the inspectorate functions of the DoL. Not only should the DoL flag and sanction contractors that demonstrate non-compliance with registration of workers with the Compensation Fund for example, it should also be able to influence the risk perceptions of contractors.

Influence on the risk perceptions of contractors could, in turn, raise the standard of work supervision on sites. Some cited examples of violations by the interviewees are categorised as situational violations, because they are determined by context-specific factors. Such factors are not limited to time pressure, workload, and inappropriate tools and plants, which should not happen if an organisation is keen to promote a positive safety culture. In such situations, the workers opined that tasks have to be completed in an atmosphere of non-compliance. It is therefore appropriate to avoid situational factors, such as unnecessary time and work pressures due to production requirements on construction sites. There is also a need to acknowledge that the site management and the workers have problems with complying with rules, a situation that is not easy to interpret at this stage of the research.

CONCLUSIONS

Beyond the concerns around the extent of knowledge about violations among the interviewees who were busy on live projects in 2017, the nature of violations cited in the research demands critical thinking. At the organisational level, contractors are guilty of non-compliance with legislation when they, among other things, fail to register their workers with the Compensation Fund. The level of commitment of contractors to safety on their sites is also in the spotlight, as proper induction is not being done. Relying on safety induction and toolbox talks (which are few and far between) to tackle safety is inappropriate. Although this study was conducted using a qualitative approach, which does not allow for statistical generalisation, the efforts made to strengthen the results, through the use of multiple field investigators on

several project sites in three provinces, give credence to the argument that both routine and situational violations may be commonplace in South African construction. The results also suggest that there may be a link between these violations, problems with rules, and lax enforcement. There may equally be a link between these violations and the level of commitment of construction contractors to safety.

While the desired state would be one where performance is driven by a positive safety culture, the existence of the aforementioned violations suggests that countermeasures have to be monitored closely. A step in the right direction would be appointment of qualified full-time safety professionals on project sites, irrespective of the size of the project. The current use of project size to determine whether safety professionals are appointed is not effective in an industry where routine and situational violations may be pervasive. The cost of such appointment is less than the cost of accidents or fatalities. In essence, clients should take the lead, by making adequate financial provision for compliance-based safety.

Finances should cover deployment of required safety professionals and other items highlighted in the project safety plan. However, the countermeasures would be better implemented if contractors have a need to avoid a penalty, rather than paying fines. The problems with compliance with rules should also inform the decisions of the DoL. These suggestions would, however, be validated through additional future evidence and data on violations in the construction industry. Given that theory-building research usually employs multiple data-collection methods, it can be argued that there is a need for this research to continue through other methodological and sample choices. Further studies should involve interviews, observations, archival sources, and surveys, so as to provide stronger evidence around the problem areas and the needed countermeasures in the industry. Future studies should aim at contributions to knowledge that are usable in practice through policy interventions and implementation.

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APPLICATION OF VALUE MANAGEMENT TO REFURBISHMENT PROJECTS: A SRI LANKAN CASE STUDY

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Refurbishment offers profound solutions to contemporary issues such as deterioration and obsolescence of buildings by upgrading, altering, extending, renovating and improving facilities. Nevertheless, refurbishment projects are uncertain and sophisticated with many challenges and lead to subvert value for money. Value management (VM) is recognised as a suitable approach to ensure value for money in construction projects. The application of VM to refurbishment projects remain unprecedented although investigating the application of VM in new building projects is a continuing concern. This research therefore, sets out to examine the application of VM to refurbishment projects in Sri Lanka, through a single case study of a hotel refurbishment project, which has employed VM. Subsequently, data was collected through unstructured interviews with seven participants of the VM study, document reviewing and observations and analysed using content analysis. This project employed a VM job plan derived from the SAVE 40-hour job plan during the demolition and construction stage of the project with the focus of reducing costs through alternatives. The unstructured VM job plan constituted of pre workshop, information gathering, project analysis, options developing, analysis, presentation and post workshop phases. VM is predominantly interpreted as value engineering (VE) in Sri Lanka, although the alternative use of both VM and VE was evident amongst the respondents. VM proposals yielded a cost saving of 5.06% from the total cost of the project and a reduction of operational and maintenance budget by 8.31%, although the ad-hoc manner of application of VM contributed to a time overrun of two to three months. This study recommended that an initial VM study should be conducted during the concept design stage, which is to be followed by a second VM workshop during the demolition and construction stage to revisit and revise original design solutions to match with the existing conditions of the building.

Keywords: refurbishment projects, Sri Lanka, value for money, value management

INTRODUCTION

Building maintenance and preservation of usable conditions have necessitated ensuring value and functionality of the buildings (Puḷṭe and Geipele 2017), predominantly for the aging building stock, in which refurbishment is perceived as a strategic avenue to conquer many contemporary issues associated with buildings (Babangida *et al.*, 2012). As revealed by Mansfield (2009), refurbishment offers solutions to inevitable physical deterioration and obsolescence. Ali *et al.*, (2009) pointed out that refurbishment is materialised as an alternative towards the end of

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service life of the building or when the building is on the verge of failing to perform the required functions. Despite the notion of enrichment of market value of old buildings through refurbishment, building owners are reluctant to administer refurbishment decisions (Chau *et al.*, 2003), primarily due to the inevitable challenges associated with the existing building. Juan (2009) also confirmed this view by highlighting that majority of the refurbishment projects are characterised with high level of risk, uncertainty and complicated coordination compared to new buildings. Hence, the same approaches used in the new building construction projects are not always suitable for the refurbishment projects as the challenges are peculiar to existing buildings (Rahmat and Ali 2010) and these challenges could result in subverting value for money.

In this context, there is a need for an approach to overcome the challenges and thereby enhance value for money in refurbishment projects. According to Kelly *et al.*, (2004), value management (VM) is a process to enhance value for money from the concept phase through to the operation and use of a building. A multitude of research on the application of VM in construction projects is evident throughout the history. However, a very few instances of probing the application of VM can be found in the construction industry of Sri Lanka. Perera *et al.*, (2003) discussed about the application of VM practices during the initial stages of “World Trade Center” project. The authors asserted that the fragmented construction industry of Sri Lanka limits the application of VM. Karunasena and Gamage (2017) further highlighted that there is a lack of pre-defined method to apply VM in Sri Lankan construction industry.

As pointed out by Dallas (2008), VM may not only be applied to new building constructions, and can also be harnessed to improve the buildings in operation, which have subjected to degradation of value over time. In this context, VM could be regarded as a suitable approach to enhance value for money in refurbishment projects. Therefore, this study is focussed on exploring the application of VM to refurbishment projects via a single case study of the Sri Lankan context. The study adopted a derived form of standard SAVE 40-hour job plan to derive VM proposals.

Achieving Value for Money by Applying Value Management

Achieving value for money is the final outcome of all construction projects and thus, agreement on value parameters for earning client’s satisfaction is necessitated (Emmitt *et al.*, 2005; Martinsuo and Killen 2014). However, “value” is interpreted in different perspectives by different participants of building projects (Bowman and Ambrosini 2010). Value is defined as the level of importance placed upon a function, item or solution (Potts and Ankrah 2013). Furthermore, Yan (2012) suggested that value of construction projects should be interpreted in terms of function, quality, cost and time. When inventing the concept of VM, it was identified that the focus on function could stipulate better value for money (Potts and Ankrah 2013). Therefore, the rationale behind VM is that the elements contributing to the poor value of projects need to be addressed to improve value for money by enhancing project performance while removing unnecessary costs (Shen and Yu 2016).

The Concept of Value Management

Various definitions of VM have been presented in the literature. Amongst such definitions, VM is described as “a structured and analytical process which seeks to achieve value for money by providing all necessary functions at the lowest cost consistent with the required levels of quality and performance” (AS/NZS 4183:1994). Moreover, Oke and Aigbavboa (2017) emphasised that VM was introduced to

compare alternatives in order to arrive at the one that provides the best function at the lowest possible overall cost. The main idea of the concept of VM, which is encapsulated from various definitions is that VM focuses to enhance value for money by providing all necessary functions at the lowest life cycle cost without degrading the quality and performance. In the construction industry, VM and VE are tend to be used interchangeably to describe a systematic process of appraisal of the functions of a project to ensure effective delivery of outcomes (Al-Yami and Price 2005; Ilayaraja and Eqyaabal 2015).

Olawumi *et al.*, (2016) asserted that a well-planned VM study should yield savings in 10-15% of total project cost while the cost of VM study is about 0.3% to 0.5% of the project cost (Daddow and Skitmore, 2005). Value studies of a project can be carried out at any stage of the project from its inception to its development and even during construction. However, earlier the application, higher the acceptance of value proposals would be, since late studies reveal higher cost of application, thus lesser acceptance of proposals (Ilayaraja and Eqyaabal 2015). According to Coetzee (2009), inception is the best stage that can improve the value of a project, and latter implementation of VM techniques gives less benefits and can interrupt the construction process. Further, Abdulaziz (as cited in Abdullah and Arabiyyat 2016) identified three different design stages where VM could be applied. The first instance is during the planning stage where functions and requirements of the project are established. The second instance is when the design is at 15% to 30%, and the third instance is where the design has developed up to 80% to 85%.

The systematic VM offers a job plan, which can guide to address the issues effectively throughout the building's life cycle (Jaapar *et al.*, 2012; Shen and Tu 2012). It is commonly known as the VM job plan, and it has been discussed in many forms consists of five to eight phases (Al-Yami and Price 2005; Chhabra and Tripathi 2014). VM job plan is sometimes referred to as VM workshop as well as value study process and are in the forms of SAVE 40-hour job plan, contractor's change proposal, charette, truncated workshop, concurrent study and VE audit (Kelly *et al.*, 2004; Shen and Yu 2016). The widely practiced standard SAVE 40-hour job plan is generally organised in three main stages: pre workshop, VM workshop with the sub phases; information, function analysis, creative, evaluation, development and presentation phase, and post workshop stage (Rad and Yamini 2016; Shen and Yu 2016).

Application of Value Management to Refurbishment Projects

The construction industry has long been employing VM for reinforcing the value of construction projects (Zhang *et al.*, 2009). However, very few studies on the application of VE or VM to refurbishment projects are recorded over the history. Witschey and Wulff (1998) investigated the application of VE in the renovation project of the Science Museum of Virginia and the authors emphasised the importance of VE as a strategy to reduce costs, while ensuring the quality. Moreover, Alan Short *et al.*, (2007) investigated the application of VE in five capital arts projects, which involved refurbishment as well as partly new construction. VE was applied in those projects to reduce budget overruns. In both studies, VM, which was perceived as VE was applied in an ad-hoc manner, because application of VM was customised as per the requirements of the projects. However, the mainstream literature suggests the lack of exploration of the applicability of VM to refurbishment projects.

RESEARCH METHODS

This research seeks to address the research problem of "how VM is applied to refurbishment projects in Sri Lanka" through a qualitative approach, as qualitative methods contribute to conduct in depth investigation on emerging concepts and is more appropriate, when the research has a small sample of respondents (Yin 2011). Due to the lack of applicability of VM concept in refurbishment and other construction projects in Sri Lankan construction industry, drawing a large sample of respondents for the data collection was constrained for the present study, hence a qualitative approach was administered. Since the case studies enable an in-depth examination of the context (Fellows and Liu 2008; Yin 2011), it was considered that case study approach would supplement and extend the in-depth investigation. A single case study is appropriate to explore a unique circumstance (Yin 2011). The author further explained that the criteria for selecting a case depends on the convenience, judgement, time and cost constraints. In this research, the unique case of a hotel refurbishment project, which has employed VM was selected considering aforementioned factors. This single case study was undertaken as a pilot study to a larger subsequent investigation.

Yin (2011) pointed out several data collection techniques to be included in case study research such as interviews, observations and document reviews. Punch (2005) highlighted interview method as a most commonly used data collection method, when the research embodies a qualitative approach. Employing un-structured interview method is preferred in qualitative approach since the respondents are given the opportunity to answer independently with a limited control imposed by the researcher (Dawson 2007). Accordingly, un-structured interviews were conducted for collecting data focusing on selected respondents, who involved in the VM study of the selected refurbishment project. This refurbishment project was scheduled to be undertaken in two phases. For the case study, only the details from the phase one was gathered, since the phase two of the project has not been commenced yet. Moreover, observations and reviewing relevant documents were undertaken to capture the required data. The authors referred to documents such as VM proposals, bill of quantities (BoQs), summary report of the VM workshop, drawings of the design proposals, photographic analysis of project documents and archival records of the building for data collection. The refurbished areas were observed by visiting the hotel building and photographic evidence were secured. The details of the refurbishment project and the participants are summarised in Table 1. This study employed a qualitative analysis to gain insights to the application of VM in the refurbishment project. For qualitative researches, content analysis provides subjective interpretation of texts through systematic coding and patterns (Hsieh and Shannon 2005). In order to facilitate content analysis of this research, NVivo (2010) was used for code based content analysis along with the manual content analysis.

Although the kitchen and laundry design consultant and the interior designer also participated in the VM study, the authors could not approach them as they are international design consultants.

Table 1: Profile of the refurbishment project and the respondents

Project details	Details of the respondents
Five star rated hotel with 19 storey building located in Colombo operating under the brand name of an international parent company.	A1: Project manager with 24 years of work experience and 10 years of prior experience in VM
Under phase 1 of refurbishment, front of house, selected back of house areas, lobby lounge, public toilets in lobby, Chinese restaurant, All day dining restaurant, main kitchen, board walk, executive lounge including mechanical, electrical and plumbing (MEP) services, the kitchen and laundry, lotus pond, air handling unit (AHU) room, fire commanding centre and lift lobby were refurbished.	A2: Cost consultant with 21 years of work experience and 11 years of prior experience in VM A3: Lead design consultant with 27 years of work experience and less than 1 year of prior experience in VM
The project was traditionally procured and the contract type was re-measurement contract.	A4: Contractor with work experience of 15 years of work experience and 5 years of prior experience in VM
Contract price was LKR 220,000,000 and final project cost was LKR 250,000,000.	A5: Chief financial officer (CFO) as the representative of the client with 18 years of work experience and no prior experience in VM
Planned duration of the project was 9 months but the actual duration of the project was 14 months.	A6: Chief Engineer (MEP Engineer) with 11 years of work experience and no prior experience in VM A7: Maintenance engineer with 12 years of work experience and no prior experience in VM

RESEARCH FINDINGS

Achieving Value for Money in the Refurbishment Project

Achieving value for money in the project was triggered due to challenges encountered during the refurbishment process. All the respondents confirmed that refurbishments are prominent in hotel buildings in Sri Lanka compared to other types of buildings, as hotel buildings need to be upgraded and modified frequently to maintain the tourist attraction. The top most challenges attributed are the budget overruns in superficial designs and construction activities, time overruns for refining designs to cater unanticipated building conditions, limitations to introduce changes to the existing building structures and the interruptions to building occupants due to simultaneous operations. These challenges adversely affected in achieving value for money in terms of cost, time, quality, hotel customer satisfaction and sustainability.

The Value Management Job Plan

The current status of the application of VM to refurbishment projects as captured from the opinions of the respondents deduced that although application of VM is becoming popular in new building projects, application of VM to refurbishment projects is very low. They also pointed out that VM is recognised as VE, despite lead designer's claims; "actually we interpreted it mostly as VE, however, we tend to use VM and VE alternatively". Regardless of its ad-hoc nature of application, all the respondents confirmed that VM workshop was conducted during the demolition and construction stage perceiving VM primarily as a cost reduction technique. Chief engineer noted; "some designs needed to be changed due to unanticipated building conditions encountered when actual construction activities started and mainly wanted to overcome resulting cost overruns". The reasons for not adhering to any standard or systematic approach for conducting the VM study for this project as opined by project manager; "the need for employing VM did not emerge when the project was initiated and we did not have enough time and knowledge to go by the book". Hence they indicated that VM should be initiated during the concept design stage and another VM

workshop should be conducted during the demolition and construction stage. Since there are no trained VM facilitators in Sri Lanka, the cost consultant played the role of the VM facilitator. The VM job plan adopted for this project was derived from the standard SAVE 40-hour job plan, which was conducted in the hotel premises for three consecutive days, with a duration of maximum 6 hours per day as follows.

14. Pre workshop stage- Similar to the standard job plan, VM team was formed and a briefing on the VM study was conducted to make the participants aware of VM. The objectives of the VM study were communicated by the cost consultant. Recently completed refurbishment projects of 5-star and 4-star rated hotels in the neighbourhood were studied.

Workshop stage- This stage comprised of five sub phases as below:

Information gathering phase- This phase corresponds to information phase in the standard job plan and focussed on collecting necessary information. As built drawings, relevant BoQs, structural survey reports, site inspection reports by the contractor and contractor's initial proposals were obtained. Problems identified during the site survey and initial demolition works were discussed through presentations and brainstorming.

Project analysis phase- The activities conducted during this phase were analogous to function analysis phase. Four value enhancing opportunities were determined. The required functions were identified and the costs per function were assigned with reference to BoQs. These activities were aided by functional analysis.

Options developing phase- Similar to the creativity phase, various alternatives were determined through brainstorming sessions and presented as VM proposals.

Analysis phase- The subsequent phases of evaluation and development in the standard job plan correspond to the activities conducted in this phase. BoQs for generated alternatives were developed and they were compared in terms of initial cost, maintenance cost, time of construction or installation, degree of quality achievement, maintainability, aesthetic appearance, environmental friendliness, durability and availability of material. Best alternatives were selected after evaluating the ranked options through checklists.

Presentation phase- Corresponds to the presentation phase in the standard job plan, selected best alternatives were turned in to written recommendations and project manager presented them to the VM team in the form of a summary report.

Post workshop stage- The implementation of accepted VM proposals and the follow-up session was undertaken.

None of the VM job plan phases were well structured even though the activities carried out were analogous to the standard SAVE 40-hour job plan.

Value Management Proposals and Their Impact

The VM proposals and the decisions made in formulating them along with the resultant impacts are highlighted below.

15. VM Proposal I

Initially, 4 decorative metal screens of satin bronze were proposed to be fixed to walls in the lobby area, to provide a metallic finish to enhance aesthetic appearance. In order to achieve the same function, screens of 2,400×3,000mm in metallic paint finish

on laminated HDF board were proposed and it in turn achieved a cost saving of LKR 88,199.02. The metallic paint finish resembles the satin bronze finish without impairing the expected quality.

16. VM Proposal II

The quantity of hanging glazed pendant lamps in all day dining restaurant was initially decided as 46. After the functional analysis, a new layout was proposed and the quantity of lighting fixtures was reduced from 46 to 42 without lowering the luminance level and the aesthetic appearance. The resultant cost saving of the modifications was LKR 12,072,960.00.

17. VM Proposal III

The initial proposal of laying 20mm stone tiles in the Chinese restaurant area was evaluated with the alternative of timber flooring. Before the refurbishment, this area had already been a timber floor. The functional analysis suggested that it was less time consuming, cost effective and convenient, if the existing timber floor was replaced with another timber floor instead of stone tiles. However, in terms of durability and aesthetic appearance, laying of stone tiles would have enhanced quality, because timber floor could subject to wear faster than stone tiles. In order to overcome this issue, engineered timber flooring of 900mm x 15mm was introduced by saving a LKR 841,963.20.

18. VM Proposal IV

The service lines, duct lines and electric cables running inside the ceiling were laid inappropriately, and it was realised after removing the ceiling. Hence, for the reception area, the initially proposed average 900mm dropped gypsum board suspended ceiling was proved to be frail and less moisture resistant. Alternatively, a moisture resistant gypsum board suspended ceiling of, average 900mm was introduced incurring an additional cost of LKR 341,275.50.

In total, the VM proposals achieved a cost saving of LKR 12,661,850, which is 5.06% saving from the total cost, LKR 250,000,000. Additionally, a reduction of annual operational and maintenance budget by 8.31% was reported for the areas, VM proposals were implemented. There was no additional cost incurred for the VM study, since the VM workshop was conducted simultaneous to project meetings. However, maintenance engineer pointed out; "time was consuming in the workshop, mainly because VM had not been planned from the outset of the project". Although, changing some design alternatives as per the VM study contributed a delay of 2 to 3 months in the project, project manager, cost consultant and contractor indicated that project could have gone through a time overrun of 7 to 8 months, if VM had not been implemented to enhance value through best design alternatives. Although there was no evidence to quantify the impacts quality improvement, hotel customer's satisfaction and achievement of sustainability, all the respondents endorsed the view that application of VM contributed immensely in the success of the refurbishment project of the hotel.

DISCUSSION AND CONCLUSIONS

Previous studies have suggested that despite the notion of enrichment of market value of old buildings through refurbishment, building owners are reluctant to administer refurbishment decisions (Chau *et al.*, 2003), primarily due to the inevitable challenges associated with the existing building. Findings of the current study have corroborated

the above notion, by highlighting that the need for VM was triggered as an approach to achieve value for money by overcoming the challenges. However, a very few instances of probing the application of VM can be found in the construction industry of Sri Lanka, primarily due to the lack of a proper guideline to apply VM (Perera *et al.*, 2003; Karunasena and Gamage 2017).

Comparatively, lack of exploration of the applicability of VM to refurbishment projects is evident. The study of Witschey and Wulff (1998) on the application of VE in the renovation project of the Science Museum of Virginia and the study of Alan Short *et al.*, (2007) on the application of VE in five capital arts projects, which involved refurbishment as well as partly new construction, are among the few examples, in which VM was perceived as VE and applied mainly as a cost reduction strategy. Similar findings were derived from the present study, in which VM was applied to a hotel refurbishment project, interpreting it as VE. VM was employed in this project to achieve value for money in terms of cost, quality, time, hotel customer's satisfaction and sustainability. Despite the ad-hoc nature of application, VM was actually employed mainly to reduce unnecessary costs, which the project had been suffered from the outset. The present study has practiced the VM workshop stage in an unstructured process of information gathering, project analysis, options developing, analysis and presentation phases. It can be inferred that ad-hoc nature of application of VM in the project is mainly due to the lack of knowledge about VM and incapability of planning the use of VM from the outset of the project. According to Olawumi *et al.*, (2016), a well-planned VM study should yield savings in 10-15% of total project costs while the cost of VM study is approximately 0.3% to 0.5% of the project cost (Daddow and Skitmore, 2005). Although no additional costs were incurred, the present VM study have secured a cost saving of a 5.06% and a reduction of annual operational and maintenance budget by 8.31% . Although it has been suggested to apply VM to construction projects at inception and design stages (Coetzee 2009; Ilayaraja and Eqyaabal 2015; Shen and Yu 2016), these claims have focussed on new building projects. However, the approaches used in the new building projects are not always suitable for the refurbishment projects because the challenges are peculiar to existing buildings (Rahmat and Ali 2010). Hence, the present study recommends that VM should be should be initiated in refurbishment projects during the concept design stage and another VM workshop should be conducted during the demolition and construction stage to revisit and revise original design solutions to match with the existing conditions of the building.

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HIGH IMPACT EDUCATIONAL PRACTICES IN CONSTRUCTION EDUCATION: AN EVALUATION OF STUDENT INVOLVEMENT AND PERCEIVED VALUE

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Recent focus on high impact practices within the collegiate experience has intensified. The National Survey of Student Engagement (NSSE) defines high impact educational practices (HIEP) as those activities that have the following traits: demand time and effort, facilitate learning outside the classroom, require meaningful interactions, encourage diverse collaboration, and provide frequent and substantial feedback. One U.S University has made an intensified effort over the past five years to ensure construction management students are meaningfully engaged in multiple HIEPs. A survey to assess the perceived value of HIEPs was administered to forty-eight graduating students in Fall 2017. The results show that over 80% participated in at least two high impact experiences with “service learning” and “industry internship” being most popular. A normalized Borda count was used to evaluate the highest ranked HIEP. The industry internship was perceived by students as most valuable. Students connected with themes that connect HIEPs with faculty and peers over an extended period of time and activities that allow students to connect on and off campus learning. Suggestions for improvement include expanded competition team opportunities and connecting learning outcomes with HIEPs. Future research may include measurement changes in knowledge, skills, and abilities before/after students engage in HIEP.

Keywords: construction education, educational strategies, experiential, high impact

INTRODUCTION

High impact educational practices (HIEP) represent purposeful, engaging, educational activities that supplement the traditional college experience. Each requires time and effort, and all activities have been linked to higher levels of student learning through research studies (Kilgo, Sheets, and Pascarella, 2009; Kuh, 2008; Sandeen, 2012). HIEP's include a variety of activities (Table 1). In the U.S, the National Survey of Student Engagement (NSSE) collects information annually from students regarding the quality of collegiate experiences on a national basis. This survey was established in response to a perceived problem regarding how 'quality' in education has been centred on the wrong things. The NSSE approach attempts to solve this disconnect by asking students directly about their educational experiences, and then using those

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responses as a proxy for college quality. Specifically, they ask questions about students' participation in programs and activities that institutions provide for their learning and personal development. Results indicate student perceptions of how undergraduates spend time and what benefits they realize from attending college. Since 2000, about six million college students at more than 1,500 institutions in the U.S and Canada have completed the NSSE (NSSE, 2007).

Table 1: Activities included in the HIEP

Learning communities	Internships/Co-op
Common book programs	First-year seminars
Collaborative assignments/projects	Problem-based learning
Undergraduate research	Service/Community-based learning
Study abroad/away	Advising/Mentoring
Capstone experiences	Digital/Technological learning
Writing-Intensive courses	ePortfolios

Data from the NSSE study has been used on a global level to make specific recommendations for HIEPs. Specifically, data has been gathered that indicate which practices best add to the educational experience. Studies have also been done that explore how these practices benefit under-served communities in education (Kuh, 2008). Additionally, the results have yielded attempts to better connect learning outcomes with high impact practices to further amplify the potential of HIEP.

While the NSSE data empirically confirmed “best practices” in undergraduate education, no data has been aggregated specific to construction management. This introductory study considers high impact practices in construction management at one U.S institution. What current HIEP are most beneficial from the perspective of the student? Why are the selected HIEP beneficial, and what could be done to improve experiences that engage the student? If these behaviours by students of construction programs could be better understood, the undergraduate educational experience could be improved.

LITERATURE REVIEW

In 1998, the Boyer Commission presented ten recommendations for the “reconstruction” of undergraduate education at research universities (Carnegie Foundation for the Advancement of Teaching, 1998). In that report, the university was considered part of a larger ecosystem that emphasized how students and faculty were on a shared mission of learning and research. All of the ten recommendations would meet the requirements of HIEPs under today’s guidelines:

Make research based learning the standard	Use information technology creatively
Construct an inquiry-based freshman year	Culminate with a capstone experience
Build on the freshman foundation.	Educate graduate students as apprentice teachers
Remove barriers to interdisciplinary education	Change faculty reward systems (to incentivize recommended practices)
Link communication skills and course work	Cultivate a sense of community

The Boyer Commission had determined that undergraduate institutions in the U.S had fallen short of intended outcomes. Outstanding research opportunities were advertised to students, but most would graduate without ever experiencing either. Classes were

taught by either unprepared graduate students or educators who did not fully engage students. Concerns were expressed as to whether or not graduates were able “to think logically, write clearly, or speak coherently” (Carnegie Foundation for the Advancement of Teaching, 1998, 15). Thus, the concept of HIEPs was born in an effort to provide diverse experiences, solve challenging problems, force independence and self-reliance, and foster stimulation (Carnegie Foundation for the Advancement of Teaching, 1998; Kuh, 2008).

Traditional reports on student success have included such items as access to education, retention rates, graduation rates, and grade point averages. These results encourage campus climate, mentoring opportunities for students, and peer to peer engagement. These results tend to not capture learning that is both valued by society and that empowers the individual. Additional measures were needed to address the quality of the educational experience and not just a students’ persistence and completion (University of Indiana, 2007).

George Kuh spotlighted and confirmed a set of “effective educational practices” that correlated with increased educational results for students from a variety of backgrounds (2008). Deemed HIEPs, each of these activities provide increased educational benefits to students. HIEPs address directly the knowledge, capabilities, and personal qualities that will allow a student to contribute to the global economy. Kuh’s results further show that the benefits of HIEPs are increased for underserved communities and for those who enter college with lower test scores.

Kuh focuses on “deep” learning which he defines as learning that emphasizes both acquiring information and understanding the underlying meaning of the information (Kuh, 2008). Of the students who participate in such learning, most tend to earn higher grades and retain, integrate, and transfer the information gained at higher rates (Nelson, Shoup, Kuh, and Schwartz, 2008). Other authors report that HIEP participation is a significant predictor of future career plans and early job attainment (Miller, Rocconi, and Dumford, 2018).

HIEPs are deemed effective with students because they contain five critical items that are especially meaningful (Kuh, 2008):

- Require considerable time and effort on purposeful tasks
- Demand that students interact with faculty and peers over an extended period of time
- Connects students with diverse individuals
- Receive frequent feedback about their performance
- Allows students to see how what they are learning works in different settings and help put the learning in perspective (on and off campus)

These events allow students to connect learning experiences with specific experiences. Such events tend to “blur the boundaries between students’ academic and out-of-class lives” essentially increasing the social and cognitive impact of the experience (Terenzini, Pascarella, and Blimling, 1996). Students have a better perspective on themselves, and they acquire tools to act with confidence as they return to the classroom or move to professional practice.

Other researchers identify the need for HIEPs to be intentional (McNair and Albertine, 2010). They argue that institutions must start with their learning outcomes and the particular academic and developmental needs of their cohorts. Institutional culture and context should also be considered. Developing a purposeful implementation plan

prevents HIEPs from being “a solution in search of a problem” (McNair and Albertine, 2010).

The National Survey of Student Engagement (NSSE, n d) includes three areas that “explore the degree to which students report having made gains in a variety of personal, practical, and general education competency areas as a result of their undergraduate education.” These scales include “general education”, “practical competence”, and “personal and social development”. In addition, NSSE has developed a list of activities that researchers associate with “deep approaches to learning”. Scores in these four areas were normalized to a one-hundred-point scale, with higher numbers indicating that a student reported higher gains in learning or more experiences connected to deep learning. For all four measurement areas, students who participated in more HIEPs indicated consistently higher levels of engagement with deep learning. Gains in “general education”, “practical competence”, and “self-reported deep learning experiences” exceeded “gains in personal and social development” at all levels.

METHODS

Traditional measures of academic success (including retention rates, time to graduation, and grade point average) focus on measures that may not adequately measure the quality of the learning experience in undergraduate education (Carnegie Foundation for the Advancement of Teaching, 1998; Kuh, 2008). Recent efforts in HIEPs have indicated higher perceived learning experiences for students across multiple curriculums. This study explores the use of four HIEPs at a U.S institution within their construction management program. If the value of HIEPs could be better understood, improvements may be possible in construction education.

Since 2014 the construction management program at Auburn University has had a strategic objective to “increase opportunities for students to have an enriching educational experience”. The program has been collecting participation rates in four HIEP’s offered by the program through a graduating senior exit survey. For the 10 semesters surveyed from Fall 2014 through Fall 2017, the high, low and average participation rates in HIEP’s are identified in Table 2.

Table 2: Participation Rates in HIEP’s

	% Participation Rate per Graduating Semester		
	High	Low	Average
High Impact Education Practice			
Construction Specific Service Learning Project	100%	89%	94%
Construction specific study abroad or international experience	70%	11%	31%
Competition Team	63%	20%	40%
Industry internship or co-op	100%	81%	89%

Results show that all the HIEPs have robust participation rates that do vary from semester to semester due to availability of activities.

The purpose of this study was to determine which of four HIEPs in use within an existing construction management program was perceived as the most valuable by the students. Further, the study sought to identify what elements of the HIEPs make the

experiences valuable and what opportunities may exist for improvement from the perspective of the students.

A survey was distributed to sixty graduating seniors in a construction management undergraduate program in the Fall of 2017. The sixty seniors represented the full population available for the study. Forty-eight responses were received. The subjects represented are a homogeneous group having completed the same undergraduate education program aiding in establishment of reliability of the study. Participation in the study was voluntary, and no compensation was provided for participating in the study.

Both quantitative and qualitative measures were used. Descriptive statistics determined which HIEP was highest ranked while qualitative measures were used to evaluate the open-ended questions regarding “what was valuable” and “what could we do differently”. Descriptive research is defined as the “procedures and measures by quantitative data” (Wiersma and Jurs, 2009). The study of education often includes descriptive research with measures of relationships being one common descriptive statistic (Merriam and Simpson, 2000). Qualitative measures of theme identification were used consistent with qualitative research (Ryan and Bernard, 2003).

The instrument used contained four questions:

Which “engaged educational experiences” did you participate in while in the Construction Management Program?

- Construction specific service learning project
- Construction specific study abroad or international experience
- Competition team
- Industry internship or co-op

For the experience in which you participated, force rank the programs in the order that they added value to your education

For the experience, you ranked as “#1”, why was is considered you top program?

What is one thing that we could do different that would enhance engaged educational experiences like the ones shown above?

Results reported initially include a percentage of students who forced ranked each HIEP in order of value to their education. Because not all forty-eight students experienced each HIEP, the sample size for each ranking is different. With multiple sample sizes for each activity, the data was normalized in an effort to judge whether the count was ‘high’ or ‘low’. This provided an appropriate basis for comparison. The normalization approach was simply to use a percentage basis of responses so the number of rankings in a specific HIEP was divided by the total number of people who participated in that HIEP.

The Borda count was then calculated for each HIEP. This approach determines the outcome of a winner of an election by giving each HIEP, for each vote, a number of points corresponding to the number of HIEPs ranked lower (Tsai, Hu and Ke, 2014). For this study, a point-based score of 1 was matched with a top ranking, .75 was matched with a 2nd ranking, .50 was matched with a 3rd ranking, and .25 was matched with a 4th ranking. This approach was consistent with Borda’s original proposal which bases the points on the total number of candidates in an election. The number of votes for each ranking was multiplied by the score, and these totals were added to determine a total point score for each HIEP. The HIEP with the most points is the winner. This approach tends to value broadly-acceptable options rather than those

dictated by the majority essentially making it a consensus-based system (Emerson, 2013).

For the open-ended questions in the survey, responses by students were coded by major theme as identified by the literature review for the five critical items that make HIEP especially effective:

- Theme #1-Require considerable time and effort on purposeful tasks
- Theme #2-Demand that students interact with faculty and peers over an extended period of time
- Theme #3-Connects students with diverse individuals
- Theme #4-Receive frequent feedback about their performance
- Theme #5-Allows students to see how what they are learning works in different settings and put the learning in perspective (on and off campus)

The principle investigator then went through the survey data and cut out all the quotes that pertained to each of the five major themes. Then, the other researcher confirmed the placement of quotes into the major themes identified. Quotes were then sorted by theme matching a common approach to identifying subthemes (Jehn and Doucet, 1996).

RESULTS

Figure 1 shows the results of the forty-eight people who participated in the study. All had completed a construction specific service learning project (48); 44 had completed an industry internship or co-op experience; 26 had competed on a competition team; and 16 had completed some type of international experience. Approximately 47 had completed two HIEPs, 26 had completed three HIEPs while 13 had completed four IEPs. The industry internship and the service learning project specific to construction were the top two experiences when forced ranked by the students.

Figure 1 shows a forced ranking of Construction Specific HIEPs:

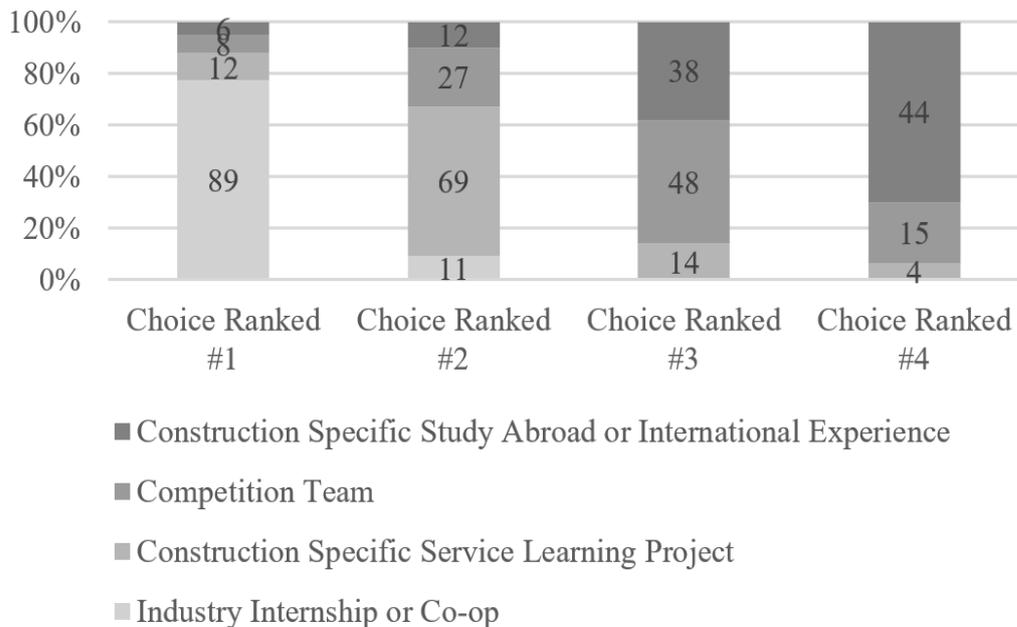


Figure 1: Forced Ranking of Construction Specific HIEPs

Table 3 shows the calculated Borda count for each construction specific HIEP. Essentially, this approach determines the winner in an election context by giving each

HIEP a number of points corresponding to the number of HIEPs ranked lower. This shows that the Industry Internship or Co-op is the most highly valued HIEP and that study abroad or international experience is valued least.

Table 3: Borda Count for Each Construction Specific HIEP

	Borda Count (Normalized)
Industry Internship or Co-op	.97
Construction Specific Service Learning Project	.72
Competition Team	.49
Construction Specific Study Abroad or International Experience	.31

For the qualitative data, connections were made from specific quotes of students to identified key criteria that make HIEPs especially effective:

- Theme #1-Require considerable time and effort on purposeful tasks
- Theme #2-Demand that students interact with faculty and peers over an extended period of time
- Theme #3-Connects students with diverse individuals
- Theme #4-Receive frequent feedback about their performance
- Theme #5-Allows students to see how what they are learning works in different settings and put the learning in perspective (on and off campus)

Students offered 47 comments regarding their HIEPs with 5 of the comments touching multiple themes. The analysis shows that students relate strongly to HIEP Theme #5 (45 occurrences) and moderately to Theme #2 (7 occurrences). One person connected with Theme #1. Examples of student comments and corresponding themes are shown in Table 4.

Table 4: Student Quotes Connected to Criteria that Make HIEPs Effective

Student Quote	Assigned Theme
I enjoyed working with my peers to build both a wood deck and an alligator pond. It helped build my problem solving and teamwork skills. (Service Learning)	Theme #2, Theme #5
It taught me specifics of learning how to design and develop a project as a group and use basic construction training practices and learn development sequences. (Service Learning)	Theme #2, Theme #5
Required you to apply what you learned in a more realistic “industry” like setting. Tested you because you’re on your own without a coach, and you have to work well with other people. They’re also great networking and travel opportunities. (Competition Teams)	Theme #2, Theme #5
Because I had 2-3 months contracted in the field, 10 hours a day, it showed me how the industry really played out. (Internship or co-op)	Theme #1, Theme #5
Learned the most in real world experiences. (Internship or co-op)	Theme #5

DISCUSSION AND CONCLUSIONS

A recent focus has been placed on HIEPs within undergraduate education. These activities demand considerable time and effort, facilitate learning outside the classroom, require meaningful interactions with others, encourage diverse collaboration, and provide frequent and substantial feedback to the students. As a professional degree, construction management is uniquely suited to make connections for HIEPs through connection with industry and the built environment. This study considers one U.S University’s attempt to determine which HIEP is perceived as most valuable by the students. Building on existing studies from the National Center for

Student Engagement which show students in all majors self-identify HIEPs with improved educational growth and professional competence, the study attempted to determine why the HIEP was deemed valuable and what opportunities exist for further improvement of HIEPs within Construction Management.

Over 80% of graduating students participated in at least two high impact experiences with “industry internship” and “service learning” being the most popular by total number of participants. Students in this study had no required internship as part of their curriculum but were required to complete two service learning construction oriented projects during their undergraduate studies. Students had at least two opportunities for study abroad during their curriculum. In addition, approximately 15 teams compete each year providing space for approximately 60 students (distributed over four classes of students).

The number of students participating in either competition teams or an international experience was substantially (on the order of 50% or more) lower than those engaged in internships or service learning. Barriers to international experiences and competition teams exist. Students reported concerns over cost of international experiences and for this study failed to connect the experience with their learning. The authors recognize that the impact of the study abroad experience through improved intercultural competencies and interpersonal accommodation may only be realized after some time. Also, students report a lack of understanding of both the availability to be on a competition team and a lack of opportunity. Many competition teams are limited to 4-6 people, and the costs of operating these teams is high limiting the number of teams in any single academic year.

Based on the Borda count, the students rank the internship or co-op as their top HIEP. While competitions and international experiences were viewed favourably, they were valued less than either internships or service learning. The high value placed on internships and service learning by the students is encouraging for the program as exit survey data shown in Table 1 confirms that this is where the greatest student participation in HIEP’s has occurred.

The qualitative responses also revealed some of the connections students make between HIEPs and identified key criteria that make HIEPs especially effective. Student comments revealed that clear connections are made with practices that demand interaction with others over an extended period of time and those activities that allow students to see how the material they have learned works in a variety of settings allowing them to put the learning in perspective. Students did not make connections with criteria that include requiring considerable time and effort on purposeful tasks, connecting students with diverse individuals, and receiving frequent feedback about their performance. Student’s failure to connect the length of time required for HIEPs may be due to how the time matches other non-HIEPs in which students participate. Results appear to indicate that opportunities for diverse experiences in current HIEPs may not exist at a significant level. Even with activities such as study abroad, no formal immersion with students with individuals with a diverse background occurred.

While the capstone experience the students participate in was not specifically addressed in this forced ranking, several students noted in the qualitative comments that they viewed it as a HIEP. Interestingly, they questioned why more specific HIEPs could not be included as part of the capstone experience. Study is needed to

determine what opportunities may exist and how those opportunities could best be delivered within the format of the capstone experience.

No formal connection currently exists between the HIEPs offered in the construction management curriculum and the learning outcomes defined by the program. Further work should seek to make a clearer connection so that direct and purposeful pathways may be defined for students and institutions. If a link could be established between HIEPs and specific learning outcomes, HIEPs could serve as means to fulfil and/or measure the outcome.

Currently, not all students have access to all HIEPs. Ideally, at least one HIEP would be available to every student at least once per year; every HIEP selected would be done at a high level. Additional work is needed to balance HIEPs across the curriculum, assure availability to all students, and accurately measure the level at which HIEPs are delivered. One way to do this would be to include measurement of changes in key knowledge, skills, and abilities before and after students engage in HIEPs.

For this program, HIEPs are being done above and beyond the typical undergraduate educational experience and are considered outside the parameters of what is formally required. Only one of the HIEPs considered was required, and that activity occurs in a specific class without focus on an overall learning outcome required of the student. Opportunities for enhancement of these opportunities exists, and research suggest this would improve the quality of education for all students. Construction management programs should make HIEPs a reality and a priority for every student.

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A MODEL FOR EARLY STAGE ESTIMATION OF OPERATIONAL EXPENSES (OPEX) IN COMMERCIAL BUILDINGS

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Usually, Operational Expenses (OPEX) consume a substantial share (70-80%) of Life Cycle Cost (LCC) of commercial buildings. Despite its contribution to the LCC structure, often OPEX is given less focus in investment decision making and investors tend to mostly rely on initial cost alone. This is due to lack of reliable historical cost data related to building operations and maintenance. In addition, a varying range of models are available and application of those are limited to the later stage of building life cycle as these models require an extensive set of operational cost data. Therefore, this study introduces a model, which can facilitate the early stage estimation of OPEX in commercial buildings together with OPEX indices for commercial buildings in Sri Lanka. The data related to OPEX and building characteristics were collected from 35 commercial buildings in Sri Lanka. The hedonic regression model developed indicates that 94.6% of variance in the annual OPEX/sq. ft. in commercial buildings could be expressed by working days/week, working hours/day, gross internal floor area, building height, and the number of occupants. These findings would enable an investor to optimise the OPEX by controlling the impact of physical characteristics in commercial buildings. Further, the developed indices will be beneficial for industry practitioners in measuring relative changes in OPEX in commercial buildings over a period of time.

Keywords: cost modelling, hedonic regression, indices, OPEX

INTRODUCTION

It is often said that when the design of a building is finished, although only a 10 to 15% of the total cost has been spent, 80% of the cost has been committed (Kehily 2010). Green (2009) asserts that local marketers will increasingly demand buildings with low operating costs, driving demand for tools and techniques that model a building's operating costs and incorporate and budget for building Life Cycle Cost (LCC). LCC perspective has proved to be most meaningful during the design phase, where the possibilities of cutting down the costs related to operations and maintenance (O&M) are large (Sterner 2000). The mathematical LCC models generally aid design-team decision making in conjunction with analyses of alternatives at the initial stages (Al-Hajj and Horner 1998). Early implementation of cost estimation models is

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therefore essential as it provides explanations of the relationships between cost and design parameters (Durairaj *et al.*, 2002). Those models further contribute to cost reduction by identifying high-cost contributors. However, cost estimation during the design phase is not an easy task as there is no adequate cost and building performance data, particularly, which is available during the operational phase. Thus, the application of cost estimation methods and models developed to date are underutilized due to a number of documented barriers to adoption in terms of the quality and availability of data. Notably, these include the use of limited cost data, use of historical cost records maintained based on an available cost structure rather than on the standards cost structure, and absence of data normalisation (Kirkham 2002; Opoku 2013; Krstić and Marenjak 2017). Krstić and Marenjak (2017) further opined that the application of cost-based models is limited to the later stage of building life cycle and ignore some important cost determinants such as building age, location, and number of occupants. For instance, the cost models developed by Kirkham *et al.*, (2002) and El-Haram *et al.*, (2002) are purely based on cost components and ignore significant factors affecting LCC of buildings particularly, building characteristics (El-haram and Horner 2002; Ungar 2003; Kerama 2013; Perera *et al.*, 2016).

Commercial buildings consume higher running cost than residential, institutional and industrial buildings (Lai and Yik 2008; Goh and Sun 2015). Amongst commercial buildings, running cost of an office building varies between 72 to 81% of its total LCC (Wong *et al.*, 2010). Similarly, in Wang *et al.*, (2014) study, commercial buildings came first with running costs accounting for over 69% of total LCC. Further, the comparison of U.S. private-sector office building OPEX figures indicates a 35% of increase in OPEX from 2009 to 2016 (Building Owners and Managers Association [BOMA] International 2016). Given the dramatic increase in running cost of commercial buildings and limited application of existing LCC estimation models, this research develops an early stage supportive cost estimation model for OPEX in commercial buildings. The developed model uses a wide set of operational and maintenance cost factors, which are known at the early stage of buildings life cycle. A detailed discussion on how the developed model addressed aforementioned limitations is provided in the research methods section of the paper. The study therefore believes such information could help both building constructors and owners to make informed cost decisions over properties.

Further, having an index for OPEX allows building developers and owners to monitor changes in the general level of operating costs of commercial building ownership. The academic research published in this arena has primarily focused on models to forecast or predict changes in the general construction price level. Despite several standards and guidelines, i.e. British Standard International Organization for Standardization (BS ISO) 15686-5:2008 standards and RICS new rules of measurement: NRM 3, which provide consistent rules for the quantification and measurement of building maintenance work items, very few studies have taken effort to develop indices for OPEX in buildings. For instance, the New York City Rent Guidelines Board (2017) developed a Price Index of Operating Costs (PIOC), which measures changes in the cost of goods and services used in the O&M of apartment buildings in New York City. Similarly, the BCIS has developed online running cost indices, which provide a central location for those who involved in the O&M of buildings. Goh (2016) designed a whole life building cost index for non-residential green-rated buildings in Singapore. Besides, none of these indices was compiled to provide an indication on the trend of OPEX incurred by buildings based in developing

countries like Sri Lanka as there is a huge difference in terms of economy, environment, and social aspects with compared to developed states, which can affect OPEX of commercial buildings. That emphasises the need for regional/locational cost indices and with that motivation, this study further extends to develop OPEX indices for the commercial building sector in Sri Lanka. Accordingly, the information provided by indices can be particularly useful to commercial developers in helping them to capture the price movement of the most significant running cost components of buildings which the existing models and indices fail to measure.

LITERATURE REVIEW

Factors Influencing OPEX in Buildings

The factors influencing OPEX in buildings have widely been discussed under eight broad categories: building characteristics, maintenance factors, managerial factors, design& construction defects, tenant factors, environmental factors, political factors, and social factors as illustrated in Table 1.

Table 1: Factors influencing OPEX in buildings

Determinant	Sub-factors	Sources
Building characteristics	Function, Location, Building age, Size, Height, Type of structure, Building materials and components, Building services, Finishes	Ungar (2003), Kerama (2013), El-haram and Horner (2002), Perera <i>et al.</i> , (2016)
Maintenance factors	True cause of defect, Lack of preventive maintenance, Poor workmanship, Faulty maintenance, Low concern to future maintenance, Failure to execute maintenance at the right time	Ungar (2003), Kerama (2013), El-haram and Horner (2002), Perera <i>et al.</i> , (2016)
Managerial factors	Budget Constraints, Lack of building maintenance manuals, Poor quality spare parts/materials, Poor financial control, Poor or lack of training, Poor maintenance management, Unavailability of skilled and educated labours	Ungar (2003), Omari (2015)
Design and construction defects	Poor supervision, Architectural design defects, Poor quality control on site, Defective construction materials, Poor structural design, Lack of proper reinforcement in concrete, Site defects	Omari (2015)
Tenant factors	Vandalism by tenants, Misuse of property, Expectation of Tenants, Ignorance about maintenance works, Accessibility to the property, Right to buy policy	Kerama (2013), El-haram and Horner (2002), Perera <i>et al.</i> , (2016)
Environmental factors	Natural deterioration, Harsh climatic conditions	Omari (2015)
Political factors	Changes in legislations (New H&S regulations), Changes in O&M standards, Price inflation, Changes in taxes and utility tariffs	Ungar (2003), Kerama (2013), El-haram and Horner (2002), Perera <i>et al.</i> , (2016)
Social factors	Cultural practices, Third-party vandalism	Omari (2015)

Amongst, literature mostly highlights the effects of building characteristics and tenant factors on OPEX. For example, age of the building is one of the essential elements, which influences the maintenance budget (El-Haram and Horner 2002) as older buildings would invariably require additional maintenance work. Similarly, Shabha (2003) discussed how poor building finishes can cause deterioration or defects in building components resulting in a high maintenance cost for repairing or replacing such components. Further, being one of the building characteristics, building services contributed to 20 to 45% of the total running cost (Ali *et al.*, 2010). Authors further stressed that improper material selection over the life of a facility or a building component is one of the dominant factors affecting condominium O&M costs. Refereeing to tenant factors, the demand made by tenants for a better lifestyle or a living environment results in increased maintenance. El-Haram and Horner (2002) too identified ‘use of the property’ as a prominent determinant of condominium

running costs due to the unavailability of property operating manuals and proper tenant education about the condominium living environment. Authors further stated that inability to gain access to the property due to privacy or cultural reasons is one of the major factors that affect condominium maintenance costs. Further, early response to building failure would be necessary in order to reduce maintenance costs (Perera *et al.*, 2016).

Existing parametric models for life cycle cost estimation of buildings

Throughout the years numerous LCC models have been generated which are based on either cost or building characteristics. For example, Al-Hajj and Horner (1998) have presented a running costs model for institutional buildings, with eleven cost elements and to an accuracy of 1.13%. Similarly, Kirkham *et al.*, (1999) have developed an energy cost model for sports centres, which based building characteristics such as the number of users and floor area. Subsequently, Kirkham *et al.*, (2002) and El-Haram *et al.*, (2002) have developed WLCC models for hospital buildings where cost components such as facilities management costs, energy costs, maintenance costs, residual costs, and discount rate were determinants of WLCC. However, Dhillon (2010) explained that there is still plenty of reasons for not having a commonly accepted model, including user preference, the presence of various systems of cost data gathering, and many different types of equipment, appliance, or systems. And also, the application of Kirkham *et al.*, (2002), El-Haram *et al.*, (2002), and Al-Hajj and Horner (1998) models are restricted to the later stage of building life cycle as those are based on historical cost records. Further, Krstić and Marenjak (2017) argued that these models are usually not based on adequate historical cost records and based the available cost structure, rather than standard cost structure. Authors further indicated that models developed so far ignore some important factors such as the age, location, level of occupancy, and standards of operation (Krstić and Marenjak 2017).

To this end, there is no simple model for predicting OPEX based on building attributes, operational arrangement and user characteristics (Krstić and Marenjak, 2017). Parametric cost estimation approach is preferred in most of the situations as it essentially correlates cost and product/system parameters describing the items to be costed (Kirkham, 2002; Caplehorn, 2012). However, the application of purely parametric cost estimation methods is limited due to lack of reliable historical cost data and building characteristics, which have a direct influence on its LCC. Giving the limitations of existing models and the limited application of parametric models, the current study introduces a reliable and simple model for estimating OPEX at the early stage of commercial buildings. The study further develops an index, which enables to obtain the changes in OPEX of commercial buildings over the time and predict the future trend.

RESEARCH METHODS

The research was primarily approached quantitatively to develop an early stage supportive OPEX estimation model together with cost indices for OPEX in commercial buildings. The documents including architectural drawings, bills of quantities, historical cost records, and monthly utility bills were reviewed to collect the required data from 35 commercial buildings in Sri Lanka. Generally, a sample size of more than 30 at 5% confidence level is sufficient for many types of research (Altunışık *et al.*, 2004).

A summary profile of selected buildings is presented in Table 2.

Table 2: A summary profile of selected buildings

Function	No.	(%)	No. of floors	No.	(%)
Office	17	49%	3 to 12	22	63%
Bank	13	37%	13 to 25	09	26%
Institution	03	9%	above 25	04	11%
Retails	01	3%			
Multi-purpose	01	3%			
Total	35	100%	Total	35	100%

As shown in Table 2, commercial buildings selected for the study consists of 49% of office buildings and 37% of banks while remaining include educational institutes, retails, and multi-purpose (i.e. hotel + apartment) buildings. Further, a majority of the selected buildings (63%) consists of three to twelve floors while remaining 26% and 11% are thirteen to twenty-five and above twenty-five storied buildings respectively.

Although the review of the literature identified a list of factors, which influence the LCC of buildings, this study has collected data related to thirteen (13) building characteristics, which are quantitative in nature and convertible (nominal data). Further, the OPEX data was collected in accordance with the standards of BCIS, BS ISO 15686-5:2008 standard, and NRM3, for three consecutive financial years: 2014, 2015, and 2016.

Basic data analysis tool employed within the study is statistical analysis tool of SPSS 22. Firstly, the missing data within the collected dataset were imputed with the aid of 'Multiple imputation' analysis technique. Multiple imputation is a simulation-based procedure and its purpose is to handle missing data in a way resulting in valid statistical inference to minimize compromising the validity and reliability of the output due to unavailability of data (Field 2009). Most importantly, the dependent variable: total OPEX were normalised dividing by the Gross Internal Floor Area (GIFA) of respective buildings. Second, both the dependant and independent variables were analysed to check the assumptions that need to be satisfied to run a multiple linear regression analysis as recommended by Field (2009). Subsequently, the hedonic regression modelling was used to develop the cost model as it presents OPEX of the property as a function of its structural and location characteristics where there is no adequate cost data. This approach has been used over the years in economic studies including Feenstra and Diewert (2001), Hill and Melsner (2008), and Forenbacher and Husnjak (2016) but not evident in building cost estimation.

Finally, the hedonic price imputation approach along with the Fisher's index was employed for the imputation of OPEX indices. A number of index number formulae are recommended but a good overall choice appears to be the Fisher ideal index since this index can be justified from several different perspectives (Hill and Melsner 2008). The Fisher index is the geometric mean of the Laspeyres and Paasche indices, thus eliminates drawbacks of these two key index methods (CPI Manual 2004). Further, Fisher's index is the ideal to be replaced by the hedonic price imputation approach and the combination of these two methods has been used over years, for example, in studies of Ball and Allen (2003) and Yu and Ive (2008).

DATA ANALYSIS AND FINDINGS

An early-stage model for estimating OPEX in commercial buildings

In order to proceed with the multiple linear regression analysis, there is a set of assumptions to be satisfied. Firstly, both dependent and independent variables should be the continuous form of data. In this study, the dependent variable, which is OPEX/sq. ft. and independent variables including working days/week, working hours/day, building age, GIFA, net floor area, circulation area, height, number of floors, window area, Window-to-Floor-Ratio, and number of occupants are scale data. In addition, two dummy variables namely, the grouping of buildings (1=Detached, 2=Attached), and type of structure (1=Steel frame, 2=Concrete, 3=Pre-cast panels) were added to the analysis to represent the nominal data collected. Therefore, satisfied the first assumption.

Next, the Shapiro-Wilk normality test was conducted to explore the normal distribution of residual values. As observed from Table 3, the significance of the standardized residual (ZRESI) is greater than 0.5 indicates that the ZRESI is normally distributed (Field 2009).

Table 3: Test of normality: Shapiro-Wilk

	Statistic	df	Sig.
Standardized Residual	0.954	30	0.211

Finally, a stepwise multiple linear regression analysis was run on the data collected and the analysis offered six regression models. Table 4 provides a summary of the models computed for estimating OPEX in commercial buildings.

Table 4: Summary of models

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.980a	.960	.935	790.28674	
2	.980b	.960	.939	767.20236	
3	.979c	.959	.941	751.77357	
4	.979d	.959	.944	735.93866	
5	.979e	.958	.946	724.10709	
6	.978f	.957	.946	719.88679	
7	.977g	.954	.945	725.32214	2.233

According to the Durbin-Watson statistic (2.233) shown in the table, errors of all estimates are independent of the dependent variable as the rule of thumb is that test statistic values in the range of 1.5 to 2.5 are relatively normal (Field, 2009). Subsequently, among these six models, the best fit model was identified considering the highest adjusted coefficient of determination (R^2), as it is more accurate than the R^2 and this ranges between 0 and -1. Although both fifth and sixth models yield the highest adjusted R^2 , which is 0.946, the sixth model was selected as the best model considering the minimum standard error. Accordingly, the goodness of fit of the model is 94.6%, which implies that approximately 95% proportion of variance in the annual OPEX/sq. ft. in commercial buildings could be expressed by five independent variables entered into the model namely, working days/week, working hours/day, GIFA, building height, and occupancy. For more reliability, multicollinearity effect of the selected model was checked using the collinearity statistics shown in Table 5.

Table 5: Coefficients and collinearity statistics of the model selected

Model	Unstandardized Coefficients		95.0% Confidence Interval for B		Collinearity Statistics	
	B	Standard error	Lower Bound	Upper Bound	Tolerance	VIF
6 (Constant)	-899.608	1232.369	-3462.461	1663.244		
Work. days/week	293.428	254.103	-235.009	821.865	0.508	1.967
Working hours/day	-132.931	52.237	-241.564	-24.297	0.415	2.409
GIFA	0.065	0.018	0.027	0.103	0.108	9.288
Building height	16.024	3.475	8.796	23.252	0.105	9.487
Occupancy	-0.192	0.112	-0.424	0.040	0.458	2.185

a. Dependent Variable: OPEX/sq. ft.

Although there is no formal criterion for determining the bottom line of the tolerance value or Variance Inflation Factor (VIF), Chatterjee and Hadi (2012) suggest that a tolerance value less than 0.1 or VIF greater than 10 generally indicates a significant multicollinearity. As seen in Table 5, the collinearity statistics, tolerances of greater than 0.1 and the VIFs of less than 10 indicate the non-existence of multicollinearity in this model.

Upon satisfying all the requirements, the annual OPEX/sq. ft. of a commercial building located in a tropical climate is expressed using the hedonic regression modelling. Accordingly,

$$\begin{aligned} \text{Annual Operational Expenses (LKR/sq. ft)} &= -899.608 + 293.428 (\text{Working days/week}) \\ &- 132.931 (\text{Working hours/day}) + 0.065 (\text{GIFA}) \\ &+ 16.024 (\text{Building height}) - 0.192 (\text{Occupancy}) + 719.88679 \end{aligned}$$

With the use of this developed model, the OPEX in commercial buildings can be determined at early design stages. Consequently, can reduce the excessive costs to be incurred during the operational phase of the commercial buildings located in tropics.

Cost indices for OPEX in commercial buildings

Following the model for OPEX, the cost indices for OPEX of commercial buildings in Sri Lanka were imputed for three years: 2014, 2015, and 2016. The first quarter of 2014 was considered as the base as it did not experience any extreme effects such as tariff changes and abnormal inflation conditions. The indices were constructed using the hedonic price imputation approach along with the Fisher's index.

The Fisher's index takes the following form. $P_i = \sqrt{\frac{\sum p_1 q_0 * \sum p_1 q_1}{\sum p_0 q_0 * \sum p_0 q_1}} * 100$

Where, P_i -price index, p_1 -prices of the current year, p_0 -prices of the base year, q_1 -quantities of the current year, and q_0 -quantities of the base year.

With the use of hedonic price imputation approach, prices for both base and current years were replaced by the regression coefficients (r) computed through the regression analysis for each variable and the mean value (\bar{x}) of each variable were considered as the quantity for both years. Therefore, the Fisher's index formula takes its new form

$$\text{as } P_i = \sqrt{\frac{\sum r_1 \bar{x}_0 * \sum r_1 \bar{x}_1}{\sum r_0 \bar{x}_0 * \sum r_0 \bar{x}_1}} * 100$$

Following the aforementioned procedure, cost indices for OPEX in office buildings, banks and all commercial buildings were imputed and the resulted index values are presented in Table 6.

Table 6: Quarterly OPEX indices for different types of commercial buildings and all commercial buildings in Sri Lanka

Year	Quarter	Office buildings	Base = Year 2014 (First quarter)	
			Banks	All commercial buildings
2014	First quarter	100.0	100.0	100.0
	Second quarter	96.7	96.7	96.7
	Third quarter	98.1	98.1	98.1
	Fourth quarter	99.5	99.5	99.5
2015	First quarter	116.4	105.2	80.8
	Second quarter	114.1	103.2	79.3
	Third quarter	115.0	103.9	79.9
	Fourth quarter	117.7	106.4	81.8
2016	First quarter	133.2	110.8	62.3
	Second quarter	132.1	109.9	61.8
	Third quarter	132.9	110.6	62.2
	Fourth quarter	133.4	111.0	62.5

As observed from Table 6, index values for offices, banks and all commercial buildings in all quarters in 2014 are similar indicating that there is no change in the trend of OPEX among offices, banks and commercial buildings as a whole in 2014. Further, there are slight increases in OPEX of offices and banks over the time and conversely, a significant decrease in all commercial buildings. Moreover, it is observed that OPEX in first and fourth quarters are slightly high in every year in all categories.

DISCUSSION AND CONCLUSIONS

The study initially developed an early-stage cost estimation model for OPEX in commercial buildings including a wide set of factors influencing the OPEX while previous studies, Al-Hajj and Horner (1998) and Kirkham *et al.*, (1999) have ignored some of those important factors such as the building age, location, type of structure, and level of occupancy. Accordingly, the model developed based 05 independent variables: working days/week, working hours/day, GIFA, building height, and occupancy, which are frequently known at the pre-construction stage of buildings. Further, the model developed expressed approximately 95% of variance in the annual OPEX/sq. ft. in commercial buildings. Therefore, challenge the accuracy of Al-Hajj and Horner (1998) model, which provides an accuracy of 1.13%. It implies that a proper combination of these variables will lead to optimising the cost incurred during the operational phase of buildings. Moreover, unlike previous studies, which used multiple linear regression analysis for the model formation, this study used an improved version called the hedonic regression modelling, which offers reliable models for cost estimation of properties purely based on its structural and locational characteristics. The study further provides quarterly OPEX indices for commercial buildings for three recent years. OPEX indices are important since many investors, and also the government, in some way are tied to the commercial building market. Whilst all existing OPEX indices are based in developed countries, the constructed indices can be generalised to nations, which are developing alike Sri Lanka. With the use of developed model along with indices, both construction industry professionals and investors can make informed decisions on implications of OPEX in commercial properties at its early design stages, eliminating excessive costs to be incurred during the operational phase of buildings. And also, the finding of the study may have policy implications for building cost management and resource allocation at the national level.

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CONSTRUCTION PLANNING EFFICIENCY AND DELIVERY TIME PERFORMANCE: ANALYSING FAILURE IN TASK-LEVEL 'HIT RATES'

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Construction project delivery is considered successful by contracting firms if scope, time, cost, and quality outputs are attained, with any shortcomings in one or more of these representing a failure of sorts. Focusing only on the criteria of 'time', it is noticeable that more recent research efforts have been concentrated on poor time predictability and performance aggregated at construction 'industry-level', but minimal attention is retained on planning efficiency at individual 'project-level'. Yet it is precisely because time performance enactment of individual 'projects', and their 'project phases', 'work packages', and 'construction tasks' remains unsatisfactory that predictability of time at an industry level is also recorded as poor. The main aim of this work therefore was to advance the discussion of construction planning efficiency via an analysis of time performance on a small range of recently, and nearly, completed construction projects. Data were obtained from a convenience sample of several major UK contracting organisations, which allowed quantitative analysis to be employed by measuring planning- and delivery- efficiencies. The paper contributes through an explanation of the methods used, and discussion of the findings, which show how in this sample, planning and delivery efficiency is worse than previously considered, with an average of only 38% of project activities starting on and finishing on time. Evidencing such time-performance failure should inform further project-level predictability and productivity research.

Keywords: failure, measurement, planning efficiency, predictability, productivity

INTRODUCTION

Project success is evaluated when considering the attainment of: longer-term, more strategic 'outcomes', and short-term, more tactical, 'outputs'. Outcomes would variously include the realization of project benefits, impact, relevance, and sustainability aspirations, as well achieving stakeholder satisfaction (Craik, 2018; Davies, 2017). In contrast, outputs are those elements that are measured immediately post-delivery, against set scope, time, cost, and quality targets. Depending upon the stakeholders' requirements, project failure has variously occurred when one or more of these criteria does not meet with expectations. In the construction sector, where the underperformance of on-site project delivery efforts, particularly regarding 'predictability' remains a principle concern (Crotty, 2012; Love *et al.*, 2011; de Melo

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et al., 2016), for contractors, shortcomings in meeting one or more of the 'Iron Triangle' criteria of 'time', 'cost', or 'quality', more viscerally represents project failure. Being more easily measured than quality, 'predictability' of project- and construction-cost and time performance is presently quantified and recorded annually via industry standard key performance indicators (KPI's) with project-level data aggregated and reported at industry-level. Table 1 presents results of these indicators from 2007 - 2017.

Table 1: Overall project-level time cost and time predictability for years 2007 - 2017 - percentage of projects delivered on target or better. (Table adapted from Constructing Excellence, 2017).

KPI	2007	2008	2009	2010	2011	2012	2013/14	2015	2016	2017
Predictability Time: Project	58	45	45	43	45	34	45	40	41	66
Predictability Cost: Project	46	49	48	52	63	61	69	69	68	65

This work, which focuses on the criteria of 'time', differs from prior research concentrating on poor time predictability and performance at aggregated 'industry-level' (Gledson, 2017; Gledson and Greenwood, 2017, 2016), as instead, attention is fixed on construction planning efficiency at individual project-level, specifically in the delivery of the on-site construction duration of such projects. Although data relating to the time predictability of the 'construction phase' level of projects are also captured and reported on in industry standard KPIs (again, aggregated at industry-level, see Table 2) it has nonetheless historically remained difficult to access performance data on individual projects. Nor has it been possible to 'drill-down' to review performance of individual tasks that collectively contribute toward the performance of distinct project phases or work packages. To begin to address this concern, the present work makes further use of, and builds upon, the only known method existing within construction planning literature, of recording task-level planning efficiency. This was established by Dawood (2009:2010) who refers to planning efficiency as the planning 'hit rate'.

Table 2: Construction-level time predictability for years 2007 - 2017 - percentage of projects and phases delivered on time or better. (Table adapted from Constructing Excellence, 2017).

KPI	2007	2008	2009	2010	2011	2012	2013/14	2015	2016	2017
Predictability Time: Construction	65	58	59	57	60	42	67	48	55	67

"If You Can't Measure It, You Can't Improve It" (Frequently Attributed to Peter Drucker).

As evidenced from tables 1 and 2 above, the overall time predictability and performance of construction projects (at project- and construction- level) can be considered to be both variable, and less than satisfactory. This has also been discussed at both 'macro' (e.g. Gledson, 2017) and 'micro' (e.g. Ballard, 2000; Dawood, 2010) levels, where researchers have considered how productivity issues affect individual construction task, work package, and construction project 'phase' performance, and therefore overall project time performance. Kenley (2014), advises that efforts to improve productivity and process are perhaps the "holy grail of construction research", yet within literature, reports of widespread measurement of

task-level time performance seems limited, and equally in practice, little evidence exists of any dramatic improvement in this area.

Ballard (2000) sought to combat this with the development of the Last Planner System (LPS), by identifying a range of problems that typically affect task conformance against schedule and argues that the achieved 'planned percentage complete' (PPC) of individual construction tasks (prior to applying LPS) is typically 50%. In this, the work of Ballard contributes as much to productivity research, as to the overall Lean Construction movement. Similarly, the Lean Construction Institute (LCI) aims also to improve productivity in construction management, reinforcing why LPS was considered a useful addition, thus: "traditional project planning was unable to produce predictable workflow: only 54% of the assignments made by foremen to be completed in the week were actually completed" (LCI, no date). Unfortunately to date, widespread use of LPS is not apparent. Nor presently are other planning process innovations advocated within wider construction planning literature, as being useful for addressing this concern. These include the likes of probabilistic task duration calculation methods (Baldwin and Bordoli, 2014; Morris, 1997; Winch, 2010), the critical chain method (Goldratt, 1997; Herroelen and Leus, 2001), location-based planning methods (Seppänen *et al.*, 2010, 2014), and 4D BIM (Dawood, 2010; Gledson and Greenwood, 2017; Hartmann and Fischer, 2007). Arguably, adoption and use of any individual or combination of these methods should result in improvements in planning efficiency, however just like time predictability itself, the adoption of process related planning innovations remains a concern (Gledson and Phoenix, 2017; Lindgren and Emmitt, 2017; Shibeika and Harty, 2015).

Returning, however, to the issue of measurement of task-level time performance, leads to the work of Dawood and associates (2009: 2010), who devised a means of calculating planning efficiency on construction projects. These researchers believe that 'traditional' planning, undertaken without use of the types of planning process innovations listed above, yields an average industry task percentage reliability of around 55 per cent, meaning that for only 55% of the time, there is zero variance in the planned start dates or planned finish dates of construction activities or work packages. Dawood and Sikka (2009, 445) further identify that a "critical success factor for a construction project is the reliability of the commencement date for each activity as per the planning schedule". Inspired by this approach, a version of the method was applied to analyse the planning and delivery-efficiencies across a small range of recently- and nearly- completed projects undertaken by several major UK contracting organisations, in order to provide comparator data. The subsequent sections report on how this was done, and what was revealed.

METHODOLOGY AND METHOD

The work is grounded in the research philosophy of pragmatism, and it should be considered as case study research, as it allows for investigation of an in-context phenomena (Fellows and Liu, 2008; Proverbs and Gameson, 2008) by drawing on, and triangulating multiple sources of evidence, then seeking to provide meaning (Remenyi *et al.*, 2002).

To analyse time performance, quantitative secondary data from 720 completed construction tasks were reviewed. The data were obtained from a convenience sample of three finished and 'handed over' projects (Projects A-C) and one partially finished project (Project D), constructed by three different 'top ten' UK constructors. Secondary data is that which has already been collected by someone else for an initial,

different purpose. In this case, the data were originally collected by construction team members to facilitate the site progress reporting function. Here, the data obtained from the following four projects, affords analysis of task-level time predictability:

Project A performed by Company A. £27 million, comprising of 4 Nr. NHS accommodation blocks for children with learning disabilities.

Substructure: Concrete raft and pad foundations.

Superstructure: Four number timber frame and one steel frame build.

Finishes: Robust anti-ligature requirements.

Project B, also performed by Company A. £6 million, NHS adult mental health learning facilities.

Substructure: Concrete raft foundation.

Superstructure: Timber frame, mixture of brickwork and cladding and a 'Kalzip' roof system.

Finishes: Robust anti-ligature requirements.

Project C performed by Company B. £11 million, NHS cottage hospital.

Substructure: Concrete ground bearing slab.

Superstructure: Pre-cast concrete frame building with stone cladding, curtain walling and acrylic render.

Finishes: Internal partitions with suspended and MF ceilings.

Project D performed by Company C. £9 million, Energy Centre.

Substructure: Continuous flight auger piled foundation.

Superstructure: Steel frame, block work, SFS and cladding.

It should be noted here that although the projects were planned using computer aided planning and scheduling software, none of them made use of any of the planning process innovations listed above (probabilistic task duration calculations; critical chain; location-based planning, or application of 4D BIM), thus they could be considered to evidence 'typical' approaches to construction project planning (Gledson and Greenwood, 2017). As discussed, Dawood's (2010) prior research posited that there was an average industry hit rate percentage of 55 percent for 'traditional' planning, undertaken without use of the types of such planning innovations, and the method for calculating planning efficiency, known as the planning 'hit rate' established variously in Dawood and Sikka (2009) and Dawood (2010) was the basis for this work. Dawood (2010) advises that: "Hit rate percent indicates the percentage reliability of the commencement date for each activity or package(s) by comparing the planned programme against the actual programme". However, Dawood (2010) does also go on to show that achieving planned completion dates are equally as important to the calculation of planning efficiency. Thus, 'hit rate', is measured as the percentage of activities which both started, and completed 'on time', as specifically, this is contrasted against the percentage of activities which: (1) started early and finished late, (2) started early and finished early, (3) started late and finished late, and (4) started late and finished early. The present research team used a similar method of data analysis to consider Dawood's 5 existing performance measures, but then also expanded on this by considering 4 other possibilities to see whether an activity had increased or decreased in duration. These 9 measures now listed in full can help to establish the percentage of time activities:

Start on time AND finish on time, meaning *planning is truly efficient* (i.e. the 'Hit Rate' is achieved).

Start on time AND finish early, meaning a decreased activity duration.

Start on time AND finish late, meaning an increased activity duration.

Start early AND finish early, meaning duration may or may not be different from planned.

Start early AND finish on time, meaning an increased activity duration.

Start early AND finish late, meaning an increased activity duration.

Start late AND finish early, meaning a decreased activity duration.

Start late AND finish on time, meaning a decreased activity duration.

Start late AND finish late meaning duration may or may not be different from planned.

The following information therefore needed to be extracted from the project planning data files provided by the research contacts in order to truly establish the planning hit rate percentage:

Task ID, and Task name (as identifiers, for classifying the activity into one of the three construction phases).

Planned start date.

Actual start date.

Planned finished date.

Actual start date.

Planned duration in days.

Actual duration in days.

Start variance: This being the actual start date, minus the planned start date. (Note that an activity with zero variance indicates that the activity has started on time, positive variance indicates the activity has started late, and negative variance indicates that the activity started earlier than the planned duration).

Finish variance: As above, but for the finish date.

Total variance: the sum of the start and finish variance.

The researchers also sought to undertake further performance analysis by classifying the data into one of three usual, separate construction phases:

Substructure: works below the ground, typically foundations and ground supporting elements of a building.

Superstructure: structure or frame of the building above ground level and the external envelope.

Finishes: internal finishing trades within a watertight building.

This was done for a secondary purpose, to test a common construction ‘maxim’ which holds that major contractors are able to perform satisfactorily during the ‘substructure’ and ‘superstructure’ phases, but not the ‘finishes’ phase of a project.

Table 3 shows the planning efficiency measures and formulas used to calculate the planning efficiency 'hit rate' percentages, and additional measures for each project and stage in the project lifecycle. When calculating the average percentages of all four projects, the researchers used a weighted arithmetic mean calculation; this takes into account that some projects contribute more than others to the overall mean value, due to the difference in the number of activities analysed.

Table 3: Planning efficiency measures and formulae.

Percentage of activities which started on time and finished on time*	$(\text{Total number of activities} \div \text{Total number of activities having zero total variance value}) \times 100$
Percentage of activities started early and finished late	$(\text{Total number of activities} \div \text{number of activities which started early and finished late}) \times 100$
Percentage of activities started early and finished early*	$(\text{Total number of activities} \div \text{number of activities which started early and finished early}) \times 100$
Percentage of activities started late and finished late	$(\text{Total number of activities} \div \text{number of activities which started late and finished late}) \times 100$
Percentage of activities started late and finished early	$(\text{Total number of activities} \div \text{number of activities which started late and finished early}) \times 100$
Percentage of activities which started on time and finished late	$(\text{Total number of activities} \div \text{number of activities which started on time and finished late}) \times 100$
Percentage of activities which started on time and finished early*	$(\text{Total number of activities} \div \text{number of activities which started on time and finished early}) \times 100$
Percentage of activities which started early and finished on time*	$(\text{Total number of activities} \div \text{number of activities which started early and finished on time}) \times 100$
Percentage of activities which started late and finished on time	$(\text{Total number of activities} \div \text{number of activities which started late and finished on time}) \times 100$
Number of activities with no change in duration	$(\text{Total number of activities} \div \text{Total number of activities having zero start and finish variance value}) \times 100$
*Hit Rate percentage	The weighted arithmetic mean, of the planning scenarios highlighted with an *. These are activities, which started early/on time and finished early/on time.

SUMMARY RESULTS, ANALYSIS AND DISCUSSION

As discussed above, the critical success factor in any project delivery is the reliability of starting and finishing an activity per the programme or schedule. This is referred to here as the 'hit rate' percentage to establish planning efficiency. Summary 'descriptive' data of all four projects is first presented in Table 4, which reveals: two of the projects (A and B, with 23% and 30% respectively) showed planning efficiency to be much worse than thought by Dawood (2009; 2010); one project was comparable (Project D with 59%); and one project performed slightly better (Project C with 70%) When averaged across all projects, the results are that a typical 38% 'hit rate' is achieved, thus being worse than the 55% believed by Dawood (2009: 2010).

Figure 1 shows planning efficiency by project phase across all four projects. However, despite the 'maxim' discussed above, this study revealed no significant trends in the 'hit rate' of activities within certain project phases.

Table 4: Summary analysis of time performance across all tasks on all four projects (A-D)

Project	A		B		C		D		Overall	
Number and % of activities	No.	%	No.	%	No.	%	No.	%	No.	%
Analysed	427	-	67	-	175	-	51	-	720	-
That had no change in duration	209	49	24	36	145	83	43	84	421	58
Started early and finished late	14	3	9	13	0	0	1	2	24	3
Started early and finished early*	80	19	5	7	1	1	6	12	92	13
Started late and finished late	270	63	24	36	13	7	19	37	326	45
Started late and finish early	9	2	0	0	0	0	0	0	9	1
Started on time and finished late	27	6	13	19	40	23	1	2	81	11
Started on time and finished early*	5	1	1	1	2	1	3	6	11	2
Started early and finished on time*	1	0	2	3	0	0	0	0	3	0
Started late and finished on time	7	2	1	1	0	0	0	0	8	1
Started and finished on time*	14	3	12	18	119	68	21	41	166	23
*Hit Rate	100	23	20	30	122	70	30	59	272	38

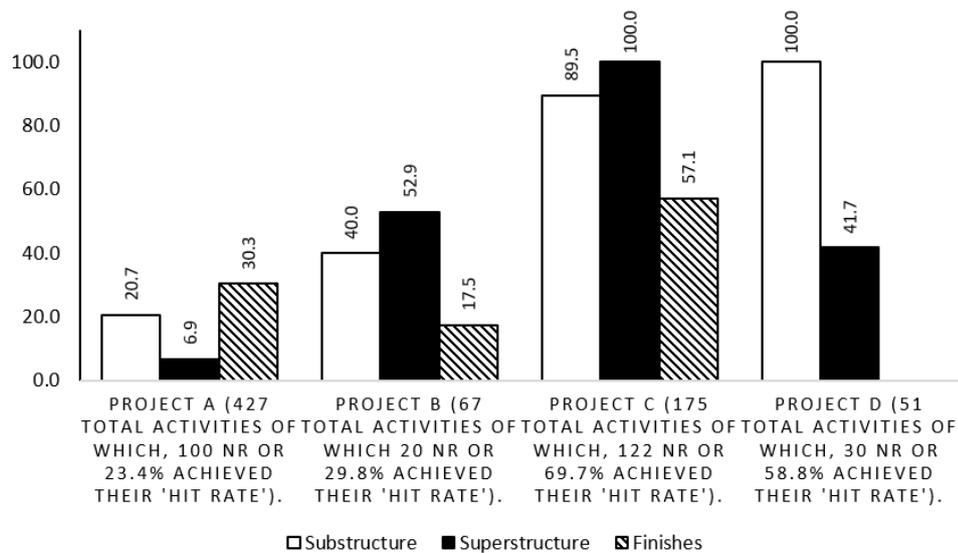


Figure 1: Projects A-D, Planning efficiency by project phase (percentages shown).

CONCLUSIONS

The objective of the data analysis was to examine the performance of a sample of past construction projects in an attempt to consider what typical levels of effectiveness in the planning and delivery of time performance in the UK construction sector might be. Whilst no significant trends in the 'hit rate' of activities across the four projects were observed, analysis has enabled several key conclusions to be drawn, which are:

1. The average planning efficiency data across all four projects is lower at 38% when compared with Dawood's assertions of 55%.
2. Planning activity appears to be somewhat effective at predicting the duration of activities, with an average accuracy of 58% recorded in this sample.

3. In contrast, planning efforts appear poor at forecasting the exact timings of when activities will actually occur (i.e. start and finish dates), as an average of only 23% was achieved in this sample.
4. Out of all the possible planning and delivery outcomes for the 720 activities analysed in this sample, the most frequent outcome was that on average 45% of activities started late and finished late.
5. In this sample, activities tend to start on time and finish on time more frequently only within the earliest, substructure phases of a project. Thereafter no such trends were observable in the remaining project phases.

The quality of planning and delivery time performance appears variable across the separate projects analysed in this study. In general, planning quality will always be affected by a range of issues including the complexity and technological difficulties of each distinct project, the skill level of the project planners themselves, the time and information available at the time of planning, and the media used to communicate the formulated plans (Gledson, 2017). Upon construction commencement, the quality of delivery also affects time performance, particularly as projects are always prone to be subjected to the various delays and disruptions of site activity. Furthermore, either strategically or tactically, on some occasions, contractors may decide to expedite specific, usually early-stage and less complex activities, to build in additional time-contingency for later more complex activities.

The scope of this research project did not focus on any of these aspects, yet through a straightforward measurement and assessment exercise, several valuable conclusions have still been drawn. Some of these are perhaps tacitly 'known' in industry but effectively they are being 'proven' here. Not least is that in this convenience sample, construction planning efficiency and delivery time performance - or 'time predictability', seems poor, certainly when performance data is considered at individual task level. The low averaged 'hit rate' recorded here of 38% is a particular concern, and further, similar research efforts performed on a diverse range of projects also using 'traditional' methods of construction planning would be welcomed either to support or reject these findings. Similarly, future research comparing the results of 'hit rates' achieved with projects that use 'traditional' methods of construction planning, against projects that instead make use of planning process innovations including the likes of 4D BIM, would also do much to further inform construction predictability and productivity research.

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CONFLICTS AND ALTERNATIVE SOLUTIONS: HOW HOSTILITIES OBSTRUCT ALTERNATIVE SOLUTIONS

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The construction industry is said to have realised fewer productivity gains than other industries. At the same time, it is marked by a claims culture resulting in conflict and hostility between project partners. Improving project performance, however, requires cooperation between these partners. Therefore, I seek to explore the contingencies between claims culture and the exploration of alternative solutions. Within the autoethnographic paper, I use personal observation from my business practice as owner of a construction company of 40 employees in Germany. I provide and analyse two contrasting examples from my perspective as an employer on construction projects to problematise these contingencies. To illustrate these effects of a claims culture I describe incidents where alternative solutions were fostered and where potentials for creative solutions were not used. My first example shows that hostility stemming from the claims culture appears to be a severe hindrance to alternative solutions. The hostilities force contractors to a strong focus on contractual provisions and obligations. In consequence, the involved persons concentrate on defending themselves and their positions and refrain from exploring and suggesting new or creative solutions. These effects become even better visible in the contrasting second example, in which the claims culture and its hostility were absent. The project partners explored alternative solutions to the satisfaction of all parties involved. However, all project partners need to embrace the cooperative approach to make it a success and still the risk to be exploited remains. Although I present practitioner research, which often is solution orientated, I focus on describing and understanding the problem from my personal perspective. My aim is not to solve a problem, but to foster a discussion by providing heartfelt insider experience.

Keywords: alternative solutions, autoethnography, claim culture, practitioner research

INTRODUCTION

This autoethnographic paper seeks to investigate the relationship between a claims culture in the German construction industry and the reluctance to pursue alternative solutions within the industry. The claims culture is characterised to have a tendency towards conflict and to act opportunistically (Rooke, Seymour and Fellows 2004). Actual or anticipated conflict leads to a defensive attitude on the side of all actors in project teams. Therefore, the problem I address here is how a defensive attitude within the project team stemming from a claims culture influences contractors' approach to alternative solutions. I wonder how the claims culture influences individual's actions about alternative solutions. One may relate this to innovations as they are "new idea[s ...] implemented in a construction project with the intention of

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deriving additional benefits although there might have been associated risks and uncertainties.” (Ling 2003: 635) However, I focus on the hostile and defensive attitudes are an obstacle to alternative solutions.

Autoethnography

To illustrate the problem, I draw on my experiences running a construction business in the wider Berlin area (Germany). The business employs ca. 40 persons most of the bricklayers and carpenters as well as some administrative staff. Our jobs consist predominantly of building structures from concrete and brickwork. Most of the jobs are on residential buildings, but we also build commercial buildings and work for agricultural businesses.

Among the many different forms of autoethnography, I research in the backyard (Wolcott 1999) of my own business. I tend towards the evocative application of autoethnography, where the emotions and impressions of the research move in the foreground (Bochner and Ellis 2016). However, I also include an analytic lens to understand my experiences within the wider academic context (Anderson 2006). The ethnographic material predominantly consists of fieldnotes and journal entries. I write field notes about experiences I made in my business. Usually, I take short notes briefly after the event and develop these notes into longer field notes in the evening. However, some material - stories and especially context - I create from memory. Often, I connect the experiences to my readings. Indeed, my attention to some problems is a product of what I read and hear in academic discussions. Ethnography and in particular autoethnography is not a straightforward method; it instead relies on what the ethnographer regards as significant (Emerson, Fretz and Shaw 2011). As it is in the case, I like to discuss here. The problem is one I struggle with in business. Therefore, I regard my approach close to “action research for the individual” (Ellis 1999: 677)

Claims Culture and Alternative Solutions

Construction contractors frequently find themselves in fierce competition during the tender phase. Often “tender prices submitted by contractors will be uneconomically low, with adverse effects on all participants in the construction process” (Latham 1994: 8) In other words, contractors submit under-priced tenders which do not cover their cost and subsequently do not produce a profit for the business (Latham 1994). Hence, they have to generate additional income. Filing claims and effectively managing them is often part of the business strategy of contractors to make projects profitable (Klee 2013, Rooke, Seymour and Fellows 2004). A vivid illustration of planning strategies to generate claims is found in Rooke, Seymour and Fellows’ (2004) account. Claim management forces the parties to the project into contractual behaviour (Rooke, Seymour and Fellows 2003).

During recent chats about planning strategies to file claims as outline by Rooke, Seymour and Fellows’ article (2004) a manager of a German construction company and a construction dispute lawyer confirmed that such mechanisms are widespread in the German construction industry. For contractors, it is disastrous if everything runs according to plan (Rooke, Seymour and Fellows 2004). Some unforeseen things need to happen to file claims. Otherwise, projects will not produce enough profit for the contractor, the manager emphasised.

My experience suggests that claim management practices as described above are more common on large-scale and public-sector projects. Regardless of project-size and

sector, all parties involved in construction process have experience with claims in one or the other form. Therefore, they are aware of cost impacts of claims. Especially the employers as well as their engineering and managing teams are suspicious of contractors as being “claims-conscious” (Chan *et al.*, 2010) and engaging in “claimsmanship” (Zack 1993). This suspicion appears to make it difficult to advance alternative solutions to making a project profitable.

In the process of filing claims, changes to the design or construction process usually play a central role (Rooke, Seymour and Fellows 2004). Changes are, thus, generally seen as problematic and costly (Shipton, Hughes and Tutt 2014). Yet, Shipton *et al.*, argue that changes can represent innovations and improvements to the project. Hence, changes should not be seen solely as negative and problematic instead one should consider positive effects of changes as, for example, improvements or cost saving.

However, when a negative attitude towards changes (e.g. alternative solutions) prevails, the opportunity of cost-saving is often neglected lest changes are assumed to produce additional cost (Shipton, Hughes and Tutt 2014). However, containing cost and generating profits not necessarily exclude each other. In my business, we seek to partner with employers; we explore the project files to identify ways of making the design more cost-efficient. Most of the time we share part of the saved cost with the clients but keep some of the money in ‘our company’s pocket’. That makes for an attractive offer for the client while raising our profit margins. (Bresnen 2009) As the project was due to commence, I came across the following experience:

DIFFICULT CONVERSATIONS

A couple of days ago we had signed a contract for a new residential project, and preliminary work on the project was about to commence. The project was an old industrial estate south of Berlin which underwent massive changes to the structure. Apart from the outer walls and some rows of columns and beams everything inside, and the complete roof had to be demolished. Our job was to improve the foundations, to secure the outer walls and to build a new internal structure of walls, ceilings and staircases.

During the tender phase of the project, we developed an alternative solution to enhance the capacity of the foundations. We brought in an external engineer in with whom we worked successfully on several prior projects. With his help, we could significantly simplify the process and hence save a reasonable amount of money. Yet the relationship with the project-engineer who designed the first solution was quite tense. The employer welcomed our solution yet raised the question why the project-engineer did not come up with something close to our proposal. And he expressed his frustration about the project engineer's performance.

I haven't been to these conversations, but I can imagine that the employer was quite frank in his critique. My experience with him suggests he is friendly and fair as long as everything runs according to plan but if not, one might find oneself in a very rough conversation with him. He won't be unfair, but the talk might be anything but comfortable. And I imagine this happened to the project-engineer he commissioned.

During this ‘warm-up’ period when the work was about to start, I took a closer look at the project. The original design said the ceilings should be made from a beam and claim block system. On previous projects, I had learned that compared to a simple concrete ceiling the original solution was quite expensive. Subsequently, I discussed my idea with my two site-manager involved in this project. We agreed on the fact that a concrete ceiling could save up to 30% of the cost for the ceilings. Yet both were reluctant to pursue my proposal. One of the site manager - who was involved in the negotiations with the client - said to me something like:

Haven't you seen how the employer acts? If anything goes wrong, he won't let us off the hook. And haven't you seen how defensive the engineer is? You can expect him to

search for every minor flaw in our proposal make a fuss of it. On top, he won't cooperate, and he won't come up with solutions. Listen, when we propose this change, and they agree we're accountable for everything. If anything with our solution does not work - even minor things - they will hold us to account. And you don't want to be held accountable by this employer. He is really tough. And you have understood how defensive the engineer is. You don't want to be in a sandwich position between the two. If we stick to their solution - the beam and block system - we can charge them for everything unforeseen, but if we switch to our proposal, they could charge us for everything unforeseen even if it has nothing to do with the ceilings. And you know, there is much uncertainty in old buildings.

Consequently, we abolished our plan to propose this alternative.

The two site managers recommended to me not to follow the established route of proposing changes and saving cost but to do business as the contract required of us. The argument originated from an idea of defending oneself. They essentially said, don't make us vulnerable to counterclaims from the engineer. I could entirely understand their concerns.

On other projects, I had had very bad experiences with changing a design. Years before a particular project was weeks over time due to late permissions. I saw that we could meet some important deadlines by a slight change in design and thus save the clients from claims of another contractor. So, I proposed these changes and we agreed. We met the deadline of the other contractors and avoided damages. Afterwards, the client and the architect argued that the changes would not have been necessary and claimed money from me for lower quality.

The recollection of such experiences still angers me. Even now I can feel the disappointment and frustration caused by this incident. Among a lot of positive experiences with proposing design changes to support clients, I made only a few negative experiences. However, I could easily see what the site manager's rationale was not to propose the changes.

They agreed that there is a cost-saving potential, although I assumed the savings to be higher. Therefore, I was more inclined to propose changes as they were. But their argument inhibited me from doing so. But more than that - it also reduced my intentions to search for further cost-saving potential.

There are essentially three major interactional aspects which contributed to our refusal to propose an alternative solution: a) a perceived defensive attitude from the project engineer, b) our impression of strictly contractual behaviour from the employer and c) our own fear of counterclaims and the inability to file claims ourselves.

That an adversary attitude connected to the claims culture results in defensive behaviour is well established in the construction management literature (Zack 1993). This defensive attitude is closely connected to a lack of trust. To trust means to make oneself vulnerable to the actions of the trusted (Mayer, Davis and Schoorman 1995). Cooperating to make construction projects more cost efficient does, however, require trust (Santorella 2017). Most alternative solutions contain a new and unknown element. Hence, this unknown element inherent in alternative solutions makes the one proposing them as well as the one accepting vulnerable.

The Defensiveness of the Engineer

We first proposed a change to system improving the foundations. We proposed it to the employer, but the reaction of the project engineer was a swift rejection. To win the contract, we involved an external engineer who got the design approved.

Subsequently, we could make a far more competitive offer without sacrificing our potential profit margin. Our strategy worked so far.

However, that did not go down well with the project engineer. Especially because the employer did confront him with the lower cost of our proposal. On top, there were other smaller scale issues where we held the position that the engineer's design was too expensive for the purpose. However, I sought to anticipate the engineer's position. The engineer might have been criticised by the employer because we challenged and questioned the engineer's design. Hence, it was perfectly reasonable that the engineer must have seen us as 'enemy'. Therefore, it looked to me as if the engineer was defending himself pre-emptively against suspected hostility from our company.

The Demanding Attitude of the Employer

Within the contract negotiations, we talked about the project engineer's performance. The employer expressed his dissatisfaction and hinted to discussions with the engineer about the high cost of improving the foundations. We assumed that the employer was very tough towards the engineer. This impression alerted me, and I believe my project managers also to the fact that we could find ourselves in the same situation as the project engineer if the employer gets unsatisfied with our performance. Hence, we sought to safeguard us against it. But, regarding the ceiling and saving cost could have also worked as a way of positioning us as working for the client. Yet, we chose not to act in an integrative manner (Fisher and Ury 1981) but stuck to a contractual course of action (Rooke, Seymour and Fellows 2003).

Weakening Our Position

Especially refurbishment projects contain a lot of uncertainty. One architect once coined it this way: "You never know what's hidden under an old floor unless you lift the boards." Of that kind was the concern of my project manager. He did not know whether the walls that supported the ceilings whereas stable as they seemed. He knew little about the old iron beams beneath the ceiling, which should be kept in place and support the new ceiling. He knew there were a lot of unknowns.

Since the surveying and assessment of the old building parts as well as the design were the engineering team's task, we were not accountable for anything related to it. Altering the design would have changed this. We would have been in part liable for faults or incorrectness. As long as we left the old design as it were, we were not to blame for deficiencies and so could retreat to contractual behaviour. Pursuing the change, we would have deprived us of this option. One may argue that although we did not plan for any particular claim (Rooke, Seymour and Fellows 2004), we kept open the options to file for claims.

But even more, we would have seen us defending against perhaps spurious counterclaims from the client due to unanticipated cost. We suspected that there were some deficiencies or hidden risks. The possibilities ranged widely; there could be, for example, a hollow wall, some bricks defect, or a beam too heavily corroded. We just did not know "unless we lifted the boards". Yet we suspected a negative reaction from the client to rising costs, and we thought the engineering team would defend themselves. Hence, we believed they would seek to shift the blame on us and our proposal. Not raising the issue, not changing the design was our pre-emptive defence strategy. This threat manifested itself in the project manager's statement that we would be held responsible for everything even if it had nothing to with the proposed change.

Fostering Divisions - Widening the Gap

Moore and Dainty (2001) argue that cooperation is restricted through the division of the design stage and construction stage. Each party defends his idea about how to realise the project. A discussion about the underlying interest and reason for the positions (Fisher and Ury 1981) does rarely take place. Subsequently, the necessary exploration of the others' interest is lacking. For my side, I do not pay enough attention to others' concerns, and I do not share my interests when embroiled in hostile relationships common in a claims culture environment. Sometimes, I am already reluctant to explore when I anticipate or suspect such climate. I concentrate on safeguarding my position. That hinders me to search for options actively.

Exploring and Creating

I do not explore the others' interest and concerns. I rather look at the project file to see what is required of me by contract. It is very contractual behaviour (Rooke, Seymour and Fellows 2003) that I employ. I do not ask why the client wants a certain quality or a special material or what the purposes for the employer's choices are. Neither do I investigate why the design team made the choices now reflected in the drawings. Without this knowledge or at least an idea about the underlying reasons, I cannot begin to search for more suitable solutions. Without knowing what the others have in mind my suggestions for alternative solutions feel like mere 'fishing in the dark'.

The other aspect is that I am far too engaged in defending. I seek to safeguard myself against potential attacks. I try to stick as close to the contract as possible. I seek to expose myself as little as I can. I engage in distributive behaviour (Fisher and Ury 1981, Rooke, Seymour and Fellows 2003). And on top, I search for flaws and deficiencies in the design and the work of others that I may exploit immediately or later. I am not concerned about helping them to make the project better but only to look after myself.

The felt hostility, one may call it aggressiveness, and subsequently, my defensive attitude results in a lack of attention to the concerns of the others involved (Lévinas 1994). That inhibits me from seeing options for beneficial changes. Thus, I am unable to propose them, and subsequently, the options for alternative solutions are missed.

The employer and engineer seemed not to be interested in whether a certain design 'works' for me or not. I too did not investigate whether another material or detail would have met the engineer's requirements. This open discussion between the engineer, architect, and me did unfortunately not take place.

GOOD CONNECTION

To contrast the first example, I will draw in the following on another very recent experience with another client.

Some ten years ago I met the employer first on a building site in Potsdam. He had a lot of experience in the real estate sector in Potsdam and had developed a lot of projects over the years. For him, we worked on logistically tricky site in Berlin.

The engineer on this project was known to me by name only - I had worked with colleagues from his consultancy before. Yet, we could easily work together solving problems that occurred during this project. Our thinking in term of engineering issues was very similar. I could effortlessly explain what I thought, and he could easily follow and vice versa. The project ran smoothly to everybody's satisfaction.

Over the years we worked a couple of times on the same team together - the employer, the engineer, and my company. One day the employer called me to talk about a new project. There was no question if I should do the job but only whether I have the necessary capacities for a new project we were talking about. That does not mean that we were not haggling over prices; the employer wanted a good deal. However, the negotiations were never aggressive, there was always the underlying question of how we could make it work for all involved.

Preparing the last two major jobs with this client, I met with the engineer to discuss details, materials, special problems etc. The meeting during the preparation for the last project was very special. Both projects were closely related and had some similarities. Therefore, the discussion resembled around, 'how we did it last time' and 'could we make it any better'.

When we came across a problem, the engineer often said what he needed to address a certain structural issue. Then we discussed advantages and disadvantages of possible solutions each seeking to understand the other's concerns. One may use the metaphor that we faced a problem together. We worked together, not against each other when solving a tricky issue.

The client himself was not involved in the discussion directly, although he encouraged us to discuss the project. Of course, he had the final say about the design. However, many issues we were discussing no one recognises when using the building. For example, foundations are usually hidden in the ground. Hence their size makes no difference to the appearance of the house. Yet other things like the surface of concrete wall interested him very much because he had a clear idea how things should look like. However, within these margins, we were free to decide.

One may argue that in the case above a close integration of planning and building - good contact and exchange between the design team and contractor - was present (Moore and Dainty 2001). When we discussed solutions, we constantly tried to think the other's way. I tried to understand his argument and connect my suggestion to his problems while telling him about costs of material and necessary manpower. In a way, we dissolved our roles for the moment (Winch 2000). This understanding of each other also leads to quite amicable relations between the parties on such projects. There is a back and forth between understanding each other's concerns and good relations. In the example above these relations were good from the beginning and have grown over the years. It was a positive spiral.

The problem in the first example was that we were engaged in hostilities almost from the very beginning of the project. I could not imagine that a fruitful discussion about the design could have happened in a hostile environment. Even if I were involved in the design process, would not have suggested much.

Knowing that I would almost certainly get the job was a great motivation for me to engage in the discussion about the project design. There is little value for me in sharing my knowledge when I may just be used to streamline the project without the benefit of the job. The attitude here was rather one of appreciation. The client honoured my engagement in designing a fit-for-purpose-building by awarding me a lucrative contract. Commitment is a driver of new solutions in general (Winch 2000), yet this example demonstrates that commitment is especially important on the individual level.

It is this impression that the employer seeks a good deal but does that in a manner of 'live and let live'. We were not in fierce competition to get the contract awarded but in an honest discussion about the cost and the budget of the project. With this impression and the feeling of being valued, I am much more willing to contribute. It is the mutual interest in the other's concerns that fostered the search for alternative

solutions in the second example (Fisher and Ury 1981). The very close relations and the open exchange would not have been possible without the amicable relations.

Risk Involved

Comparing the two examples, we anticipated far more risk within the former project. The anticipation is not based on facts but a mere gut feeling that the relations could easily deteriorate during the project. Whereas in the second example the relations had been already 'proven' to work smoothly. However, hard evidence for this assumption is missing. It was the subjective impression of the employer and the engineer that made the difference.

Additionally, we compared the risks involved with the possible benefits. We assumed it was not worth the effort and could backfire. In case the amount of expected saving would have been higher we may have given it a try. However, with the employer and the engineer from the second example, I certainly would have discussed the issue.

That shows a hostile climate on projects may particularly inhibit incremental changes. Large-scale radical changes (as for example strengthening the foundations) might be applied, but opportunities for small-scale incremental changes will certainly be missed. That is regrettable since in sum small improvements could make a huge difference as, for example, the lean approach has shown (Santorella 2017).

Regrets

The shift in me is that I am much more reluctant to advance alternative solutions in such situations, which is regrettable in itself but probably, more importantly, I do not actively search for options to improve the project, for possibilities of cost saving. I can only guess how many options I miss.

Only when I think about the wasted money projects, it 'hurts'. Wasting money on bad or inefficient solutions is something I experience as uncomfortable. It runs against my ethos a civil engineer to build something I consider a solution not fit for purpose. That can be either wasting money on too expensive material or unnecessary use of material (e.g., too much steel in a concrete beam), but it includes solutions that will not work (e.g., insufficient thermal insulation) or bear an unacceptable high risk of failure. In turn, when I am forced to do exactly that due to contractual requirements my commitment to the project vanishes. Hence, I am far less inclined to foster better alternatives.

What I do in these situations is shifting accountability away from my business. I seek to notice the architect, project manager, and the client about the risks involve, and so avoid liability. Sometimes I build constructions of which I think they are not serving the best interest of the client. I do that only because a contract requires me to do so. But I am doing no one favour doing it. Luckily this is seldom the case.

SUMMARY

Although my examples stem from a different context and different persons were involved, I could show that the claims culture has a negative impact on the attitude towards alternative solutions in the construction industry. This is especially the case for small incremental changes. These possible improvements only surface to specialist's eyes when working on projects. Hostilities within project teams seem to pose a particular danger.

The first hurdle for improvements was my inability to see the opportunity. Due to hostilities, I was more engaged in defending myself as in exploring the project partner's concerns. This lack of knowledge about my project partner's interests left me unable to see possibilities for alternative solutions. Hostilities cut short the very inclination of specialists like me to search for options to improve the project performance. Interestingly, no one could coerce me to search for alternatives, to save costs. It ultimately depends on my willingness to be creative.

Even if I spot them, I do not propose them because I fear suspected risks involved from making and realising my proposal. The reluctance to propose changes is the second hurdle caused by hostilities. In sum, hostilities among project partners lead me into a defensive mode of action and not to pursue creative solutions.

The research shows that a hostile environment stemming from a claims culture has a negative impact on the pursuit of alternative solutions. How to address these hostilities is beyond the scope of this research, but given the results presented in important question to raise. The nature of my research does not allow for giving figures on the missed alternatives, which could be an interesting route of exploration. Another very important question could be how to turn the tide to less hostile relations in the project team. So far, I keep investigating because cooperating with a nice team and building constructions I am proud of is so much more fun.

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CONSTRUCTION ORGANISATION STRUCTURE AND INNOVATION ADOPTION

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Innovation adoption in construction is widely considered by both academics and industrialists as a key factor to driving efficiency through the industry yet something which is by and large not a priority for the majority of main contractors. The contemporary business landscape is in the middle of the 4th industrial revolution. This research explores the impact of organisational structure on innovation adoption in construction. The aim of this research was to identify the key themes of impact when considering innovation adoption in the UK's main contracting construction arena. 4 interviews were conducted and a thematic approach to data analysis was conducted engaging a thematic approach using Nvivo. The research moves from a deductive to an inductive approach to theory development utilising a review of literature and qualitative semi-structured interviews respectively. The main findings are that organisational structure has the most impact upon innovation adoption. A consolidated workforce/organisational structure was found to have a positive impact in converse to a fragmented structure. In addition, a collective decision making approach with innovation at the core of the organisation is considered of significance.

Keywords: innovation adoption, fragmentation, collective decision making

INTRODUCTION

The construction sector alongside society at large is at a pivotal stage in the development of implementing innovative advancements (technological and non-technological) which promise, if utilised correctly to have an overwhelming effect on productivity of work, efficiency and consequently improving both profit margins and overall outcomes for all stakeholders. Innovative advancement has the potential to solve many of the issues highlighted in past and present research. Latham (1994), Egan (1998) and Constructing 2025; Strategy (2013) highlighted the inefficiencies in the construction industry and recommended the areas for improvement such as integrated project processes, improved management, supervisory skills and adoption of innovations.

The International Council for Research and Innovation in Building and Construction (CIB) Task Group 76 (2015) defines innovation broadly as: "Humanly created changes in established ways of creating value".

The construction industry is historically blamed for slow adoption of innovative practices (Morledge, 2011) and a majority of construction organisations, constructors and professionals alike may be classed as "Laggards" Rogers *et al.*, (1957). With

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industries such as the automotive industry actively embracing innovations, it has been vastly revolutionized and is constantly pushing the envelope on what is achievable. This poses the question of why is the construction industry is seemingly falling behind (Blayse, 2004)?

Literature reveals the role of innovation in construction at an increasing rate of interest (Aouad, 2010), primarily due to its ability to secure a sustainable competitive advantage, improving one's project performance and profitability (in the case of the private organization) or by adding value for money (in case of public sector client) (Davidson, 2013). In addition to this primary objective, innovation also promotes stakeholders to become "challengers" by penetrating new markets and pitting themselves against less successful "incumbents" in niche markets. Stakeholders within the construction industry seeking to gain competitive advantage from competitors; may develop and/or adopt what the organization for Economic Co-operation and Development (OECD, 2005) defines as "technical" and "non-technical" innovations which can be further sub-categorized by Slaughter (1998) as "incremental" (small, and based on existing experience and knowledge), "radical" (a breakthrough in science or technology), "modular" (a change in concept or systems), or "system" (multiple, integrated innovations). It is agreed by the CIB TG76 that innovation is not invention but intervention of existing systems, process or products.

In pursuit of innovations, an organization will incur significant issues at an organisational level which are reported widely by the current researchers and industrialists (CIB TG76). Of those issues the most notable include; organisational structure/fragmented nature of the industry, bespoke projects, hidden nature of construction innovation (Barrett, 2007), structure of production, relationships between individuals and firms within the industry and between the industry and external parties and the nature and quality of organisational resources (Blayse, 2004), not to mention capital investment. However, organisational structures (fragmented and consolidated) are not explored in any depth currently and this is where this study attempts to contribute original scope for further exploration. Within Cooper's (1999) 25 years of research on the adoption of innovation generally, "organisational structure" is identified as a key to success or failure. This characteristic is also further identified and compounded by Blayse (2004) as a widely accepted construction industry related issue but not specifically in relation to innovation adoption. This issue has been explored in part but requires further investigation and understanding as the majority of large main contracting organisations utilize a similar fragmented structure which is less dynamic in relation to innovative processes than the alternative.

Recently there has been a move towards a more consolidated structure by a leading firm. It is unclear why some organisations are consistently more successful than others at innovation diffusion (Gledson, 2017). To this end particular reference to fragmentation vs consolidation organisational structure requires further investigation. Of the 180,000 construction firms in the UK, 96% are thought to have less than 8 employees. In terms of the construction sector, over 86% of employees work within SMEs, and are responsible for 75% of the turnover.

The focus of this research is the sociotechnical exploration of administrative process innovation and organisational structure, which are intrinsically linked through management of the construction organisation. The study combines a literature review, which led the author to construct an analytical framework. The method in which the

research was conducted and data analysis follow on, concluding with thematic findings, limitations, implications both in terms of research and practically.

Innovation Background and Theory

Research of innovation across the business sector as a whole has been debated and discussed for decades as such it is critical to define what the current perspectives of researchers are:

Table 1 Eminent Researcher’s Innovation Criteria

Innovation Definition Criteria.	Eminent Researchers					
	Chesbrough, H	Baregheh <i>et al.</i> ,	Davidson	CIB Task Group 76	Holt	Zhu <i>et al.</i> ,
Year	2005	2009	2013	2015	2015	2017
Differentiation for Advancement.		X				
Adoption Across a Range of Businesses/Market/s (not singular).	X		X	X		X
Meaningful, Lasting Impact.	X	X	X	X		X
Creating Value /Economic Impact.		X	X	X		X
Intervention of an Existing Process /Product.		X	X	X	X	X
New Inventions (also included).	X		X			

The etymological definition is specific about existing systems, process or product interventions and does not consider entirely new inventions. The etymological definition is specific about existing systems, process or product interventions and does not consider entirely new inventions. In its simplest of forms, we can elude to the most recent eminent researcher’s agreed definition. Consider as an example that the wheel was invented and not merely an intervention of an existing product that had been modified from a less attractive system/product. It could be argued that the wheel has undergone many iterations of interventions/innovations across the centuries, which is undeniable however; there was also a moment when the original was conceptual. It is necessary to progress with current research to assign invention to completely new concepts/ideas/products and consider innovation as an intervention of an existing process or product. The CIB Task Group (2015) has further compounded this thought in its Construction Innovation publication (2015).

Therefore, innovation in a construction context can be defined as:

An intervention to a process, product or service that has the potential to increase value and efficiency socio-technically and/or socio-economically.

Comparable Industries and Innovation Diffusion

When looking at innovation and other comparable industries, the automotive industry is frequently examined. If we are to follow the ubiquitous comparative approach to construction research against that of the automotive industry, we could expect deep technological changes albeit the pace of change would almost certainly be over a longer period. The construction industry lacks the rapid consumer reaction/critique/expectation that the automotive industry is afforded and the ability and willingness to respond to. Rogers *et al.*, (1957) created the technology adoption lifecycle model or Rogers’ Bell which when we attempt to draw a cross comparison between automotive and construction industries, it is widely accepted that the

automotive industry sits between “Innovators” and “Early Adopters” spending many billions annually, whereas the construction industry is often considered as “Laggards”. Many of the leading construction industry publications over the last 3 decades have commented this on. The Latham report (1994); The Egan Report (1998) and the Her Majesty’s Stationary Office publication more recently in its Accelerating Change: Consultation Paper by the strategic Forum of Construction (2002) which underlined the potential importance of information technology in achieving greater integration, and set the tone for future UK government initiatives.

The construction industry would significantly benefit from the introduction of a widespread, standardized method of implementing innovation. However, as Latham discussed, the fragmentation within the construction industry is a significant barrier to this ideology. The hope of developing a sustainable method of improvement within the construction industry remained a key issue within the industry for several years after ‘Constructing the team’ was published.

In July 2013, the Government Published the ‘Construction 2025: Industrial strategy: Government and industry in partnership following various themes underlined in previous reports such as the Construction Strategy 2011, The Latham Report, Egan Report, etc. This report outlined the government’s targets for the construction industry, and highlighted particular issues such as cost, time, emissions and improvements in exports deemed necessary to improve the industry. The report also highlights the Government’s industry vision over the course of its delivery underlining key factors for success, which are categorized as; People, Smart, Sustainable, Growth and Leadership. Greater assistance in construction managerial processes will inevitably support the supply chain, which is responsible for delivering these targets making the successful implementation of innovation vital in the view of the public sector. Whilst key factors are stated, it does not address the inherent issues of the industry and how these broad categories will be adopted by a largely fragmented industry with slim profits.

Organisational Structure in Large Main Contracting Firms in the UK

Profit maximisation is the main reason for the majority of (private) businesses and this is no different in the construction sector. Profit maximisation ensures survival, return on investment, growth and the additional performance indicator of economic value added (McKee, Varadarajan and Pride, 1998). The UK construction sector is intrinsically linked to this combination of business goals however their cause is further complicated by a market structure that is considered highly competitive, unpredictable with poor profit margins, a blemished Health and Safety record (Ming, Runeson *et al.*, 1996); and a need to innovate for economic success (Abbot, Jeong *et al.*, 2006). These issues are further compounded by the fact the sector is fragmented by small to medium enterprises (sub-contractors and suppliers) and so when all these challenges are combined it often has a detrimental effect on success and even survival (Thomas Ng, Tang *et al.*, 2009). The tangible benefits from the adoption of innovative practices include efficiency in processes, in some instances differentiation, overall organisational efficiency (Frambach, 1993) and consequential super-normal profits (Levin and Meisel, 1992). However, the internal process within a construction company that innovates regularly across the organisation is obscured and unclear. Damanpour (1991) highlights three elements of regularly occurring innovations namely, administrative and technical, process and product, and radical against incremental.

The department for Business Innovations and Skills (2017) stated that funding is the essential barrier to research and development within construction. The industry consists

largely of small to medium sized enterprises (SMEs) with restricted resources and low profit margins. This indicates that the mantle of innovation lies heavily with the remaining larger companies who have the resources to fund research and development. However the onus is not exclusively on the private sector. The public sector represents a significant proportion of annual spending in construction. This sector has been instrumental in prompting innovation through its own internal processes (Construction Strategy 2025). The issue of fragmentation (Farooq, 2012) also has an effect on an organisations willingness to innovative. Organisation size i.e. number of employees has a profound effect on innovation diffusion (Damanpour and Schneider, 2006) due to critical mass of staff members to be reached and impacted. Thence, the utilization of innovation becomes wide spread in large organizations and bring with it resultant economies of scale. In converse, SMEs may see the significant expenditure to a small number of employees as wasted income, were other organisations will also benefit from their endeavours. This unwillingness to take the necessary first step due to the fear of handing over cost effective solutions to competitors for no cost is a fundamental barrier within SMEs in the construction industry's structure.

The aim of this preliminary research is to examine the impact of organisational structure towards achieving innovation adoption - A study related to large main contractors in the UK construction industry with opposing fragmented and consolidated organisational structures. It attempts to explore the impact of leadership and organisational culture within these types of differing organisational structures, leading to the identification of themes for further and detailed analysis. The above aim will be achieved by the pursuance of the following objectives. The objectives move from a critical review of literature to the construction of an analytical framework, then on to data collection and analysis, identifying key factors for further research.

Analytical Framework

A deductive approach from the key factors discovered in the literature namely; organisational structure; decision making in regards to innovation adoption; will be utilised to identify how a main contractor's organisational structure, specifically consolidated vs fragmented workforce may impact innovation adoption at organisational level. This will be measured by a cross comparison of two opposing structured construction organisations of the same size and turnover. Exploratory/inductive further research will assist in defining the level of adoption perceived by both organisations at senior management level and project professional level. Furthermore, the most effective decision making approach to innovation adoption will be explored.

METHODOLOGY

From a pragmatic philosophical stand-point, the approach to theory development led the author to a deductive literature review to elucidate parameters of existing knowledge and thus constructing an analytical framework. A stratified convenience sampling technique was adopted to ensure alternative organisational structures could be explored. An inductive cross case analysis (mono-method) using four qualitative semi-structured interviews lasting approximately 1 hour each allowed the researcher to examine two UK based main contractors with local, national and international standings of a similar size in construction related turnover in the UK (The Construction Index, 2017) but with differing organisational structures with the intent on examining the key factors that have arisen from the literature. Namely, contractor "C" has a consolidated organisation, attempting to execute the works utilising its own in-house workforce and resources. In

contrast, contractor “F” takes a fragmented organisational approach to executing the works, choosing to sub-contract the majority of the work to other organisations. To further validate the data the sample draws from experienced (organisational senior management level) national managers and (project level) newly qualified professionals (see Figure 1). Nvivo is utilised as an effective means of data analysis with a thematic approach to analysis.

Consolidated Approach Organisation	C1	C2
Fragmented Approach Organisation	F1	F2
	Newly Appointed Project Professional	Experienced National, Senior Manager

Figure 1: Study Sample

FINDINGS

Cost and Fragmentation were identified by all participants as the most significant barriers to innovation adoption in the industry generally, with short-termism, mimetic behaviour, age and bureaucracy also were highlighted in the data but did not appear as regularly and across all data collected. This compounds the existing literature and the author’s industry experience (Volk *et al.*, 2014) and validates the line of inquiry. The data has been thematically analysed, condensed and tabulated into its simplest form to create themes for discussion (see Table 2 to 5).

Both interviewees from the fragmented organization identify their organization as a “Laggard” (Rogers, 1957). Volk *et al.*, 2014 identify fragmentation in the construction industry in a long line of previous authors such as Paavola, 2014; Rezgui *et al.*, 2013 and McAuley *et al.*, 2012. They all point to the issue of each project being bespoke due to this factor. The interviewees identify this a significant challenge to overcome for their organization, one which hinders innovation adoption wholesale as a common thread/theme.

Table 2 Fragmented - Organisational Structure and Findings

Interviewee	Organization Structure	Professional	Measured Opinion on Organizations Innovation Adoption (Rogers, 1957)
F1	Fragmented	Newly appointed	Late Majority
Qualitative Comment	“Innovation is talked about at senior management levels and external influences engaged to promote. Not seeing it filter down yet. Anecdotal without any specifics”		
F2	Fragmented	Senior Manager	Late Adopters
Qualitative Comment	“We perform poorly at innovation although we have promoted ourselves as highly innovative to clients in the past but in reality it seldom gets down to the operational level”		

Furthermore, the fragmented organisation interviewees described their organisation’s approach to decision making with regards to innovation, as optional (see Table 3). This is defined as providing individual flexibility to those adopting the potential innovation. It is done so on their terms and is not part of any legislation or authoritative direction. The senior manager went further to elucidate that this also is a key factor of challenge that their organization must deal with. Professionals at all levels are working at full capacity to ensure targets financial and programme and seldom have the luxury to consider innovation in the short, medium or long term. As this is not used as a key

performance indicator within this business it is often overlooked. This confirms the research conducted by Everett M. Rogers (1981) and Thunberg *et al.*, (2017).

Table 3 Fragmented - Optimum Decision Making Approach to Innovation Adoption

Interviewee	Organization Structure	Professional	Decision Making in Innovation Adoption
F1	Fragmented	Newly appointed	Optional
F2	Fragmented	Senior Manager	Optional

The interviewees from the consolidated organization both considered their organization an innovator (Thunberg, 2017), however the newly appointed professional went further to compare themselves against other industries and conceded that in comparison they were perhaps less innovative and have a long way to go before they can compare themselves to automotive, aeronautical or manufacturing albeit the construction industry was identified as a manufacturer but creating unique products. The interviewee went further to highlight their use of modular construction and off-site manufacturing allowing them to make considerable improvements to their ability to adopt innovations. In many ways they have gained much success in this which leans them towards manufacturers in a sense. The senior manager and newly appointed professional describe their organization as having innovation at the core of their business. It is led by the owner, filtered to board of directors, onto senior managers and down the chain of command at project level. As they complete the majority of the work themselves they are able to continuously feedback and improve/innovate. It was further highlighted that the process of innovation is bottom up and top down, everyone is expected to look for innovative practice at every level. Innovation is the cultural at the heart of the business before profit maximisation. The long-term strategy to self-improvement through innovation is given weight and forms part of employee’s annual review.

The senior manager stated that having a consolidated workforce with innovation at the core of the business, driven by the leadership and championed at each level creates a motivated workforce to engage innovation. These two factors were described as the key to their perceived success in innovation adoption.

Table 4 Consolidated - Organisational Structure and Findings

Interviewee	Organization Structure	Professional	Measured Opinion on Organizations Innovation Adoption (Rogers, 1957)
C1	Consolidated	Newly Appointed	Innovators
Qualitative Comment	"Highly innovative in comparison to peers, slightly less when compared against other sectors".		
C2	Consolidated	Senior Manager	Innovators
Qualitative Comment	"Innovation cultural and leading the business from its core, top down and bottom up".		

Although, it was stated a number of times that the owner of the organization was a driver of innovative culture and as such could be considered an “authoritative” approach to decision making, both interviewees consider their approach to innovation as “collective”. This is a balance between the maximum efficiency and freedom of choice. This may be a result of guidance from opinion leaders or change agents promoting their ideas (Hemström, 2017). The newly appointed professional went further to describe the organization as innovation focused which gave employees autonomy and as a consequence ownership of innovation which had a significant and positive impact on seeking and adopting innovation at all levels. A consolidated organisational structure was highlighted as the key to ensuring a culture of innovation adoption at all levels and allowed a constant feedback loop to decision making in the same regard.

Table 5 Consolidated - Optimum Decision Making Approach to Innovation Adoption

Interviewee	Organization Structure	Professional	Decision Making in Innovation Adoption
C1	Consolidated	Newly Appointed	Collective
C2	Consolidated	Senior Manager	Collective

CONCLUSION

The purpose of this research was to identify the key themes of impact when considering innovation adoption in the UK's main contracting construction arena. 4 interviews were conducted and a thematic approach to data analysis was conducted engaging a thematic approach using Nvivo. The main findings are that organisational structure has the most impact upon innovation adoption. In particular a consolidated organization with innovation at its core and embedded into its culture is deemed more successful. Furthermore, the best favoured type of decision making when considering impact of innovation is the "collective" approach.

The practical implications of the research is that the mainstream model of outsourcing work has less impact on innovation adoption than having your own workforce. If we refer back to the Government report; Construction 2025, its core intent is to promote innovation to drive efficiency and productivity, however this may be stifled partly due to the fragmented nature of the industry.

If a wholesale change back towards perhaps a dated model of the past is deemed inefficient and burdensome, it can only suggest that the supply chain be considered on a long-term strategy basis, tying organizations together similar to that of the other comparable industries. Profits must increase and the construction industry on a whole must be valued more in order for that to happen.

A collective approach to decision making with innovation embedded culturally creates a positive impact.

The limitation of the study is in sample size, further research is planned with a quantitative questionnaire to a larger sample to further test the impact themes.

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RISK MANAGEMENT MATURITY OF CONSTRUCTION PROJECTS IN THE NETHERLANDS

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Construction projects are bounded with uncertainties and therefore, the occurrence of risks in these projects is unavoidable. Literature confirms that risk management increases the possibility of project success. A Risk Maturity Model (RMM) is a tool, which can help projects measuring the maturity of risk management and plan for risk management improvements. This research implements a Generic Risk Maturity Model (GRMM) in one contractor and two public organizations in the Netherlands. By means of individual and group interviews, 19 experts in 11 construction projects are asked to assess the risk management in their projects. The results show that risk management is properly performed in these projects, however, the organizations seem better in identifying risks rather than mitigating risks. Experts assessed their organizations high in performing 'Risk Assessment'. The results show that the experts in the public organizations evaluate 'Policy and Strategy' of risk management and 'Management Commitment' towards risk management low. The contractor could improve its risk management by giving more attention to evaluation of the risk management process. Further research into the ambition level of risk management is suggested.

Keywords: evaluation of risk management, risk maturity model, risk

INTRODUCTION

The construction industry is faced with a variety of situations involving many unknown, unexpected, frequently undesirable and often unpredictable factors. Literature shows that risk management increases the possibility of project success (Flyvbjerg, Bruzelius, and Rothengatter, 2003; Ren and Yeo, 2004). A Risk Maturity Model (RMM) can help projects. According to Wendler (2012), the 'maturity' concept is increasingly utilized by organizations to measure the quality of their processes. The term 'maturity' for an organization is known as a measurement concept that demonstrates progress in development and carrying out processes that are documented, managed, measured, controlled and continuously improved (Loosemore, Raftery, Reilly, and Higgon, 2006; Öngel, 2009). Maturity in terms of risk management points out an evolution towards full development of the risk management process. A major benefit of RMMs is identifying the improvement's areas of applying risk management (Loosemore *et al.*, 2006; Wendler, 2012; Yeo and Ren, 2009; Zou, 2010). Risk maturity models help to organise the processes required for improving the management of a certain risk (Schiller and Prpich, 2014). Wendler (2012) maps 237 articles related to the maturity models in more than 20 domains. Results reveal

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that despite an increasing trend in developing maturity models, not many discuss the validation and application of maturity models, particularly risk maturity models. This research contributes to the existing literature by implementing a risk maturity model and discussing the areas of improvement in risk management of construction projects.

This paper discusses risk management maturity of construction projects in the Netherlands. The objective of this research is to help projects in the construction industry advance their risk management practices by investigating the improvement areas of risk management of construction projects in the Netherlands and hence advance the performance of their project management practices. The research discusses the implementation of a Generic Risk Maturity Model (GRMM), developed by the authors, in 11 construction projects in two public organizations and one contractor in the Netherlands. In the next section, literature is reviewed and the GRMM is introduced (Section 2). Next, Section 3 explains the methodology of the research. In Section 4, the results and analysis are presented and afterwards, the results are discussed. The paper ends with conclusions and recommendations for future research opportunities.

LITERATURE REVIEW

Background

The idea and the concept of ‘maturity’ goes back to the field of quality management (Wendler, 2012). During the last two decades, several maturity models are also developed in other domains (Yeo and Ren, 2009).

Specific to risk management maturity, several researches have been conducted by organizations and researchers (IACCM, 2003). There are few literatures, which discuss the application of risk maturity models in construction projects. For example, Öngel (2009) explains developing and implementing a risk maturity in construction projects in Turkey. He concludes that the level of risk management varies per project and between local and international projects. Besides, companies, which do not allocate a budget to risk management activities, encounter immature risk management process. A similar study by Mu, Cheng, Chohr, and Peng (2014) assesses the risk management capability of subway project contractors.

The Generic Risk Maturity Model (GRMM)

To measure the maturity of construction projects in the Netherlands, the auteurs developed a Generic Risk Maturity model (GRMM) (own work). Figure 1 presents a schematic model for the GRMM. It consists of two categories: Organization and Application and Process. The Organization category contains those activities, which ensure that risk management can be performed in a project (e.g. training, culture, risk management policy and strategy and commitment towards risk management). As shown in Figure 1, the Organization category contains of four aspects: Policy and Strategy, Culture and Personnel Knowledge, and Management Commitment. The Application and Process category contains the steps of the risk management process. This category checks the application of risk management and contains three aspects: Risk Assessment, Risk Treatment, and Monitor and Review. The feedback loops between the two categories in the GRMM reflect the continuous improvements based on the results of the GRMM application.

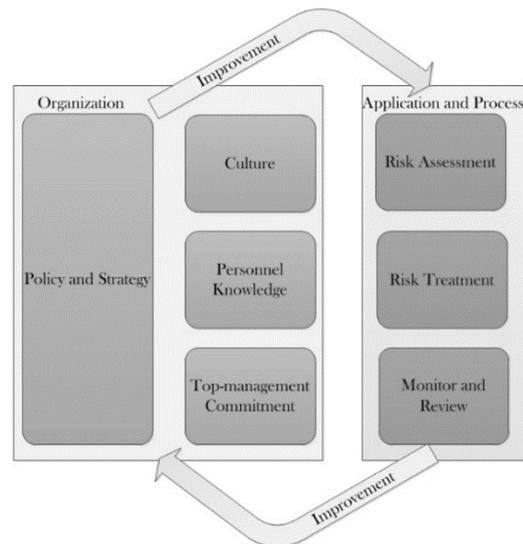


Figure 1 the GRMM model

METHODOLOGY

This research benefits from a mixed-methods approach, combining or mixing quantitative and qualitative research methods (Tashakkori and Teddlie, 1998). The goal of mixed-method research is not to replace either qualitative or quantitative approaches but rather to benefit from the strengths and minimize the weaknesses of these methodologies in a single research (Johnson and Onwuegbuzie, 2004). The research has followed a parallel ‘design’ (Tashakkori and Teddlie, 1998) meaning that the experts are asked to evaluate their project by implementing the GRMM (quantitative design). Afterwards, the experts were asked to elaborate on their answers by means of individual and group interviews (qualitative design).

To compare the risk management maturity of the contractor and public organization in the Netherlands, two public organizations and one contractor are selected based on their availability for participating in the research. In each of these organizations, a few ongoing projects are selected since gathering data from ongoing projects is easier, and the project members of these projects are easier to approach. The projects selected in the public organizations are among the projects that these organizations should regularly execute (e.g. improvement and reinforcement of the dikes, sluices and ways). The contractor’s projects are selected among the pilot projects, which implemented a new framework to execute projects. Table 1 provides an overview of the number of projects and number of experts in each organization.

Participants in the public organizations (POs) are selected among the project team members who are actively involved in risk management: project managers, project controllers, risk managers or cost experts. At the contractor, two roles are considered relevant for this study: risk managers and design managers. After filling the GRMM by the participants, interviews are conducted and the participants are asked to elaborate (if possible) on statements with a low score. For the first public organization (PO1) and the contractor (CO), this step is held as an individual interview while in the second public organization (PO2) this step is conducted as a group interview because of restricted availability of the experts at PO2. Before the group interview, the experts had filled in the GRMM individually. Next, the

statements with a low score (1 or 4) were collected, and the experts were asked to elaborate on these in the group setting.

Table 1 overview of the number of participants and projects in each organization

Organization	First public organization (PO1)	Second public organization (PO2)	Contractor (CO)
Number of participants	7	7	5
Number of projects	4	4	3

RESULTS AND ANALYSIS

While there are many possibilities to analyse and present the results (i.e. analysis based on each project, analysis based on roles, comparing the current level and ambition level), this paper focuses only on the current level of maturity and presents the average results at company level. The results are analysed at two levels: ‘category’ and ‘statements’. The ‘category’ level discusses the results in ‘organization’ and ‘application and process’ categories of the GRMM. The ‘statements’ level discusses the result per aspect of the GRMM and elaborates on the statements in each aspect, particularly those that are evaluated low by the experts.

Analysis of the results at category level

Figure 2 presents the maturity of each organization per aspect. In the PO1, the aspects ‘Culture and Personnel knowledge’ and ‘Risk Assessment’ with the scores respectively, 8.14 and 7.84 are the most mature aspects. The aspect ‘Management Commitment’ has the lowest score. Results of the PO2 reveal that the aspects ‘Risk Assessment’ and ‘Risk Treatment’ are the most mature categories. The ‘Policy and Strategy’ category received the lowest maturity score. In the CO, the ‘Risk Assessment’ and ‘Policy and Strategy’ aspects are the most mature, with scores of 8.40 and 8.11 respectively.

In all of these organizations, the ‘Risk Assessment’ aspect is among the highest scores while the ‘Management Commitment’ aspect has the lowest maturity level.

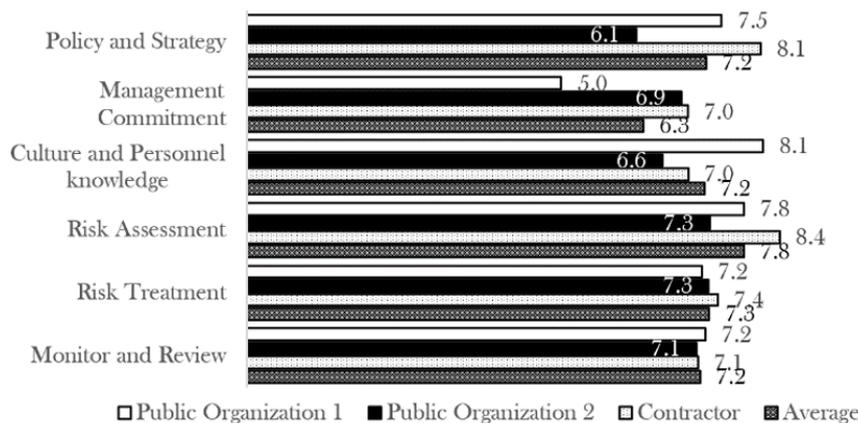


Figure 2 scores of all organizations per category of the GRMM

Figure 3 summarizes the GRMM scores and reveals that all three organizations are more risk management mature in the Application and Process category. Besides, the CO shows a more mature result than other two POs. The interviews revealed that the CO has a specific risk management process that each project should follow, hence explaining the higher scores in the CO.

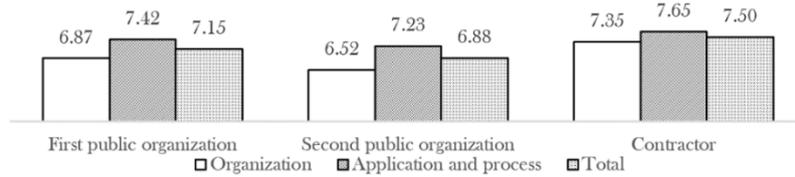


Figure 3 scores of risk management maturity of each organization per category

Analysis of the results at statement level

This section describes the statements that are evaluated low (i.e. the scores of 1 or 4 in the value column) by the experts in each organization, since the aim is to derive improvement opportunities.

Policy and Strategy

Figure 4 presents the results for the ‘Policy and Strategy’ category. For this category, the CO shows a better risk management maturity. The comments focus on the statements related to ‘risk appetite’. According to one of the respondents at the contractor: “There is no specific risk appetite document” or “Risk appetite is not completely integrated in the projects.” In addition, an expert in the PO1 mentioned, “we take all the risks for treatment...risk appetite is not something that we decide before-hand.” Likewise, stated by an expert in the PO2: “there is no risk appetite. The ambition is to define [risk appetite] high.”

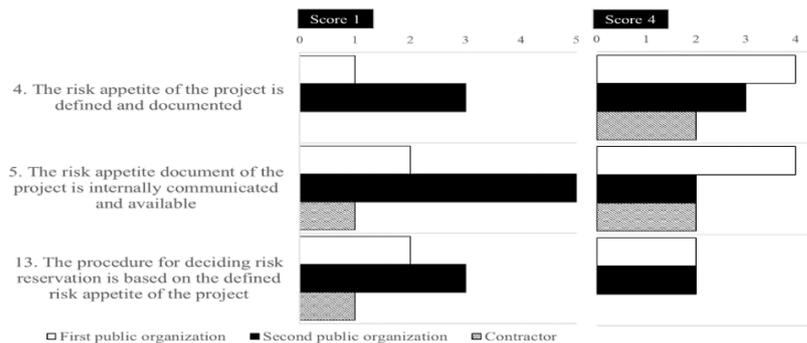


Figure 4 Statements with low scores (score 1 is shown left, score 4 is shown right) in the ‘Policy and Strategy’ aspect

Management commitment

The results of the second aspect, ‘Management Commitment’, are presented in Figure 5. The results in this figure (and Figure 2) show that this aspect has the lowest average score for all organizations. Statements 2 and 4 received the lowest scores. The experts in the PO1 stated that there is no direct steering or clear instruction on how to perform risk management within the projects. Also, there is no control whether risk management is performed. According to an expert in the PO1: “the management does not communicate about risk management and there is no clear way to deal with the risk management within the organization.” Furthermore, stated by another expert: “I don’t think that [the management] knows what [risk management] means.” One expert in the CO mentioned that: “[the management uses risk management reports] implicitly.” An expert in the PO2 gives a similar statement. In addition, several experts in the PO2 stated that the communication about risk management needed to be improved. Interviews with PO1 revealed that management does stimulate risk management by quarterly asking for the risk status in the projects via the progress reports that have to be filled in. However, this never leads to a real

conversation about risk management, especially with the average-size projects. The reason resides in the workload of the line manager, who not only guides several projects but also has a department to manage. This refrains him from paying equal attention to all projects.

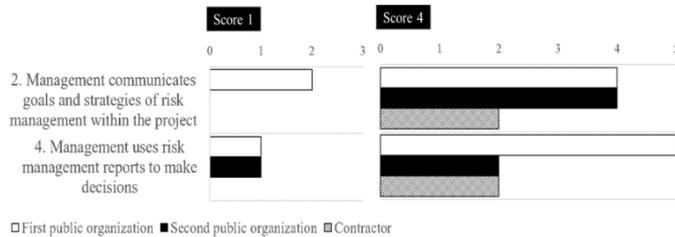


Figure 5 Statements with low scores (score 1 is shown left, score 4 is shown right) in the ‘Management Commitment’ aspect

Culture and personnel knowledge

Figure 6 presents the results of the third aspect, ‘Culture and Personnel knowledge’. The PO1 shows a higher maturity score in this aspect (Figure 2 and Figure 6). The statements 4 and 5 have received the lowest score. Regarding the statement 2 one expert in the PO2 mentioned that: “mistakes are not always accepted. [There are] often discussions about who could avoid this (a problem).” The experts in the PO2 and the CO confirmed the lack of training regarding risk management within their organizations. Stated by PO2: “There is no training to improve risk management skills.” Furthermore, stated by CO: “We do not train the people explicitly... This is also time dependent. No time is considered for that [for training].” Not mentioned among the low score statement, the group interview with the experts in the PO2 declared that experts expected more attention to risk management in their organization. For instance, it was mentioned: “not all the team members give risk management a high priority to their work” or “[it should be] more attention and time to risk management among the team members.” During the interview with the experts in the PO1, it was mentioned several times that some risks are explicitly not communicated to the management. As mentioned by an expert: “[we are told to] take some of the risks out because the management does not understand it and cannot influence the risks, and we get just questions... therefore, you create a culture of scare, and you bury your head in the sand.” Or “... we treat these risks in our team, and we do not need to bother the management.”

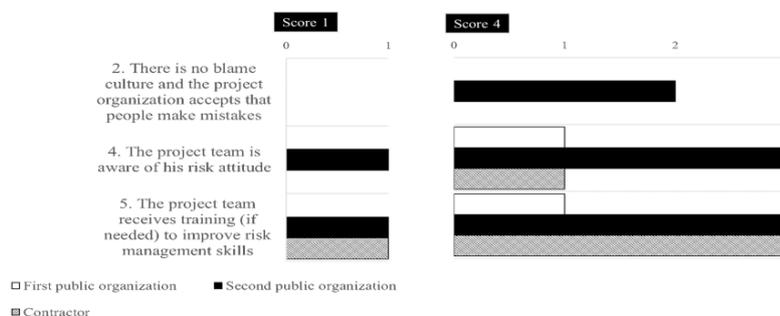


Figure 6 Statements with low scores (score 1 is shown left, score 4 is shown right) in the ‘Culture and Personnel Knowledge’ aspect

Risk assessment

The results of the ‘Risk Assessment’ aspect are presented in Figure 7. As shown, the statements 2 and 6 have the lowest score. Regarding the statement number 2, one

expert in the PO1 mentioned: “Key external stakeholders like municipals, companies and residents do not physically participate in the identification session, but the input from these externals is considered through the communication manager.” Likewise, mentioned by another expert: “The risks are identified by the project team and the people who work in the project...external people are not attending [the risk identification].” As mentioned by the experts in the PO2: “more external stakeholders can be invited to the risk identification sessions.” Some experts mentioned that the involvement of the external stakeholders could be improved.



Figure 7 Statements with low scores (score 1 is shown left, score 4 is shown right) in the ‘Risk Assessment’ aspect

Risk treatment

Figure 8 presents the scores for this aspect. Interviews revealed that all the three organizations determined control measures for treating the risks, however, the risk response strategies are not decided specifically. Risk response strategies are: avoid, transfer, reduce and accept (PMI, 2013). In reality, no other risk response strategy was used other than ‘reduce’. One expert at the contractor mentioned: “We do have control measures, but it is not explicitly based on strategies”. The interviews revealed that in the CO, less attention is given to the evaluation of control measures after implementation. The results from the POs show that the secondary risks are not considered in the project. Secondary risks are defined as risks that arise from implementation of an agreed response strategy to the basic risk (Hillson and Simon, 2007).

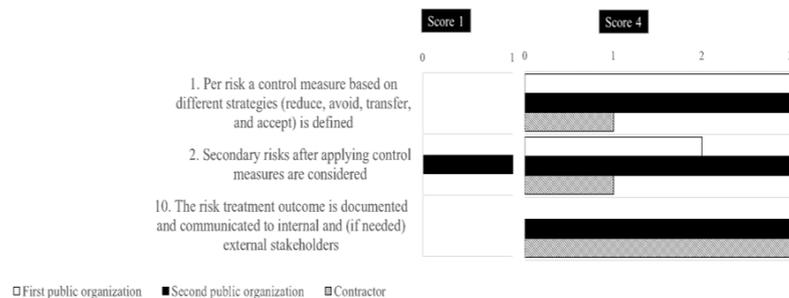


Figure 8 Statements with low scores (score 1 is shown left, score 4 is shown right) in the ‘Risk Treatment’ aspect

Monitor and review

The results of the last aspect, ‘Monitor and Review’, is presented in the Figure 9. The statement number 6 regarding the communication and documentation of this aspect has received the lowest score by the experts. Among the respondents, it was mentioned that: “[the results of monitor and review] is documented and shared limitedly” or “lessons learned are documented, but they are not further shared or used.” One expert in the CO stated: “We have organized several sessions with the client and contractors, but that is not enough.” Regarding the lessons learned, for

example, the CO mentioned that "... We don't do it due to time pressure." The experts in the PO1 came with the similar arguments. Besides, it was stated by the PO1 that capturing lessons learned, especially for internal projects, is not always performed.



Figure 9 Statements with low scores (score 1 is shown left, score 4 is shown right) in the 'Monitor and Review' aspect

DISCUSSION

The paper examined the risk maturity of construction projects in the Netherlands in two public organizations and one contractor. The Generic Risk Maturity Model (GRMM) applied in these organizations examines the risk management application in two categories: Organization and Application and Process. These two categories consider both the essential requirements of apply risk management, ('Organization' category of the GRMM) and risk management steps ('Application and Process' category of the GRMM). Results reveal that most of the primary steps in risk management are performed in all three organizations. Hence, it can be concluded that all the examined organizations recognize value and benefit of risk management. Results show that the Application and Process category of risk management is more mature than the Organization category in all three organizations. There is a decreasing trend in the maturity scores of the aspects 'Risk Assessment', 'Risk Treatment' and 'Monitor and Review' (Figure 2). This indicates that the studied organizations are more advanced in identifying and quantifying risks, than in mitigating the risks and evaluating the whole risk management process.

Among the studied organizations, the CO shows, in general, a higher score on risk management maturity. The CO has developed its own risk management guideline, which has to be used from the start of each project. Besides, the CO actively used a project database to keep the project information up-to-date. This suggests that risk management is better established at the CO. In contrast, the POs, as exposed by the interviews, have either no defined risk management process or the risk management process is not actively used in their projects. The Experts in the POs mentioned that it was for a large part up to the project team to decide on how to set up risk management. According to one of the experts: "It would be helpful if there is a risk management framework for the organization... each project has its own kingdom" or "There is no instruction or guideline on how to deal with risk management. As a project team, you decide how you fill it [risk management] in, and because there is no control it can lead to not paying attention to it." This can clarify the difference between the CO and the POs in the aspect 'Policy and Strategy'.

One clear difference between the POs and the CO is the risks they decide to mitigate ('Risk Treatment' aspect). This has direct relation with the risk appetite of the organizations ('Policy and Strategy' aspect). We observed that most of the experts had difficulties in understanding the term 'risk appetite'. This can explain the low

scores for the statements number 4, 5 and 13 in the 'Policy and Strategy' aspect. The ISO (2009, 10) defines risk appetite as "the amount and type of risk that an organization is prepared to pursue, retain or take." The POs in this study are part of the government that is responsible for executing public projects. These public projects are fully subsidised by the government. Mistakes at these projects can lead to critics from society. Therefore, these projects are less willing to take risks and try to avoid any kinds of risks. The experts in POs confirmed this: "We, as a public organization, are not willing to take risks." Likewise, "we are in an organization that has a culture of 100% safety; therefore, all risks should be avoided." Therefore, all the identified risks in these projects are mitigated. This can be seen in the 'Risk Treatment' aspect where the project does not apply any other risk mitigation strategy rather than 'reduce'. Besides, this causes that the POs have larger risk reservation and, as a result, higher budget estimates. On the contrary, the contractor, due to the competitive market, has to come with a reasonable bid. Therefore, they decide only the important risks for treatment. In contrast with the POs, the CO has an implicit 'risk appetite'. The interviews with the experts at the contractor revealed that only the risks with consequences higher than a certain amount of money (in this case 100.000 euro) are selected for treatment. Besides, the contractor divides the risks in three categories and only the risks in the second and third category with higher priority are quantified. Results from Figure 7, Figure 8, and Figure 9, illustrate that experts from all three organizations expressed that the communication and documentation about risk management should be improved.

A recommendation for the POs is to develop a risk management framework for the organization and its projects. Basically, it means making clear appointments between the internal stakeholders of the project about the level of risk assessment, treatment and monitor and review; interval times and goal and set up of risk sessions and reviews, responsibilities, agreements on risk reservation, communication, etc. This can be in the form of a risk management plan or as part of the integral project plan. At the contractor, more attention should be given to train the project team and to evaluate the risk management processes. Furthermore, in all studied organizations, documentation and communication of risk management demand more attention.

CONCLUSION

This research contributes to the existing literature by implementing a risk maturity model and discussing the areas of improvement in risk management of construction projects in the Netherlands. A Generic Risk Maturity Model (GRMM) was applied in one contractor and two public organizations by means of individual and group interviews. The results show that risk management is performed in the projects in the studied organizations, and most of the risk management steps are properly implemented. However, some steps can still be improved. Results reveal that the 'risk assessment' and 'management commitment' aspects have respectively the highest and the lowest risk management maturity score. For the public organizations, a possible improvement could be developing a framework for risk management.

LIMITATION AND RECOMMENDATION FUTURE RESEARCH

The limitations in this study can be considered as opportunities for future research. First, one of the limitations of this study is the number of organizations, which has been investigated. A possibility for future research can be to investigate more organizations. The authors will perform this study in more projects in the future. In this research, only the current risk maturity (scores in the column value) of the

projects is examined, whereas as a second recommendation it would be interesting to investigate this over time. Third, future research can also consider the scores on the ambition level. Finally, fourth, defining and comparing the risk management maturity of projects based on different roles in the project is another possibility for future research.

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PERFORMANCE OF RETROFIT WITH ICT OF SOCIAL HOUSING - PROVING TECHNOLOGY OPTIMISTS WRONG?

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The costs of social housing retrofit are critical for social housing companies, for efforts to build sustainable cities, and for society. Compared to available resources, retrofits are deemed costly, and there is a need to improve productivity. One approach is to realise digital integration and (partial) automation processes, creating more performative digital practices. However what digitalisation should target and its scope is difficult to decide. Even standard concepts like Virtual Design and Construction (VDC) have many variants. To capture the performance gain of digitalisation requires measurement methods, while most methods are designed for new built and production, and does not appreciate the costs and values that characterize retrofit using digital practices. This paper aims at conceptualizing a method for understanding performance in digitalized retrofit of social housing. A review of approaches to productivity, efficiency and performance is done. Values produced are multidimensional and cannot be reduced to costs per m². Performance is proposed conceptualized as values produced for clients, tenants and companies, and then compared to costs and effects of the digital practices. The context is two phases of a large Scandinavian retrofit project, followed by a longitudinal study using a mixed method approach. The social housing consists of 900 apartments in blocks and in row houses at 70.000 m². The refurbishment encompasses new bath rooms, ventilation and parts of the building envelope. A gradual VDC implementation is carried out, avoiding an ambitious overall implementation. The performance is dependent of hybrid ICT and organizational practices, where the interaction with tenants is important. It is therefore a hybrid set of factors that lever performance, including intense coordination among contractors, continual communication, interaction with tenants and the craftsmen's learning during production. The impact of ICT is more indirect. Technology optimism or not, It is not technology alone that improves the performance.

Keywords: refurbishment, information technology, performance, stakeholder

INTRODUCTION

The benefits of renovating the European building stock are multiple and go beyond energy savings (Copenhagen Economics 2012, Mangold 2016, Wittchen and Kragh 2016), Yet renovations, refurbishment or retrofits come at serious costs, that should

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energize a considerable interest in how the renovation can be done in an efficient and societally responsible manner. This includes a series of issues; efficient methods, processes, technology and financing are central. The choice of depth of the renovation is also important, and here the interest is in deep renovation, defined as a retrofit, refurbishment or renovation aimed for the deep refunctioning of the building envelope, heating, cooling, ventilation, hot water and /or the building's mechanical systems (GBPN 2013). Deep renovation could probably lead to improvements in the range of 30% - 50% of performance of the mentioned function areas (GBPN 2013). Through this definition, it is sought to overcome definitory overlaps between renovation, refurbishment and retrofit and to aim at a type of renovation that involves considerable investment.

Moreover, the focus is on the use of Virtual Design and Construction (VDC) as a means to make deep renovation more efficient. VDC is a concept for integrated use of ICT, organisation and management in design-build processes of new built (Kunz and Fischer 2012). However, it can be posited here that it can be accommodated also in the context of deep renovation. Especially, the research project appreciate that a medium-sized contractor has limited resources for "big bang" ICT implementations of VCD, yet at a time have an organisation ready for ongoing stepwise implementation of mundane ICT changes. On this background the questions of the paper are

-How can a VDC implementation be shaped that prepares for performance improvements of a refurbishment project?

-How can a performance improvement of such a VDC variant be measured?

In our response to the first main aim involve capturing characteristics of a particular variant of VDC suited for deep renovation. For the second main aim, a measurement concept is developed, but a guiding question has moreover been, would it make sense to measure price/ work hours per square meter in a refurbishment project? And it is posited that much more is needed to understand the value produced.

The contribution of the paper is first to commence conceptualising a comprehensive digitalization concept for refurbishment of social housing, framed as a VDC variant, technically involving integration of more information systems for supporting the building production process (rather than focusing on design) and a organisationally a VDC variant where tenants are very present and recurrent clients. Second to present a framework for measuring the performance of this renovation VDC variant through comparing two processes of deep renovation carried out on dwelling block with the same technical building features. The comparison consist of four main value/cost dimensions measured in four main steps and in 50 measures in total.

FRAMEWORK OF UNDERSTANDING

Below the framework of understanding is developed corresponding to the two main research questions; shaping of a VDC variant and matching performance measurement concept.

Understanding of VDC

VDC is a concept for integrated use of ICT, organisation and management in design-build processes. The concept has diffused in the industry for a decade and exist in several variants (Kunz and Fischer 2012, Eastman *et al.*, 2011, Sen 2011, Andersson *et al.*, 2016, Tjell 2016). Kunz and Fischer (2012)-s well-known definition combine visualization, integration, automation, and metrics. VDC would normally operate a

constellation of ICT-systems in what can be called an information infrastructure. Andersson *et al.*, (2016) for example argue that VDC is beyond BIM, because BIM is merely information modelling in their view. They provide case examples where Revit, cloud-based collaboration software, Synchro scheduling, Excel, and more systems are brought together (Andersson *et al.*, 2016).

An infrastructure understanding of VDC moreover leads to a further focus on the Kunz & Fischer (2012) dimension of integration. For long, systems used in VDC infrastructures have been poorly integrated, but over the years, data exchange standards, such as IFC and other means, have improved the interoperability, leading to lower transaction losses (Gallaher *et al.*, 2004 compared to Svensk Byggtjänst 2016). Moreover, this leads to a VDC development where minor steps in the information infrastructure such as new software systems, plugins, more thorough use of functionality, developing object families etc., enters an emergent path of mundane steps only occasionally disrupted by major investments. Such paths are likely to be project and company specific leading to a host of variants (Gustafsson *et al.*, 2015). A VDC variant is thus characterised by a particular constellation of information systems more or less integrated in an information infrastructure. This variant would in a deep renovation context probably involve technologies for (re)measuring the buildings and for involving and/or informing tenants in the process.

Importantly a VDC variant would have an organisational and collaborative side. And some VDC variants have indeed also been understood as mainly an issue about collaboration and coordination in co-located and/or virtual practices, such as big rooms (Tjell 2016).

From Productivity to Performance

Construction productivity is usually defined as an output/input ratio of a particular building processes. However, most authors continue immediately to add more concepts to qualify this (Bernold and AbouRizk 2010, Bröchner and Olofsson 2012, Josephson 2013). Josephson (2014) point to three types of definitions

- 1) Outputs/Inputs
- 2) A combination of efficiency (doing things right) and effectiveness (doing right things)
- 3) Includes any characteristics that makes the organization function better.

Performance function is defined as consisting of two factors productivity and effectiveness. The short-term focus on the output of the operation neglects the condition that the business consists of many other components. For example, the performance of the purchasing department might be critical to the success of the company (Bernold and AbouRizk 2010). This understanding has wide reaching consequences. ICT leads to involving a broader understanding of value creation for the stakeholders of the company, appreciating end-users' attribution of final value, the knowledge creation of the participating companies, but also their headquarters spend of resources as a cost.

Performance of VDC in Construction Projects

Counter to the above developed understanding of VDC variants, studies of performance and return of investment of VDC and BIM, in contrast, usually assume BIM and VDC are well described, unitary and relatively stable configurations (Azhar 2011, Giel 2013). They point to a series of aspects of VDC leading to improved

performance. Improved collision control, material take off, coordination reviews are examples (Azhar 2011, Giel 2013, Sen 2012). However, these are portrayed as related to VDC and/or BIM as such, in a non-differentiated manner. And typically, while recognizing the human element of the infrastructure in use, not conceptualising what impact the form of collaboration or organisation will have on performance. VDC-variants that appreciate the close intertwinement in performance of VDC and BIM between the social and the technical such as big room concepts (Tjell 2016) are not measured, even if Kunz and Fischer (2012) propose dimensions for such measurement.

Performance of Digital Practices

Davies and Harty (2013) and Whyte (2011) have studied the performance of digital practices. Davies and Harty (2013) focus on the building site and find emergent digital practices onsite involving building workers and managers related to the use of BIM models on a tablet computer. Similarly, Whyte (2011) in her study of design find examples of digital coordination of design. Engineers and architects develop different relationships with a shared digital model; different software packages and tools have become linked together into an integrated digital infrastructure, which create emerging hybrid practices. Such results call for a renewed understanding of cause-effects relations in use of VDC.

Summary of Theoretical Framework

Virtual design and construction is understood as an information infrastructure of ICT systems, interwoven with a set of collaborative practices. A particular variant of renovation is prevalent probably involving partial BIM-models, technologies for (re)measuring the buildings and organisational approaches for involving and/or informing tenants in the process. These two elements, technical and organisational, merge into digital practices. Rather than large one-off implementation, VDC is developed through adding to an existing ICT-infrastructure in a "puzzle brick" manner, where VDC come to consist of several software systems juxtaposed. Performance is conceptualised through types of values produced for the clients, the tenants and the companies, compared to the costs and the effects of the digital practices. The VDC variant are assumed to contribute to improved performance through digital practices on site and in design in a complex intertwined manner, extending into company knowledge creation and end-user value dimensions.

METHOD

This research adopts an overall interpretive sociology approach. Within this, the research design responding to the two main research questions is a mixed method set up combining qualitative and quantitative methods (Creswell and Clark 2011). This design is mainly due to the complex value pattern generated in the project both in processes and in the final result. It is an important positioning here, that data collected for performance measurement, that are quantitative, is rooted in a number of qualitative evaluations, such as for example decisions on where processes start and end. The research is a longitudinal study following briefing, design, production and commissioning enabling a capture of process cost and values created. The basic idea of the performance measurement is to compare two deep renovation processes carried out on comparable dwelling, one without VDC and one with use of VDC. The context analysed is two phases of a renovation project of entire apartment district consisting of 11 four floor dwelling blocks and 50 row house blocks in total a gross

area of dwelling of 71,000 m², distributed over 1000 apartments and rowhouse units. These blocks were built at the same time and operated over a long period by the same housing association with similar maintenance across the blocks. The client and operator of this portfolio is a social housing company, with a central office/headquarter, a local association of tenants and the tenants themselves. The contract sum for the deep renovation is 77 million euro plus a design consultant fee of 2.2 million Euro. The timescale is approximately 5 years. The project can be considered as a deep renovation because bathrooms, ventilation, staircase facades, balconies, end facades, bottom back side, roofs are all to be renovated. However, side facades and building structure are major examples of elements not to be renovated. From March 2015, a series of meetings have been held with the project organisation and the participating companies on site. During 2016 most of the engineering and architectural design was carried out. This was followed through quarterly meetings and a round of interviews with representatives of the architects and engineers. In 2017 while the production has been emerging, a series of interviews and meeting observations have been carried out, following the construction processes. 13 days of presence on site including participation in Last Planner Scheduling meeting, informal dialogue, interviews, and round on site has been carried out. The field programme continues week by week the next year. Also in 2017 the contractor has been preparing the VDC variant. Solutions considered include use of drones, upgraded BIM models, improved location based scheduling, tenant's administration, tenant information. Over these meeting the researchers took part in discussing and prioritizing what to implement. It is a limitation of the project that even if ICT is carried out using early contractor involvement here, there has not been a strong ICT integration between architects, engineers and the general contractor. It is likely that learning will improve performance over time and correction for this competing effect to use of VDC has to be corrected.

The Measurement Concept

The project should document performance chances by introduction of a variant of VDC on a renovation project of social housing. This is done by comparing two phases of the renovation process. Four main measures are carried out: Measure 1 is of briefing and design (14 measures) focus on initial specifications, budget, ICT and knowledge resources invested, value expectation. Measure 2 is of the 1. Phase using existing ICT-approach and process. This period ran from start-up in late 2016 until 1 September 2017. Measuring phase 1 us done through a series of units that the renovation is targeting; roofs, bath rooms, ventilation, end facades, lower back side facades, balconies etc. 14 measures in total are put in place. Measure 3 is on the 2. Phase, where the focus is the process using the particular part of VDC. The period extending from the start-up in about September 2017 - late 2017. Measuring 2 shows how the project changes or improves. 13 measures in total. Measure 4 is on the result of phase 1 and 2 focusing on output, the refurbished dwellings. In total 9 measures.

Dimensions to Measure

Following the framework of understanding above, collection of data and qualitative field work is carried out. This covers the following four main dimensions:

1. Company knowledge, 2. customer perception, 3. productivity and 4. real estate economic value.

1. The knowledge in the involved companies is a performance dimension which involves a longer-term perspective. Here ICT will firstly be evaluated how personnel

competence and organisatoric embedded knowledge of ICT-platforms are developed. Second, knowledge is developed in the specific building project. Third knowledge is communicated and shared, i.e. are experiences captured and how are they communicated. Fourth, knowledge about the project material (input) is developed, for example does the actors of the project know, what is expected and what should be produced (output). And where do they seek information. Most of the measures in this knowledge dimension will be qualitative.

2. The customer perception dimension covers the perceived customer value created by the project. This includes satisfaction with the process, evaluation of how the housing association choose add-on optional solutions, a measure of perception of value before and after the renovation project, and finally an evaluation of the impact of renovation on tenants appreciation of quality of life. The measures in this dimension will be a combination of quantitative and qualitative.

3. The productivity measure will focus on the hours spent by building workers on site, foremen and site management distributed on the above-mentioned units. However also hours spent on design, project preparation, management and facility management preparations will be evaluated. The measurement of hours spent will be used to evaluate the units that the renovation is producing including roofs, bath rooms, end facades, staircase facades. In principle, all units valued more than 130,000 Euro will be measured. There is a measure of supply of material including manual work connected to receiving goods. And finally, the costs and investments in IT, software, websites, and infrastructure will be measured. The productivity measure is predominantly quantitative.

4. The real estate (economic) value involves the architectonic value. The value of the renovation for the area. The price augmentation of the estate (including its valuation for taxation purposes). The outdoor areas improvement, and the more symbolic change of a concrete housing district from the 60-ties changed into modern dwellings. The real estate value will amongst other things be evaluated by a real estate broker.

PRELIMINARY RESULTS

Present and Future ICT Infrastructure

19. Present ICT

The present ICT infrastructure comprises well known construction software systems (such as Revit, 2D Autodesk, project web), as well as more generic software (such as ERP used for accounting and material purchasing). The project uses a project web system, where all drawings and documents are stored and shared. The use of spreadsheets is widespread and include control of budgets and project economy. 2D based quality control (QC)-system and digital photos are used a lot, as well as normal email communication. Time planning of operations on site is being done location based on scheduling software used to coordinate and optimize the many different locations and teams to gain better workflows. A major challenge is the many warnings and option lists which is being corrected for the tenants and used by the contractors site management, it is time consuming and hard to grasp.

Future ICT

The future implementation is concerned with integration, i.e. easing the data flows between different actors, data repositories and systems. An essential ICT-optimization to gain better communication and planning between the actors, is the connection between; BIM data, locations, resident journals, options list and graphical

representation of i.e. bathroom types. Location based scheduling is surely a value-adding tool, but the use can be increased by connect time scheduling and the BIM-model. A future planned feature on the construction site is to embed BIM-models and time scheduling (4D). To face the challenge of many different bathroom types and resident options, the contractors are collaborating with the local retailer to optimize the ordering process. The target is to get small and specific units with the right materials and quantity for each bathroom type. Ordered by smartphone tablets.

The Design Processes

In the initial phases, pre- investigations, briefing and interaction with the clients, tenants and housing association representatives was carried out. The architect and engineer companies then elaborated a preliminary project, in compliance with sector agreements, and this project was used for tendering a contractor, which thus became involved in relatively early stage under the banner of early contractor involvement. In the subsequent phase, the main project, was elaborated. The architects chose to operate several partial Revit models of different parts of the building reflecting the areas adopted for deep renovation. For example, a large number of bathroom mock-ups was developed to document the many variants of bathrooms found in the building. The engineering company carried out design of installation, electricity and structural engineering. Revit was used for installation and electricity whereas 2D Autodesk was used for structural engineering. The internal organisation of the project in the engineering company involved a project manager, engineers and technicians that did most of the computer work in the design. The project manager carried out manual collision control, but the test block building revealed more collisions. Some of them due to dimension issues in the BIM models. The architects and engineers carried out design in parallel with the test block building process in 2016.

The Building Processes

From late fall 2015 small parts of the test blocks was made. However, the most of 2016 was spent awaiting final decisions from the client, which in turn waited for clearance for the publicly financed part of the building. By December 2016 it was possible to do the test blocks, which quickly revealed new issues to be solved. The whole building process was a bit delayed over the fall 2016 because of financial negotiations between the residents, the client and the entrepreneur. But still some of the contracts moved on at an increased speed.

Roofs

Especially the roofs, balconies, and the end façade worked out as a fast process. By June 2017 these contracts were about 6 months ahead of schedule. This is partly due to the skilled craftsmen, good management but also new and innovative scaffolding which is movable work platforms that create agility and lower assembly costs compared to traditional methods on the apartments blocks. Exactly the opposite has happened to the rowhouses, where the challenge is total cover of the roof, due to the replacement of the ventilations system. Both scenarios were unforeseen and undiscounted, and it came as a surprise to the management.

Bathrooms

The same issue is added to the bathrooms. The apartment blocks are quite easy to get to know for the craftsmen because the stairwells are equal to distributions to each side. But in the townhouses the types are very much unlike because of the lower heights and a bigger area with many different types and houses over all. A lot of pre-

investigation and registration is going on in the houses before the craftsmen are entering them. This might suggest VDC as a method to gain information in a new way, which could benefit orientation and communication before the craftsmen are entering the houses.

ANALYSIS

The case exhibits many of the specific features of renovation projects in social housing and also on contemporary use of a variant of VDC and BIM. The last aspect first, the project and the participating companies exhibit a fragmented, disintegrated use of ICT in a number of functions and processes. For example, data on the apartment units is maintained by the housing company, yet needed in the contractors planning. There is a non-integrated set of BIM models in play. There is little integration between design models and production planning software. Yet viewed separately many ICT supported elements are clearly in place in the project, such as an active use of location based scheduling. The interaction with tenants, the local housing association and the social housing company has been, what the building professionals experience as lengthy. Negotiations on different elements of the renovation, that should be included or not, continued not only in 2015, but also in 2016, making it hard to determine what the initial specification and budget was (i.e. the input of the performance measure, measure 1). Moreover, when building operations started running in the end of 2016 the interaction changed character into craftsmen directly entering the tenant's home leading to another set of interaction. The main contractor experiences difficulties in timing of demolition and moving of work platforms that made it difficult to comply with early warnings to the tenants. The site management carry out a series of coordination meetings every week, using last planner follow up and scheduling. This is done without ICT-support. Certain units in the building is presently ahead, the renovation of the roofs for example, while others, the renovation of tiles in the bathroom is catching up after a crew of bricklayers leaving the project for another more attractive employment. Finally, another recurrent aspect of renovation is the arrival of surprises during design and building. Here many variants of bathrooms and asbestos plates that has to be demounted in a particular way are examples. Moreover, also the economic capacity and willingness of tenants to invest in improvement of their own apartment came as a surprise.

DISCUSSION AND CONCLUSION

This paper set out to investigate how a VDC implementation can be shaped that prepares for performance improvements of a refurbishment project and how it can be measured? Performance of deep renovation can only cautiously be compared to new build or lighter renovation. It is a central value production for the client that interaction between building professionals and tenants is carried out in a smooth manner. This intervenes directly in the immediate daily building processes. Moreover, despite the active use of location based scheduling, the timing, rhythm of the different crews entering the tenants' apartment is very difficult to manage. During briefing and design the project went through quite some changes. Also, the architects developed experience and knowledge, digital practices on handling partial BIM models and a large number of bathroom variants. During production in phase 1 the contractors use a combination of ICT and meetings to coordinate and assure progress of their own employees and the sub-contractors. This is a digital practice relying a lot on face to face coordination. By June 2017 it is still left to recurrent planning how the

VDC variant will look in phase 2. A series of ICT-support proposals, laying more puzzle bricks into the VDC infrastructure is under consideration. This includes improving the BIM models for quantity take off, ICT-integration of the tenant's choices for the bathrooms, material purchasing alarms in location-based scheduling, 360-degree video filming of apartments, and tablets with building information. Concluding, the investigation of the VDC implementation appear to have improved performance of the refurbishment project and it has been measured what this improvement or change meant. The paper has proposed, first to measure the particular VDC variant in play and second a multidimensional framework for performance including knowledge production and end user valuation. A measurement program has been presented and the preliminary results discussed. In the first run, the existing VDC infrastructure is relatively fragmented, yet performs well on some islands, such as the location-based scheduling and architectural models of bathrooms. The performance challenges of this renovation project mirror many other projects of the same kind within social housing. Nevertheless, a particular performance in the studied context was found. And can in this exemplary manner provide learnings for future projects. It is a hybrid set of factors that lever performance, including intense coordination among contractors, continual communication, interaction with tenants and the craftsmen's learning during production. The impact of ICT is more indirect. It is not technology alone that improves the performance. A pure technological optimism is poorly grounded.

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PRODUCTIVITY MEASUREMENT - THE SOCIAL CONSTRUCTION OF REDUCTION THROUGH EXPANSION

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A recent large-scale measurement of productivity in Swedish construction involved some 880 respondents and around 500 projects. It covers construction costs, lead time, use of manpower and management in the building of office buildings, public institutions, and civil engineering. Measurements were done through questionnaires and telephone interviews, aspects of productivity such as project start and end, project costs, use of manpower, major disturbances in the process. The results showed a remarkable variety of almost all parameters including cost levels per square-meter building and meters infrastructure (roads, bridges). The aim here is to critically scrutinize the construct of such an investigation. What kind of inclusions and exclusions of concepts and devices are made to stabilize the result? What kind of value does it represent for stakeholders? Drawing on Science Technology and Society concepts, such as calculative practices and sociology of calculation, it is argued that the social construction of this investigation actually merely represents an everyday event in a society completely penetrated by auditing regimes. Building up the social network of the investigation, involves negotiation of relevance and rigor. Methodologically the scrutiny builds on self-reflection of the main author of the productivity investigation and interactions with researchers and key stakeholders. There is no more need to be modest about productivity measures, than many other big data bombardments of everyday life. Actually, most productivity measures are built on respondent's interpretation. This goes for national statistical bureaus, but it also goes for most productivity research. "Reduction" is and recurrent in the calculation process. It occurs when reducing the value of a building to square-meters, or the initiation and finalization of a building into two dates. "Expansion" is also in play following rules of large volumes of respondents, but performing in a surprising manner as it produces a representation of large variation in building projects.

Keywords: productivity, calculation, quantitative research, reduction, expansion

INTRODUCTION

Productivity is a central business concept and it receives continual attention in construct management research (Lowe 1987, Chia *et al.*, 2012, Nasir *et al.*, 2014). Some even celebrate it as a holy grail of construction management. It can be defined as the ratio of what is produced to what is required to produce it, the output divided by the input (Slack *et al.*, 2004). However, literature vary widely on how to understand

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and measure productivity (Bernold and Abourizk 2010, Lowe 1987). To measure productivity can be described as a piece of business research (Bryman and Bell 2011). This also means recognizing that the research involves measuring people (Bryman and Bell 2011, Doria 2013, Power 2004). Productivity research moreover borrows concepts and thinking from engineering approaches of operation management (Bernold and Abourizk 2010, Slack *et al.*, 2004). Doing a productivity investigation implies mobilizing business concepts from the field of productivity (Power 2004) and research concepts for quantitative research such as mean value, variance, validity, reliability etc. (Bryman and Bell 2011).

The aim here is to critically scrutinize the construct of such an investigation. What kind of inclusions and exclusions of concepts and devices are made to stabilize the result? What kind of value does it represent for stakeholders? What kind of negotiations has been carried out? Drawing on Science Technology and Society concepts, such as the concept of calculative practices, i.e. to enlarge the notion of calculation to include judgment. (Callon and Law 2005) and sociology of quantification and calculation (Doria 2013, Johnson 2012, Power 2004), it is studied how constructs and devices are mobilized, and why some are included and other excluded. It is argued that the social construction of the investigation actually merely represents an everyday event in a society where all aspects of human activity are covered by auditing regimes. Building up the social network backing the investigation, involves negotiation of relevance and rigor, but also means drawing on the wider context of the measuring. Methodologically the scrutiny builds on self-reflection of the main author of the productivity investigation and interviews with key stakeholders. The investigation process has been very long and the focus here is mostly on the calculation process during analysis and reporting, carried out from September 2017 to March 2018. Two strongly interrelated and synchronized investigations were made, following the same investigation model and research design. They were analysed and reported at the same time. In total 880 respondents and 505 unique building projects. The building and infrastructure investigation obtained answers from 369 projects from clients and site managers. The HVAC investigation got answers from 210 project managers. The contribution of this paper is, that it is one of a few construction management research accounts of the actual process of researching a quantitative investigation. It is a journey into the “soft belly” of science, i.e. into the processes where apparently unambiguous research results are socially shaped (Latour and Woolgar 1986).

METHOD

The study draws on a freshly finished quantitative survey in the Swedish construction industry. The study was carried out by the authors in collaboration with others, but the present analysis builds on an autoethnography approach in the sense of being an autobiographical account (Chang 2008, Johnson 2012). The autoethnography was carried out by constructing a narrative of the research calculation process, supported by document analysis (numerous draft of the central documents; the two manuals, the two analyses and the two reports). Moreover, an ex post mapping of the process from commencing the analysis to finalizing the report, week by week activities was carried out using an excel spreadsheet to organize the different experienced activities. There is a focus on the closest stakeholders: project group members, and the principals, which are two employers’ associations and an industry/university center for management in construction. The analysis was carried out drawing on several levels of hermeneutics (Alvesson and Skoldberg 2009). In an autoethnographic context the critical reflection of

one's own frame of thinking comes to the fore and it has been attempted to link this into broader contexts of research and reflective thinking (Alvesson and Skoldberg 2009, Chang 2008).

It is a limitation that the author was not part of the initialization of the research, but merely the last phase (from October 2017). The report is by April 2018 still to be launched in the broader public and the broader interaction with stakeholders has not occurred yet.

Framework of Understanding

The framework of understanding assembles some of the constructs, devices and processes that are supposed to characterize a quantitative piece of research. The understanding is processual rather than static, drawing on arguments from new sociology of economy, where calculation is performed. Initially a state of the art method book; Bryman and Bell (2011) is used to identify the constructs and devices that characterize the ideal quantitative investigation. Then Michel Callon and colleagues are used to present some of the new sociology of economics concepts usable on the quantitative research process. Finally, we draw on two studies of performance Powell (2004) and Doria (2013).

The ideal quantitative investigation

It quickly surfaces that Bryman and Bell (2011) is not describing one ideal process of quantitative research, but many. Moreover, there is far more concepts and devices offered than an average quantitative investigation would adopt. Bryman and Bell (2011: 168) is themselves explicit about this limitation using Cicourel's concept of 'measurement by fiat', meaning that most measures use assumptions of validity and reliability rather than systematic test. The research method of a quantitative investigation is presented as 11 steps (Bryman and Bell 2011: 155)

Table 1: The process of quantitative research (Bryman and Bell 2011)

Step no.	Activity
1	Theory
2	Hypothesis
3	Research Design
4	Devise measures of concepts
5	Select research sites
6	Select research respondents
7	Collect data
8	Process data
9	Analyze data
10	Findings/conclusions
11	Write up findings/conclusions

During step 5 and 6 the issue of sampling is important. How does it correspond to the selected field? Is it representative? It is usually assumed that the size of sampling relates to its validity. As Bryman and Bell (2011: 194) note "it is the absolute size of a sample which is important, not the relative....Increasing the size of a sample increases the likely precision of a sample". One can talk about the law of large numbers, i.e. the belief that the validity of a quantitative investigation is levered with a higher number of respondents, making research designers inclined to expand their scope of investigation and strive for high numbers of respondents (Bryman and Bell 2011).

During step 7 and 8 the issue of response rate surface. Bryman and Bell (2011) suggests that the response rate should reflect not only the distribution answering/ non-answering, but rather usable answers.

During step 9 this issue of validity and reliability has to be elaborated. Bryman and Bell (2011) point to five types of validity. Here face validity is important, meaning checking whether the measure reflects the content of the concept in question. But also, internal validity that checks whether claimed causality holds, and external validity, which evaluates whether findings can be generalized beyond the specific research context. Finally, Bryman and Bell (2011) mentions ecological validity reflecting whether a study is able to be applied to everyday life. While ecological validity is possibly rarely used, it raises important questions of abstraction and reduction when it comes to productivity studies.

Reliability evaluates the consistence of a measure of a concept (Bryman and Bell 2011). Two main aspect are important here; stability and internal reliability. Stability evaluates whether the measure is stable over time and internal reliability values whether indicators, scales and indices are consistent. A possible risk is the occurrence of outliers, extreme data that might be occurring because of measurement mistake or because they belong to another phenomenon altogether (Rousseuw, and Leroy, 1996),

Also in step 9 choices of form of analysis is made. Bryman and Bell (2011:357) discuss univariate and bivariate analysis. Univariate analysis takes one variable at a time, where bivariate investigates the relation between two variables, interested in uncovering whether there is causal relationship between them. Bryman and Bell (2011) underlines the risks related to confounding relationship and causality.

Sociology of calculations

The new sociology of economy is a research program with many aspects. However here it is the critical sociological examination of calculation processes that are of interest. Callon and Law (2005) discuss calculation as being “qualculative”, meaning that every calculation is tainted with and inseparable from judgements. Calculative practices according to Callon is a range of practices that must be understood as being constitutively open, and which also incorporate practices that are neither rigid nor rigidly predetermined. 'Quantitative methods, qualitative procedures, professional judgments, or the tinkering of daily practice, all of these are qualculative' (Callon and Law 2005: 731).

Qualculative processes can develop in indefinitely many ways and their borders are fluid. Calculative processes also feature valuation; social practices where the value or values of something are established, assessed, negotiated, provoked, maintained, constructed and/or contested (Doganova *et al.*, 2014).

Power (2004) discusses the foundations of measurement in counting practices, and their inherent reductionism. Measuring is made possible through an abstraction from many specific qualities of the phenomenon measured, it is rendered measurable through classification and calibration of quanta of data which reduces/transforms the phenomenon into parameters.

Power argues (2004: 769) that measurement distinguishes itself from judgment or guessing by being independent of who is doing it. Measurements are in principle replicable, impersonal and objective.

Power (2004) also introduce the idea of first- and second-order measurement (meta-measurement). Second order measurement consists of particular institutions of counting and data production, and as related dense networks of calculating experts operating on these numbers within specific cultures of objectivity. In other word calculation processes does not occur in a vacuum, they are embedded in broader societal phenomena. Similarly Johnson (2012) point to the entanglement between identity building of researcher and calculation. Synthesising, when applying the notion of qualculative practices on the research process of quantitative investigation, it is viewed as an entangling and mobilizing of actors and a series of concepts and devices meant to stabilize the results. Some of the more important concepts and devices are replication, reduction, expansion, validity, reliability, uni- and bivariate analysis. In the research calculation practice there is an urge for expansion yet doing it by reducing and abstracting. Moreover, calculation research practices also involve selecting and deselecting devices and concepts. The non-adoption of devices is recurrent and the second order measurement of productivity characterized by the absence, non-adoption of many of the “ideal research process” best practices. One can point to the neglect of resource limitation of the research as a key explanatory factor of the many non-adoptions.

The Counting and Calculating Process of Productivity Measurement

The research design built on an investigation model, made in a previous study (Josephson 2013). It orders a set of features of productivity in construction projects. In a positivist understanding these are factors or parameters. A main property of the model is an ambition to measure productivity as more than cost per square meter. Processual and soft aspects are entered, looking at disturbances during the process and performance of the project organisation members, i.e. the client, the consultants, the contractor, and the suppliers.

The design of the questionnaire led to a set of questions, where most had pre-given categories for answers. However, there were also a series of questions where facts and figures was demanded, as well as some open questions, relating to stated definitions, such as on client costs, and partnering. Finally, a few questions were open without definition, including questions on disturbances and learnings. The design and operation of data collection was done in autumn 2014. Arriving at the preparation of analysis, the project budget had resources for 1000 man hours distributed as 550 hours for an analyst and 450 for a combined project manager, analyst and report writer. On this basis it was decided to focus on the calculation of basis correlation and to not adopt more advanced statistics. Once the data collection was finalized it was possible to establish the response rate. For the building and investigation, the number of respondents compared to the number addresses was at 66%, whereas in HVAC it was 42%. However, these overall figures gloss over a far more differentiated response rate, differing down to the single question. This was tackled by entering the number of responses for each calculation. This practice was used throughout the report. A central decision was to follow a previous investigation to enable comparison. This implies a high level of fixation of calculation and analysis, possibly around 90 %. Given the type of calculations and analysis needed it was decided to do the analysis using Excel and not statistical software packages such as SPSS 4 or SAS. The design of planned calculations followed the previous investigation, but modified it where the research group evaluated that other calculations was needed. The planned calculation was understood as “descriptive statistics”, thus mainly attempting to map simple relations characterizing the field. It was planned to carry out roughly 70 main

calculations, uni- and bivariate and around half of them presented as diagrams with columns in bar charts, and half as tables. A manual was elaborated describing step by step what analysis to do, for example specifying which parameter from each project should be entered in a bar chart or which 1 by 1 parameter relation should be calculated and depicted. The planned number of correlations to be analysed by October was the same for the Building and infrastructure investigation and the HVAC investigation: 32 tables and 35 figures/diagrams, and 30 more were expected. An early control issue was the number of respondents versus number of projects as well as overlaps of respondents and projects. There were thus cases with more than four respondents from one building projects. Most of the control of validity became an issue of “face validity”, going through the data material and evaluating their likeness of being correct. However, the early calculations revealed extreme cases and this triggered further evaluation of validity see below. During calculations a work mode emerged: One analyst did proposals for the various univariate and bivariate analysis and the other validated the calculation and occasionally proposed changes and follow up analysis. Also at this time a third analyst was included in the project team to carry out the HVAC analyses. This was done due to the experience of delay and overrun vis a vis the scheduled deadline. Early in the calculation it was decided to split the calculation according to four types of building; institutional space, groups of villas, offices and infrastructure. Moreover, the manual of planned calculation became an emergent document adjusted and enlarged as the calculation went on. Two main surprises occurred when doing the calculation of a relationship was done. First the occurrence of variance almost any uni- or bivariate analysis came out with large variation in figures. It was maintained to calculate mean and median values even if these appeared less relevant. Second a few projects exhibited extreme responses, i.e. far more man hours spent per square meters and more than 3 hours management time per employee hour on site. An emerging analysis document became a solidifier for the process and gradually transferred into draft reports. Analyzing also challenged the analysts' assumption and common sense when it came to cost of the client, and cost of (processual) disturbances. While cost of disturbance was reinterpreted a factor 100 because of the questionnaire row of questions inferring a wrong metric of the answer, client costs were excluded as responses in many cases were the same or higher than the building sum. The reporting helped establishing overview and triggered further calculations. The report went through around 15 versions. While a large number of methodological insecurity has surfaced during the calculation processes relatively short method sections was elaborated, which however serve as important solidifying devices. At this point the number of total number of univariate calculation and correlation calculations/bivariate analysis in the shape of diagrams has arrived at 59 and the number of tables at 66 in the building infrastructure analysis. The HVAC analysis arrived at 41 diagrams and 43 tables (February 2018). Perhaps not surprisingly, the project organisation experienced a budget overrun at around 400 hours for analysis and reporting. In March and April 2018, first preliminary results and then the final results were communicated. Stakeholders were presented with main results at four occasions. These events established certain claims of the investigations, getting them closer to “facts” and also involves production of face validation when stakeholders questioned or confirmed findings.

ANALYSIS

The analysis does not systematically go through the series of counting control and calculations carried out (Power 2004). Instead a few main points are made. Focusing on replication, reduction, expansion and the wider context of productivity measure.

Replication

It is completely central for the process that it was designed and also carried out as a replication of a previous study. A long set of designs and analysis, i.e. was rendered calculative and concerns of possible inclusion or exclusion could simply be answered by “do it as it was done last time”. But the effect of replication does not burn down to efficiency. Rather the replication works as an expansion mechanism as well as stabilizer. Where the investigation does not live up to “stability” in a Bryman and Bell (2004) fashion it certainly does in a Callon and Law (2005) fashion. Where traditional quantitative research claims stability, Callon and Law (2005) expects this to be a process and an answer to open questions about where the calculation negotiations might take the stabilization process. Apart from processual stabilization, the replication even performs other effects. Especially during the planning and processing of the analysis, there were an inclination by actors to follow the previous investigations proposals as presented and communicated. A mechanism that can be labelled the power of default (author reference). Even if the adoption led to a number of worried questions as to whether to do the same, it was frequently done so.

Reductions

Throughout the process a number of reductions were carried out, reducing the value of a building to cost per square-meter, the value of a road into cost per kilometres, the initiation and finalizing of a building into two dates, And reduction through transformations such as to transform support from a headquarter to a construction project by measuring the number of man-hours spent in the contractors headquarter on a given project. And to transform the performance of the project organisation into measuring selected project participants understanding of each other's performance

However less reductive measures were also employed. The questionnaire used, also had open questions, such as “mention your largest disturbance in the building process” or “what was your main learnings of the project? Asking open question like that opens for a plethora of types of experiences, providing several surprises compares to implicit hypothesis in the research. However, it should be noted that the very situation of participating in a telephone interview and filling out a questionnaire is abstracting from the lived practices of the respondents (Bryman and Bell 2011). The reduction mechanism also relates to as to whether a respondent is fully articulate of his/her lived experience. The exercised reductions point to however, that it is not reduction per se which is problematic but rather the trustworthiness of the reduction, related to ecological validity (Bryman and Bell 2011), i.e. does the reduction appear plausible, which links into the second order of calculation (Power 2004) see below. One can bear in mind the anecdote of the Chinese map makers, which decided that the best map would be at 1:1 scale. It is this important to distinguish reduction from reductionism. The question about internal validity, i.e. whether claimed causality holds, confronted the research with the dilemma/ challenge of replicating a previously done research model. This model contains a series of implicit hypothesis about how productivity is produced and what factors influence it. These were reflected upon one by one, but most calculations were reproduced, and doubts and deviances articulated in the written interpretations that accompanies the calculations in the report. It was

not attempted to evaluate the external validity which qualifies whether findings can be generalized beyond the specific research context. And this is only one example of a series of non-adoption of devices: explicit hypothesis, confidence level, calculated variance, instruments for bivariate causality analysis etc. This actually illustrated a Callonian fluidity, i.e. a plasticity of concepts, as it appeared as a choice to be made, whether or not to adopt the devices. However, Power (2004) would probably claim that the second order of calculation; institutionalized ways of calculating productivity was performing here. Indeed, other productivity research internationally (Bernold and Abourizk 2010, Bröchner and Olofsson 2006, Chia *et al.*, 2012, Crawford and Vogel 2006, Nasir *et al.*, 2014) does not represent a remarkably different exercise or level of rigorous methods of research. Indeed, the adopted level of use of these concepts are probably aligned with the international productivity research and measurement community, or more important; the authors of this investigations assumes this is case, and thereby stabilize their own analysis with this assumption, which in turn tend to stabilize over time if not challenged. By neither choosing a standard tool for the e-mailed data collection, like survey monkey nor for the calculations like SPSS 4 or SAS, the calculation process became more open and deliberate constructing. The software packages represent strong devices in a calculation, as the software provide strong proposals for the calculations as default. The calculation process thus cancelled this form of power of default (Koch 2010), i.e. power of pre-set parameters.

Expansion lead to “performing” variance

Paradoxically by enlarging the number of respondents a landscape of enormous variance of building processes was produced. An example is the building and infrastructure types. Roughly speaking the 500 projects needed to be grouped in 20 piece groups when it comes to types such as schools, villas, bridges, pipelines etc. Variation in the calculation of costs showed differences between highest and lowest measure higher than 50%. So while it was expected to underpin one type of ecological validity, about productivity figures what turned out was another ecological validity; a representation of near-uniqueness of the building projects. So, while the research design assumed that by expanding to the 500 largest projects in Sweden in 2014 would imply stability in the data, this did not perform. It can be discussed whether the outliers, the extremes should have been let out. Outliers can be defined as data that deviates significantly from the rest, as if it were generated by a different mechanism (Rousseeuw and Leroy 1996). The outliers did get extra attention and the validation did lead to deleting some of them. However, cases of extreme cost are not seen as belonging to another phenomenon as suggested by Rousseeuw and Leroy (1996). Rather in some cases it was interpreted and stabilized as confirming a pattern of a few extreme project in the field of Swedish building projects.

Productivity in a wider context

Along with Power (2004) we would claim that the analysis calculation process is not carried out in isolation. Quite the contrary; it interacts and entangles not only with other participating project members also working on the investigation, but with a research community nationally and internationally, the societal institution commissioning the productivity measure etc. In what Power (2004) calls second order calculation. Particular institutions of counting and data production, operating in dense networks of calculating experts on these numbers within specific cultures of objectivity (Jones 2012). Construction Excellence in an UK context is an example of such an institution, but the institutional presence of productivity measures in a sense merely represent an everyday event in a society completely penetrated by auditing

regimes, i.e. measuring cuts across almost all spheres of contemporary life (Doria 2013). Not only so, they all represent reduction of qualities of social life and many involve limited rigour viewed from a research point of view. What kind of value does it represent for stakeholders? So far relatively few interactions have been done. On this limited basis it appears that the investigation will trigger debate and dissent as much as consent and alignment. The “variation” point and the occurrence of extreme projects appears to generate resonance among stakeholders. This even alludes to another aspect of calculative practices, namely the “symbolic” and aesthetic strength of visualized figures (D’Adderio and Pollock 2012). Here the visualisation of variance and extreme projects occur in coloured diagrams. This stabilization phenomenon has not been possibly to study systematically yet. Nevertheless, there is no more need to be modest about productivity measures, than many other big data bombardments of everyday life. Actually, most productivity measures are built on respondent’s interpretation. Of course, this goes for national statistical bureaus, but it also goes for most productivity research. Therefore, criticism of this method and speculation on that respondents have misunderstood, misinterpreted etc., are prone to occur by this investigation as well. Thereby the likely entanglement with stakeholders is possibly more ceremonial as a celebration of the importance of productivity.

CONCLUSIONS

The aim of this contribution was to critically scrutinize the construct of a quantitative investigation, viewing it as a process of calculation and stabilization. The framework of understanding drew on quantitative research method and new economic sociology. A series of reductions was made in the investigation process, making the researchers and the stakeholders uneasy. However, it was claimed that it is not reduction per se, but rather the trustworthiness of the reductions made that are important. In other words, reductions are a necessary research tool and reductions is not reductionism. The device of “expansion”, including more data in the investigation targeting the 500 largest projects performed in at surprising manner. It was expected to underpin an ecological validity, but turned out as a manifestation of near-uniqueness of the building projects. So, while the research design assumed that by expanding to the 500 largest projects in Sweden in 2014 would imply stability in the data, this did not perform. Rather another representation of the Swedish building sector occurred, namely the narrative of the unique building project with remarkable outliers. The analysis reveals the generation of data, the control of data, the calculation done upon them and their communication in “stabilized” report form as a pretty recurrent calculative practice. The processes exhibit fluidity as predicted by Callon and Law, even if stabilization devices such as replication, reduction, validity, univariate and bivariate analysis were enrolled into the calculation processes. Measuring productivity is indeed about human and non-human interaction, and cannot as operation management want to think it, be reduced to measuring systems of building processes.

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CEOs NARRATING LEADERSHIP: CONSTANT GARDENERS, TEAM PLAYERS, ACTIONABLE PRAGMATISTS AND BUSINESS DIRECTORS

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There is an increasing stream of leadership-related rhetoric and training interventions stemming from policy-makers, media and management consultants concerning the 'right' kind of leadership needed in order for industries to meet their current and future challenges. Yet seldom is the concept itself problematised or viewed from the perspective of leadership as it unfolds in situated practice. The purpose of this explorative pilot study is to examine CEOs discursive constructions of their leadership, their ambitions and concerns in their every-day practice. Using a narrative-survey approach, life-stories of 12 CEOs in private construction-related organisations in Sweden were collected and analysed against the backdrop of recent studies of managerial leadership of site managers in construction. Four main metaphorical themes emerged of CEOs leadership: constant gardeners, team players, actionable pragmatists and business directors. These mind-sets showed quite different orientations to those advocated in much of the normative leadership literature. Rather the practices had interesting similarities with the leadership views of construction site managers. The paper contributes with a more nuanced, and maybe humbler, view of leadership at the top, which aligns well with leadership practices on site. We also introduce a novel qualitative research tool and briefly reflect over its viability.

Keywords: CEOs, leadership as process, narrative survey, leadership, Sweden

INTRODUCTION

There is no mistaking that leadership is a hot topic today, more often than not portrayed as the cure to all kinds of ills incurred by modern organisations and societies. The construction industry is no exception. In search of a functioning nostrum for societal and organisational problems, 'leadership' and the 'good leader' have re-gained currency among both researchers and practitioners. A substantial body of this literature tends to be quantitative and normative, postulating generic traits, styles, personalities, qualities and behaviours needed to achieve 'best-practice' leadership (for reviews see e.g. Northouse 2016; Yukl 2008). In much of this literature, leadership is viewed from the perspective of a single, often 'heroic', individual who uses the aforementioned assets to influence employees to execute corporate strategies and goals (e.g. Wood 2005). Moreover, the leader-hero examples evoked are invariably at the top of hierarchically structured entities and are most often

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well-known (famous or infamous) heads of state, religious leaders and sometimes CEOs.

We are also witnessing an increasing stream of leadership theories and discourses that reject the notion of the heroic leader, and which take into account the role and impact of followers and context on the leadership. This stream largely concerns the 'right' kind of leadership aspirations and ethos needed to sustain an ethical and sustainable future in an increasingly complex world, *yet also* tends toward the normative. Some of the most recent theories within this stream are for example: collective and shared leadership (Lawson 2014); blended leadership (Collinson and Collinson 2009); distributed leadership (Gronn 2002); complexity leadership (Uhl-Bien and Arena 2017); authentic leadership (Wassenaar *et al.*, 2015); aesthetic leadership (Hansen *et al.*, 2007); relational leadership (Uhl-Bien 2006); sustainable leadership (Anderson *et al.*, 2017; Chan and Cooper 2010).

Historically, streams and perspectives have shifted (back and forth) to align and reflect changing (Western) socio-political waves, from charismatic 'hero' leader to authentic 'servant' leader, with multiple in-between labels as cited above. However, among this substantial body of leadership theories and how-to recipes, the concept of leadership (and of leader) is seldom problematised. The theoretical abstractions in the leadership literature, stemming from a deep-rooted ideological pre-conceptualisation of the myth of the 'good' leader who saves the world from the evil it faces, permeates all cultures through mythological, religious and folk tales. (Note here that the evil in these contexts is often embodied in a larger-than-life anti-hero, a toxic leader (e.g. Padilla *et al.*, 2007). Thus, there is a deeply entrenched, subconscious, ideological connotation associated with the concept of leadership, which makes it difficult to pin down and discuss 'objectively'. This pre-conceived and loaded subjective meaning is implicitly and unreflectively projected in much of the literature. The problem then is that 'leadership' is discursively inscribed and predetermined *à priori*, before it is practised or theorised. A characteristic which explains the pre-determined, sedimented subjective meaning of the term is that it is an empty signifier, a word which has no signified, i.e. no exact denotation (Laclau 1996). In other words, it 'cannot come into being' in and of itself; it can only be discursively constructed and performed, and then reproduced. As such, it remains an ideal notion, albeit it may shift or float over time and between cultures to take on different meanings in different contextual configurations. Leadership seen from this perspective is intimately tied up with identity (e.g. Ford *et al.*, 2008).

Inspired both by the practice and the linguistic turns in the social sciences, some leadership scholars have acknowledged the performativity and co-constructive nature of leadership as term and phenomenon. They argue that leadership is not a static state manifest in a person, but a processual undertaking, involving leader, followers and several contexts in on-going interaction of co-operation, collaboration and co-creation, accomplished over time through enacted processes, situated practices and dialogue (e.g. Bolden and Gosling 2006; Crevani *et al.*, 2010; Cunliffe and Eriksen 2011). From this perspective, leadership-as-practised, rather than the leader, becomes the focus of analysis, opening up for situated, practice-based research on how leadership is actually accomplished in organisations.

Rationale and Aim of the Study

In the construction-management literature, studies of leadership are usually subsumed under overarching research areas such as culture and/or project management, and

mostly apply trait or style theories and a quantitative approach (e.g. Mäkilouko 2004; Ozorovskaja *et al.*, 2007; Wong *et al.*, 2007). More recently, construction-management research applying a practice lens have provided interesting insights into the day-to-day managerial practices of site managers (Styhre 2012; Sandberg *et al.*, 2015; Sandberg *et al.*, 2016). These studies draw on work by organisation theorists such as Alvesson and Sveningsson (2003), see also Tengblad (2012), who have highlighted a need to re-think managerial-leadership theorising so as to take into account the social-interaction dynamism of the “mundane”, i.e. small acts that managers carry out every day such as listening and chatting, and which are often trivialised in the mainstream literature. Sveningsson *et al.*, (2012: 84) elaborated the notion of mundane leadership, as “influencing expectations, meanings, and values about what is desirable and necessary related to everyday work”.

The mundane leaders described in the above-mentioned literature show flexibility, experience, hindsight, judgment and improvisation, all of which are shown to be necessary qualities for organizational and situational sense-making. Styhre (2012), drawing on the mundane notion, described the leadership of construction-site managers as “muddling through”, i.e. skilfully solving problems as they inevitably crop up, and trying to be everywhere at the same time. Further, based on life-story interviews with site managers, Sandberg *et al.*, (2015) argued that site managers’ self-images and self-expectations (as well as others’ expectations of them) are rooted in masculine norms and values such as self-sufficiency, autonomy, omnipresence, crisis management and overwork, reflected in competencies of planning, problem-solving, and the ability to see the “wholeness”. The site managers enact such masculine orientations and competencies through a role of 'paternal' leader. Löwstedt *et al.*, (2014) found a strong identification mechanism among construction middle and upper-middle managers with the work and workers on site, proposing that the construction-site mind-set is reflected in the boardroom. However, research on CEOs’ perceptions of their leadership in the construction-management literature are scant (for an exception see Chan and Cooper 2010, concerning leader's futures thinking).

In the pilot study described in this paper, our aim was to move from site-managers to explore CEOs' perceptions of their leadership by allowing them to talk freely and choose the orientation and emphases of the conversation. We were interested to test whether the identification proposition held. Moreover, we wanted to evaluate the viability of the narrative survey (Shkedi 2004; Fine 2009) as a methodological tool. We contribute empirically and methodologically to the emergent practice-based managerial leadership literature in construction management by using a novel narrative approach as a tool to elicit 12 CEOs' narratives of their perceived leadership-as-practised in construction-related private organisations in Sweden. Here we offer some interesting insights into the everyday concerns, struggles and aspirations of contemporary construction leaders.

RESEARCH DESIGN

To try and understand leadership as process and practice warrants a qualitative, intersubjective and interpretative approach based on open dialogue between researcher and researchee. Inspired by Fine (2009), we used a narrative-survey methodology Shkedi (2004), which has its grounding in narrative analysis. A narrative approach is posited on the idea that individuals make sense of, and rationalise, their experiences through iterating their life stories (Chase 1995; Polkinghorne 1995). Identities are (re)constructed through the stories people tell themselves; stories in turn convey to

others the values a person espouses, his/her beliefs, attitudes and concerns (Clandinin and Connelly 1998). Life stories are animated; they shift in time and space; and they are populated by human and non-human entities. They are also imbued with contradictions, which become crucial clues for qualitative, interpretative researchers. Through respondents' stories, they are offered snapshots of situated practices such as leadership practices, as in our case.

The narrative survey is a qualitative tool that is appropriate for a relatively small data set, where the purpose of the analysis is to seek characteristics across the data set (e.g. of interviews) in order to link the characteristics found to, in our case, the aforementioned theorising on managerial leadership in general and in construction. In other words, it allows for an analytical generalisation toward the development of theoretical concepts and connections (Shkedi 2004), rather than presenting an in-depth analysis of each respondent's story or to generalise based on the specific data-set population. Similarly to Fine (2009: 186), whose aim it was "to examine (female) interviewees' discursive constructions of leadership [...] to see if women leaders' constructions of leadership suggest new theoretical approaches to leadership", we explore CEOs' discursive constructions of their leadership to seek connections with extant site-manager stories as an initial step toward the suggestion of a new theoretical approach to leadership in construction.

The narrative survey encompassed life-story interviews with 12 CEOs in construction-related large and middle-sized private organisations, the majority of which were constructors. Three of the constructors were ranked among the five largest in Sweden. One of the companies is the largest developer and supplier of building materials in the country, and one is a fairly young and rapidly growing construction project-development consultancy specialising in the development of digitalisation methods and tools such as BIM. The remaining companies consisted of middle-sized to small contractors. The sampling was purposive in that we used our respective contacts to help us obtain access to the CEOs. Upon contact, all the CEOs accepted to be interviewed, and we followed up by sending them a brief description of the pilot study. We stated that we hoped they would consent to a 90-minute informal and personal conversation concerning their career trajectory and achievements, their future ambitions and concerns for their organisation and the sector as a whole.

The respondents included 11 men and one woman, which is deemed a sufficient number for a narrative survey (Shkedi 2004). Two of the respondents, a man and the woman, had been interviewed by us several years earlier for another study, and another respondent had participated in a prior observation study. That these three respondents happened to also participate in the current study was serendipitous and advantageous since we were able to go back and triangulate prior life stories and field notes with their current narratives. The interviews took place in the CEOs' places of work.

To obtain as rich data as possible, we allowed the respondents' retrospective narratives to flow as smoothly as possible only interrupting with prompts to elicit examples or specifications. We asked them to reflect over their career path so far: their background, reasons for choosing the construction industry, what their driving forces were, what a typical day looked like. As mentioned earlier, we encouraged them to speak freely and to choose the orientation of the conversation. The interviews were recorded and transcribed. We drew on narrative analysis in our scrutiny of the transcript, sorting the text into thematic plots, which we could then connect to form

narrative themes and connections across the samples and with previous studies. What struck us were the respondents' frequent use of overlapping metaphors to convey their perceptions of self-as-leader, values, beliefs and affective proclivities. These metaphors enabled us to identify the dominant narrative themes of the 12 life stories.

FINDINGS AND DISCUSSION

CEO Commonalities: Leaving a Mark and Whitewashing the Sector

All of the respondents had chosen a construction career path early on in their lives, many already at vocational upper-secondary school, and had worked summer jobs as craftsmen on site. Eleven had higher-education degrees in civil engineering, real-estate or quantity surveying. A typical explanation for their choice was their attraction to the physical, hands-on and practical features of the sector. They talked about the satisfaction of "actually seeing and touching the outcome of one's creation."

In chemistry you deal with molecules and in physics it is about ones and zeros. I want to be able to see the results ... I want to leave a mark. Not that you don't leave a mark should you succeed in discovering a special medicine ... but I want to see it more concretely, I want to see the result right there immediately ... that is the kind of person I am, it is easier for me to understand and explain if I can point and say: Look! This is how it turned out!

This fascination with the materiality of construction, especially the pride expressed in the achieved product, has been noted in studies of construction site managers (e.g. Raiden, 2016; Sandberg *et al.*, 2018), and is one of the cohesive traits of construction workers' strong collective identification with on-site work (Löwstedt and Räisänen, 2014). Here we see that this identification does indeed follow managers all the way to the top, as proposed in Löwstedt and Räisänen. All the CEOs, but one (a man), emphasised the importance of, in their parlance, "the absolute necessity of knowing the trade through having worked in the mud and done the same job as 'the lads'". This quote and the one above are almost identical to many of the quotes by site managers in previous studies. Not only did their identification with 'the lads' give them legitimacy, the affect toward the object and site of construction may also explain the 'circuit of credibility' and 'economy of reputation' observed among managers and workers in the sector (Styhre, 2010), and which underpins the sector's norms of 'good work'. Noteworthy here is that all the CEOs had remained faithful to the sector even though they had rotated between various Swedish construction companies, and all but two had started their careers working on building sites.

Another common feature among the CEOs, was their agreement as to what the current and future challenges for the industry were. They all emphasised the need to 'wash away' the industries reputation for corrupt behaviour, sexism and racism. They spent efforts on increasing gender equality and diversity, and they all mentioned the need to work more actively with sustainability. The narratives, metaphors and body language of these CEOs revealed that heart formed an intrinsic part of their ethos. The affinity, knowledge and collective identification with the materialities and people constructed a leadership that does not align with the 'grand' theoretical models advocated in the literature (see previous sections) and taught in leadership and management-training courses. Moreover, the CEOs, with one exception, had strikingly similar notions concerning leadership, all of which could sort under 'personal' leadership.

We identified four dominant leadership narrative themes in the data, three of which sort under the umbrella practice of 'personal leadership': constant gardener, team player and actionable pragmatist. A fourth, outlier, theme was business director.

These themes overlapped and intertwined in the CEOs' life-stories, yet we felt that they revealed individual mind-sets. In the following subsections, we discuss these themes and link them to recent theoretical schemas. We start by giving different CEOs voice to verbalise their ethos before we offer a brief analysis. (Note: each quote is by a different CEO.)

Constant Gardeners

I see myself somewhat as a gardener. I take care of different kinds of plants ... and flowers ... and some of them need sun and others need a lot of vitamins, and some may even need to be cropped since they grow too fast. As leader, the better you become at understanding this, the better it will go not only for yourself, but also for the company. Because I'm only one person, but if I can get others to bloom and grow, well then, I'm doing a good job.

You have to be a friend. You must be trusting and trustworthy, and you have to take care of that trust. Once you have reached such a state of confidence, then you can start addressing other issues.

The most important resource is our employees. As such it is up to me to check [keep track] how the employees are feeling, where we stand, and what we need. It is incredibly important to me that this workplace be one in which people feel good and that they feel it is fun to go to work.

For constant gardeners, the collective, consisting of individuals, was central. They saw their most important role as that of fostering. In these narratives, words and phrases like: 'grow', 'bloom', 'trust', 'understanding', 'feeling good' and 'fun at work' were iterated. The most common metaphor here was by far the growth metaphor, the notion of seeing and helping individuals grow, which they communicated to us not only through their talk, but also through their body language. Since these particular quotes were voiced by male CEOs, it is easy to associate them with the paternalism observed in studies of site managers' work (e.g. Sandberg *et al.*, 2016; Styhre, 2011), which in turn could be associated with patriarchalism. As we see it, the fostering expressed here has more to do with an ethics of care, which has been theorised as a feminist construction (Fine, 2009) of leadership (see also discussion in Sandberg *et al.*, 2018). Our CEOs also showcased male role models with similar ethics of care, who had mentored them, and who they tried and did emulate.

Team Players

As a leader, you should never say 'I did!' It is always 'we' who did and 'we' who decided. As leader you ought never to address others in 'you' terms, especially not in problematic situations. When you do, you situate yourself outside the hockey rink ... and that does not work. The match takes place down there not in the stands. This is extremely important.

In terms of [organisational] changes, we try to be extremely involving. It isn't so that a few 'intelligent' people gather somewhere and proclaim that now we will do so and so ... rather, change takes more time ... and it really involves a large number of the employees.

Team players tended to resort to sports metaphors to express their meaning, as in the hockey metaphor in the first quote above. These CEOs emphasized how they were just "one of the team". They wanted to de-emphasise and de-dramatise traditional hierarchical structures and foreground the importance of the well-functioning team. Common expressions here were negations like: "not seeing oneself as better than others", "absolutely not sit on a high horse", "being devoid of prestige". Lack of prestige was a familiar leitmotif for us; we have heard this phrase so often over our many years of studying managers in construction. Even though these may not always

practice what they preach, we nevertheless interpret 'lack of prestige' as not only an organisational aspiration, but also a Swedish trait.

Actionable Pragmatists

You have to be determined in this sector, able to move ahead. Demonstrate grit!

I have very little patience with people who think too much and don't arrive at a resolution.

Another thing is simplicity, simplicity, simplicity ... simple messages. What are our three top priorities? It must not become too difficult or complex because then people spend too much time thinking ... so try and make things as simple as possible!

I usually say KISS: 'Keep It Simple Stupid' ... joking apart ... I believe in simplicity, simplicity, simplicity. I try to stick to three items, the three most important ones. Only three things.

There is no doubt that the key word for actionable pragmatists is simplicity. The pragmatist CEOs were mainly situated in middle to small companies and were those whose discourse and practice aligned most with the discursive construction of leadership by site managers (Styhre 2012; Sandberg 2015; 2016). These CEOs seemed to embody the characteristics of self-sufficiency, autonomy, omnipresence and on-the-hoof problem-solving abilities that Sandberg *et al.*, 2015 identified in site managers. Apart from 'simple' and 'simplicity' these CEOs often used the Swedish idiom: 'ordning och reda', which if translated would be 'order and order'. This obsession with order is also voiced in a need to be 'clear', 'straightforward' and 'simple' in one's communication.

Business Directors

Only one of the CEOs expressed a mind-set, concerns and aspirations that sharply contrasted with the other respondents, and may be said to be the exception that proves the rule. In other words, it is through this example that the organisational logic behind the leadership thinking above is offset and understood. The business-director ethos and practice in the narrative of this CEO were foregrounded in almost every utterance he made. While all the other CEOs seemed to genuinely enjoy talking with us, even going over the stipulated 90 minutes, this CEO announced that he could only give us 60 minutes at the most. In other words, right from the start, he asserted his right to decide. As can be seen from the quote below, he seemed to distance himself from the personal leadership mind-set that permeates the Swedish construction sector, making it very clear where he stood and what kinds of changes he considered imperative in order to make construction more effective and productive. Interestingly, this CEO did not have a typical construction background as did the others whose trajectories started on building sites.

It's all about business. The people in this trade are good at building, but not as good at projects or doing business. In this respect, higher education has neither been able to redirect [courses] nor had it understood changes that are afoot. A change that we must prepare all our employees for is that we shall go toward better planned and governed projects. This in turn means that we cannot have people who see it as their vocation to be their own problem solvers down at those levels ... because that in turn means that we have unsolved problems at the higher organisational levels. With better organisational processes there is no need for individual problem solving on the lower organisational levels. Rather than that a site manager be a creator, he [sic] only needs to be an assembler ... to be a performer of actual [already in place] effective processes.

CONCLUSIONS

In this paper, we have offered some snapshots from 12 construction CEOs' perceptions of their leadership practices. We used a narrative survey approach on the rather small data-set to explore CEOs' discursive constructions of their leadership and to find connection to conceptions of site-managerial leadership in previous studies. We found that the CEOs leadership ethos and practices sorted under four main themes, three of which aligned with site-managers' discursive constructions in previous studies, and the fourth being an outlier. Although deeper analysis and more respondents are warranted for further theorising, the data seem to support the proposition of a strong identification among CEOs with construction managers and workers on site.

As construction-manager researchers, we have become used to reading about how traditional, conservative and reactionary the construction sector is. These images, however, are not reflected in the personal leadership narratives that we have depicted here. Rather, the leadership practices of the CEOs show many of the modern leadership aspirations reported in recent studies such as sharing and delegating, seeing to the collective, ethical caring and presence, and fostering new generations, to name a few (e.g. Anderson *et al.*, 2017; Fine, 2009; Uhl-Bien and Arena, 2017). The personal leadership and relation-oriented practices that they describe seem well adapted to the particularities of a project-based sector in which power and responsibility have hitherto been distributed among regional and district managers as well as project leaders. It also aligns well with the depicted leadership practices of site managers (Styhre 2012; Sandberg *et al.*, 2015; 2016; 2018).

However, the business-director CEO saw personal leadership as a threat, hindering the sector from dealing with its current and future challenges. For example, the goal of increasing productivity and decreasing costs, which were his main concerns, are not feasible in a climate where employees are given as much freedom as they are in construction. The sector must standardise its processes through industrialisation, and for this to happen formal structures and hierarchies, better targeted organisational goals and strict follow-ups are necessary. This leadership narrative evoked much of the rhetoric in mainstream CEO literature (e.g. Beer *et al.*, 2011; Porter and Nohria 2010) as well as the concerns in calls for modernising and standardising the sector. Since only one of the CEOs expressed such diametrically opposed aspirations and attitudes to the sector, it would be interesting to probe the drivers, both external and internal, of these differences'

The narrative-survey approach enabled us to identify and link empirical elements in the CEOs stories and connect these to conceptual ideas and preliminary propositions in previous research. Much more work and more in-depth narrative analysis are warranted for further theory development of construction leadership. It would be interesting to delve into the implication of leadership genealogy to better understand processes of leadership and leader becoming, leader-follower-context influences and tensions, including gender and diversity issues. Suffice it to say here, genealogy matters!

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BUILDING MAINTENANCE COST PLANNING AND ESTIMATING: A LITERATURE REVIEW

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There always exists budget constraint and competing priorities in maintenance needs for existing buildings. The purpose of this article is to conduct a critical literature review on: various maintenance types; and existing maintenance cost estimating models to develop a framework for maintenance budget allocation. A comparative study of current categories in maintenance works and maintenance cost models identified crucial factors that are considered in the decision-making of maintenance cost. Preventive and corrective are main strategies for building maintenance. Performance of these strategies suffers from the allocation of the maintenance budget. Cost estimation models for the different types of maintenance have not been developed yet since lack of a reliable data system. The findings highlight the importance of information system to support inspection building condition, monitor maintenance works and recorded data of building maintenance.

Keywords: cost estimating, cost planning, maintenance management

INTRODUCTION

Building maintenance is considered as a major activity in the construction industry because it is essential whether the buildings are large or small, simple or complex, located in urban or suburb. They must be well maintained to ensure their functionality and services during their life cycle. Traditionally, maintenance is defined as work on existing buildings undertaken to keep, restore or improve every part of a building, its services and surround to its original level and not to fall below the minimum acceptable level (British Standard 3811, 1993). Over the past, stakeholders of building asset have required the outcomes of building maintenance to meet certain criteria including re-instating physical condition to a specified standard; preventing further deterioration or failure; restoring correct operation within specified parameters; replacing components at the end of their useful/economic life with modern engineering equivalents; making temporary repairs for immediate health, safety and security reasons; and mitigation of the consequences of a natural disaster and assessing buildings for maintenance requirements (Queensland Government 2, 2017). Maintainability is an inherent characteristic of system design and installation with major maintenance implications as follows (Dell'Isola and Krik, 2003).

- The choice of exterior and interior finishes.

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- Selection of light fixtures, floor covering materials and interior elements.
- Plan for and implement a maintenance program.
- Perform most or all maintenance with full-time staff, or to contract for the services.

The quality of maintenance activities is significantly influenced by the amount of budget allocated. A common challenge is recognised in allocating maintenance budget with the argument during the process of formulating the maintenance funding (Lee and Scott, 2008). It is evidence that the cost of all maintenance works annually will exceed yearly budget and then the decision makers have to decide which tasks should take priority this year to maintain the building within the funds available and what could be delayed to the following year (NWS Heritage Office, 2004). Therefore, a proper maintenance cost plan would enable building owners to get optimal of maintenance outcome.

The cost plan will provide an available maintenance budget distribution among the elements, functions, or floor areas of the building resulting in providing a work breakdown structure and a cost breakdown structure that will help to control and monitor the maintenance cost (RICS, 2015). Cost estimation methods are vital components in determining the expenditures using in maintenance strategies and plans. Overestimation or underestimation of maintenance cost could affect negatively on decision making of the hierarchy of maintenance tasks as well as prevent using the maintenance budget effectively. However, preparing estimates for maintenance cost allocation is depending on various factors that makes the task to be complicated and challenging (Shah Ali, 2009). Although there are different approaches to estimate the cost, each method has its limitation to different types of maintenance works (Haroun, 2015; Raiborn, 2013; Maher *et al.*, 2011).

This study will analyse different methods to calculate maintenance cost to find out the better alternative for building maintenance costing. To achieve the aim, the paper tries to provide a systematic overview of maintenance work classification and existing cost models using in estimating maintenance cost. Based on an analytical comparison between these approaches, future work for cost planning and estimating for the maintenance is proposed appropriately.

LITERATURE REVIEW

Maintenance Work Types

Maintenance can be categorised according to answer questions why and when it happens. Figure 1 below present a summary of categorisation of maintenance work classification which enables organisations to provide consistent services to customers' satisfaction. There are two common terms of maintenance types: planned/preventive maintenance and corrective/unplanned maintenance with other categories as shown in Figure 1. Commonly, planned/preventive maintenance aims to prevent major breakdowns to ensure a building continues at peak efficiency through regular inspection and repair (Madureira *et al.*, 2017). Preventive maintenance is planned, based on cyclic maintenance actions such as cleaning, local repair and local replacement/treatment to prevent deterioration in advance (Ruparathna, Hewage and Sadiq, 2018; Queensland Government 2, 2017; EU Standard, 2009). Statutory maintenance, time-based, condition-based, predictive, reliability-centred maintenances are sub-categories of planned/preventive maintenance (Queensland Government 2, 2017; Ruparathna *et al.*, 2018; Wang *et al.*, 2014).

Although well-planned, maintenance work must always be ready to respond to unexpected breakdown. Corrective/unplanned maintenance consists of repair and replacement elements due to the failure of preventive maintenance or natural wear and tear that sometimes is called reactive maintenance (Ruparathna *et al.*, 2018; Queensland Government 2, 2017; EU Standard, 2009; Muyingo, 2009). There will be preventive and corrective maintenance work in any maintenance strategies. The planner should ensure that there is no conflict or duplication between reactive actions and planned operation. The proposed planning of maintenance activity should base on the estimated service life of building properties, cost rationalisation and users' satisfaction.

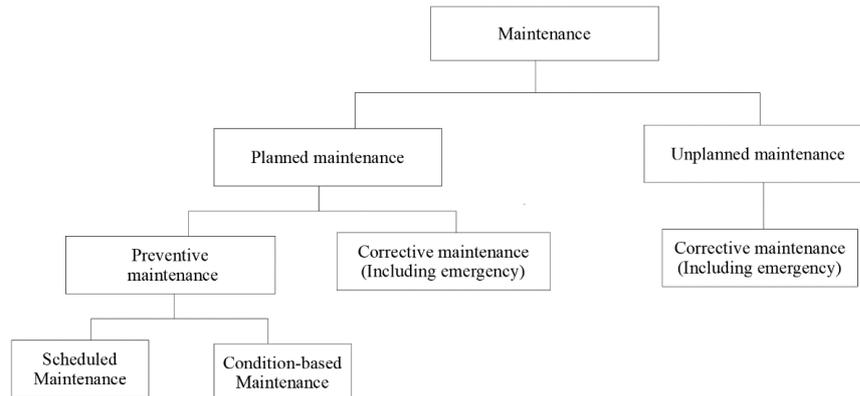


Figure 1: Types of maintenance (Chanter and Swallow, 2007).

The preventive maintenance is justifiable for health, safety and environmentally significant components/items for both items whose condition can or cannot be monitored. The corrective maintenance is appropriate for non-significant components/items and other items which the cost of applying time-based preventive maintenance is less than the cost of applying corrective maintenance (Horner, El-Haram and Munns, 1997). Based on the advantages and disadvantages of the above maintenance types, Table 1 categorises the maintenance hierarchy for building components/systems.

Table 1: Maintenance hierarchy for building components

Type of maintenance	Type of equipment
Corrective maintenance	Small parts and equipment. Noncritical equipment/item. Equipment unlikely to fail. Utility significant items whose condition cannot be monitored
Preventive maintenance	Equipment with known failure pattern. Recommended by the manufacturer. Consumable equipment. Equipment with subjected to wear

Source: Ruparathna *et al.*, (2018).

The overall maintenance plan must provide information to allocate and prioritize sufficient resource and funds for the maintenance operations. The annual list of required maintenance with an estimated cost in the five-year programme usually follows. Alternatively, the repairs will be carried out in order of priority. Therefore, some maintenance will be deferred since the resource is limited. It should be noted

that the buildings will require a certain level of maintenance whatever the current economic situation.

Maintenance Cost Planning and Estimating

Maintenance cost includes all costs of keeping the building up to an acceptable standard. It relates to the direct cost of maintenance such as spares, labours, equipment and tools as well as indirect costs such as administration, management and the inevitable overhead costs (El-Haram and Horner, 2002). When the demands of maintenance are identified, cost of the maintenance should be a prior estimate to measure resource availability and how much work should be scheduled in each period. Although cost estimates for building maintenance are normally prepared over the period to predict the likely cost of such works over the life of the buildings, they can be considered in a single annual maintenance programme. The main purposes of a cost plan for building maintenance are defined as listed below (RICS, 2015).

- Determine the target cost limit for maintaining programme works.
- Inform setting the annualised maintenance budgets and available funding constraint.
- Provide cost information to assist decision makers to make informed decisions.
- Inform what asset investment are funded or not funded and then revise life cycle cost plan.
- Ensure the employer is provided with best value for money from maintenance spent.

Like any program or plan, maintenance budgets will be subjected to change and adjustment and it must be based on forecasting or predicting aiming to best utilise fixed maintenance resource to meet the fluctuating maintenance workload (Al-Fares and Duffuaa, 2009). Total maintenance cost is the sum of the cost of preventive maintenance and corrective maintenance as shown in Figure 2. Having a proper preventive maintenance strategy can reduce corrective maintenance cost, leading to reach optimal maintenance zone. The optimal zone is where the two costs are balanced. Once funds are approved for the maintenance budget, efficient use of this money requires wise internal allocation of the funding at the operational level or locating this optimal zone.

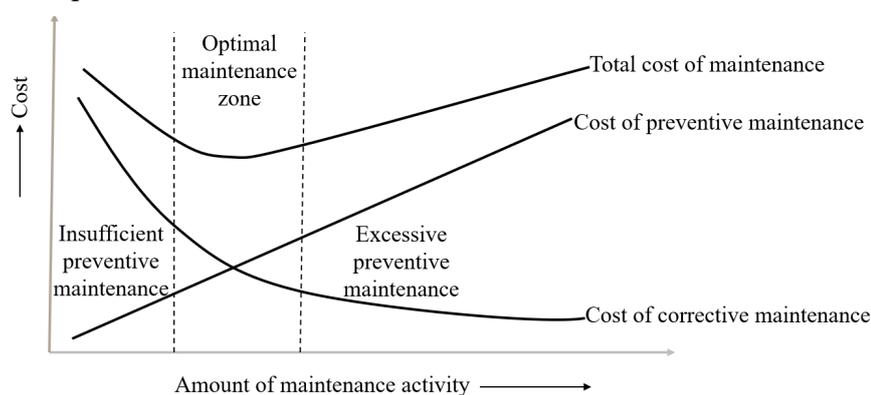


Figure 2: Total of maintenance cost (Douglas, 2017).

Douglas (2017) also summarised five stages in the optimisation process, that should be embedded in the design phase but will offer benefits to any state of a building lifecycle: (1) identify critical functions/elements/areas; (2) understand the failure models and effects; (3) evaluate existing maintenance; (4) apply predict maintenance

technique; and (5) recommend changes to maintenance strategy according to findings of best practice.

Cost planning and estimating of maintenance work require detailed information such as maintenance requirements or the employer's brief for maintenance work throughout the life of the building over the short, medium and long-term. Some agreements remain as maintenance works can be challenging to cost accurately due to lack of reliable information required as listed below:

- Type of buildings/asset/facility and the functional usage.
- Occupancy details: tenure detail, hours of operations, usage of space.
- A statement of building/asset/facility (age of the building, last major refurbishment, etc.).
- Location and building description.
- Aims of the maintenance programme, maintenance strategy.

A limited number of the building components such as roofs, paintwork, woodwork and building services play a large part in maintenance cost (Straub, 2003). Therefore, identifying significant factors affecting the maintenance cost and the relationship between the factors such as building characteristics, tenant factors, maintenance factors, political factors might help to control the factors to optimise the maintenance cost. While planned maintenance works have different technical specifications resulting in differences in requirements for maintenance resource, leading to different approaches to calculating the costs for specific scheduled maintenance work (Mirghani, 2009), the unplanned maintenance costs usually are budget based on historical data showing by percentage of actual breakdown cost and total cost of maintenance.

Existing Cost Estimating Models for Maintenance

Table 2 presents a summary of cost estimating models for building maintenance, which is produced in recent years. Batalović *et al.*, (2017) produced the models basing on historical data of buildings in the University of Osijek to predict maintenance cost models over the periods, which used multiple-regression and Stepwise analysis to identify the relationship between the variables resulting in three models.

Li and Guo (2012) developed research to show how to establish a cost prediction model of maintenance for university buildings in Taiwan that used historical data on maintenance to predict the model, using three different methods: simple linear regression (SLR), multiple regression and a back propagation artificial neural network (BNP). Au-Yong, Ali and Ahmad (2013) established six significant characteristics that are correlated to the cost performance of high-rise office buildings. ASHRAE Owning and Operating database is a database of information on equipment service life and annual maintenance costs for a variety of building types and HVAC systems. The ASHRAE maintenance cost model is based on commercial office buildings in the US aiming at providing accurate and usable building owning and operating cost data to building owners and managers in respect of strategic decisions involving the life cycle and functionality of their buildings.

Table 2: Comparisons of Cost Estimating Models for Building Maintenance.

Project 1	Maintenance cost model for University buildings (Batalović <i>et al.</i> , 2017)
Data Collection and Analysis	<ul style="list-style-type: none"> - A questionnaire survey was conducted to gather information of building characteristics, operational-usage characteristics: building age, number of stories, areas in each function, number of staff, number of students, number of shifts, time used for the purposes and reference period. - Historical maintenance and operation costs for 12 years: inspection cost, life cycle replacement costs, costs of periodic works and repairs, cost of reactive maintenance and operation costs. - The research applied statistical analysis and the application of regression analysis to form a database of independent and dependent variables
Significant variables	<ul style="list-style-type: none"> - building age - number of buildings stories - an overall hallway area
Models	<p>MOC1 = 50356.55 + 101.21*H (€) MOC2 = 133475.30 + 18039 84 * S +89.86 * H (€) MOC3 = 58635.72 + 200.27* B +118.13* H (€) where B stands for building age, S stands for a number of buildings stories, and H is an overall hallways area of building expressed in m2.</p>
Project 2	Cost prediction model of maintenance costs and budgeting for university buildings in Taiwan (Li and Guo, 2012)
Data Collection and Analysis	<ul style="list-style-type: none"> - Historical data on maintenance and repair from four university buildings over a 42-year period There were three assumed models used for estimation: <ul style="list-style-type: none"> - simple linear regression - multiple regression - back propagation artificial neural network (BPN): the maintenance and renovation costs of university buildings have a fluctuation and affected by the LCC, material prices and remedy cost value.
Significant variables	<ul style="list-style-type: none"> - building age; the number of floors; the number of classrooms - the elevators; the structure type; the total floor area
Models	<p>A = 2.6388 + 35.25x - 26.678, where x is the age of a building, and A is total the maintenance costs over the years using simple linear regression B: maintenance cost models using multi-regression B1 = - 4957.1 + 147.84*building age + 774.3*floor + 35.1*class - 34.5*elevator B2 = - 2578.6 + 14.1*building age + 403.6*floor+ 314.3* elevator B3 = - 4812.8 + 147.6*building age + 742.3*floor + 34.4*class B4 = - 3677.7 + 142.9*building age + 683.1 *floor C: maintenance cost model using BPN with the basic structure of the network included hidden layers, an input layer and an output layer with parameters are hidden layers, nodes, loops, speed and momentum factors</p>
Project 3	The findings of relationships between characteristics of scheduled maintenance and cost performance (Au-yong <i>et al.</i> , 2013).
Data Collection and Analysis	<ul style="list-style-type: none"> - This research was conducted using the triangulation approach, which included literature review, questionnaire survey that is recognised as the most appropriate method for data collection, and a semi-structured interview for validation of quantitative results - It was established that five characteristics are significantly correlated to the cost performance, the predictors of maintenance expenditure variance (MEV) included <ul style="list-style-type: none"> - skill and knowledge of labour (SKL), - level of spare part and material stock (LSP), - quality of spare parts and materials (QSP), - length of predetermined maintenance interval (LMI), - amount of maintenance and failure downtime (AMD). The multi-regression was analysed to produce the model
Significant variables	<ul style="list-style-type: none"> - Skill and knowledge of labour - Quality of spare parts and materials - Length of predetermined maintenance interval
Models	<p>Maintenance expenditure variance (MEV) is produced as below: MEV1 = 7.704 – 0.380 SKL – 0.144 LSP – 0.361 QSP – 0.317 LMI – 0.085 AMD MEV2 = 7.286 – 0.423 SKL – 0.400 QSP – 0.324 LMI</p>
Project 4	Maintenance cost model for building services (ASHrae, 2018)
Data Collection and Analysis	<ul style="list-style-type: none"> Various criteria were collected such as characteristics of buildings including location, age, size, height, a percentage of heated and cooled areas, functions, information of in-house maintenance and contract maintenance, and a proportion of preventive, predictive, and corrective maintenance cost - The indexes, base cost, and inflation index are identified from other ASHRAE research.
Models	<p>Total maintenance cost in cents per square foot = [Base cost + (Age adjustment factor x Age in years) + Heating system adjustment factor + Cooling system adjustment factor + Distribution system adjustment factor] x Inflation adjustment</p>

All the cost estimation models discussed above have not considered the type of maintenance that limit the effectiveness of internal budget allocation. Once funds are approved for the maintenance budget, efficient use of this money requires wise internal allocation of the funding at the operational level.

Therefore, with different maintenance strategies, different cost estimation approaches should be applied to calculate more accuracy maintenance costs. According to the Figure 1 and Figure 2, annualised maintenance cost [AMC] can be calculated as:

$AMC = \text{Corrective maintenance cost} + \text{Preventive maintenance cost [1]}$.

Preventive maintenance cost can use traditional order costing to estimate the cost since the maintenance works are scheduled in time, resource and scale. A framework for costing planned maintenance can be referred to Mirghani (2001). Emergency preventive, predictive and corrective maintenance occur randomly, so recorded information about previous corrective maintenance cost plays a vital role to predict the cost for future. The dataset of information should be updated regularly to be used in statistical analysis or simulation such as Monte Carlo method to estimate the uncertain maintenance such as failure by natural disasters. In the scope of this study, there is not any cost model that has been developed for the uncertain maintenance types.

DISCUSSIONS AND FUTURE WORK

This paper has identified the most widely used approaches for maintenance classification of building maintenance. Many researchers pointed out that although corrective maintenance is rational when the impact of failure is rather than small, carrying out the corrective maintenance required performing immediately. Otherwise, higher costs than expected may be consequences when these faults happen in unexpected ways and at the wrong time, causing inconvenience to users and downtime independent components or systems. The authors also stated that preventive maintenance is justifiable if the consequence of fault is high about the cost of doing something that in advance reduces the risk for the fault (Lind and Muyingo, 2012). However, limitation of this maintenance approach is redundant tasks may be carried out or manufacturer's recommendation has limited local conditions and the actual process.

The literature review also indicates that to develop a rational maintenance plan requires both building inspection data and recording data on previous conservation works. Without this information, it is hard to decide on a maintenance policy or estimate the expenditure for a budget. Traditionally, to the asset, the building condition usually by visual only hardly to discover all problems. However, new methods and technologies such as a 3D scanner and Building Information Modelling have not been applied widely yet in the areas. Additionally, failures of maintenance sometimes have occurred since lack of communication between different management levels of maintenance and lack of previous maintenance knowledge of building manager and in-house staff whose responsible for maintenance activities in the building (Yin, 2008; Shah Ali, 2009). One idea can support the issue is knowledge management system which is discussed in Zavadskas *et al.*, (2010). Key questions of the system are what components/systems should be monitor automatically and how to get lesson-learned from previous conservation and similar buildings.

The estimations will not only predict the cost of maintenance but also play an active role in shaping the role construction management which provides input for taking action (Georg and Tryggstad, 2009), The proposed framework for future research is developed by process mapping using IDEF0 method. Akasah *et al.*, (2010) stated that IDEF0 is identified as the most appropriate technique for modelling a process that involves functions and activities as found in the maintenance management process of buildings.

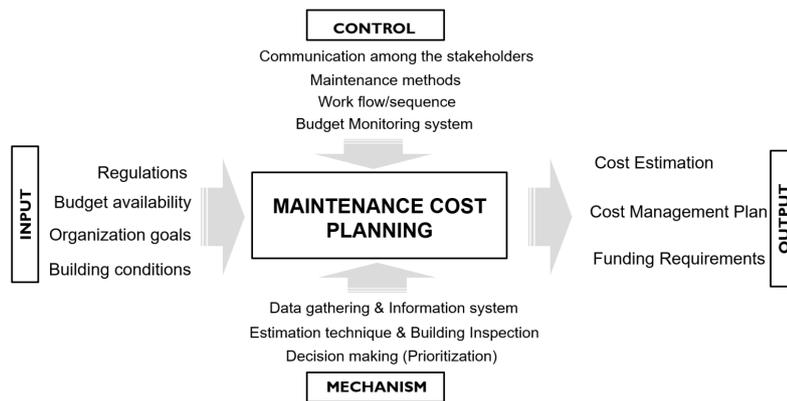


Figure 3: Proposed framework for future research.

In the method, maintenance cost planning is an activity, inputs are the data or objects to be transformed into outputs; outputs are data or objects produced by the activity; controls define conditions require to produce the correct output and mechanism are the means used to perform the activity (Erdogan, 2008). The elements in Figure 3 are proposed based on the literature review. The outputs of maintenance cost planning and estimating is the amount of maintenance cost that considers the dynamic and strategic role of building maintenance. The estimations will also propose cost management plan for maintenance work to get value for money. The cost plan is expected to adjust funding requirements since new and more users and functions/elements/areas can emerge during the service life of the building. Building conditions including innovation design and equipment; budget availability align with organisation goals and regulations such as building act or government strategy are the inputs of the cost plan. There are various factors control the maintenance cost planning and estimating. Well communication of building stakeholders will develop proper maintenance methods which are outsourcing service or in-house staff and maintenance workflow. A budget monitoring system will ensure the process standardised and transparent. Data needed including materials and labour costs, historical data and specifications should be gathered using innovation of information technology for knowledge management. Estimation technique and building inspection methods leading to the certain amount of maintenance cost will help the building owners make informed decisions. The framework aims to develop a cost plan for building maintenance in order to aid building owners to allocate the maintenance budget reasonably, thus allowing them to monitor/control the funding for maintenance in a standardised manner.

CONCLUSIONS

The literature review reveals that maintenance decisions made have a significant implication on maintenance cost. Good estimating of the anticipated cost of maintenance contributes to performing the tasks within the overall period of the budget. Especially in public sector, since almost public buildings use public funding, it requires that effective allocation practices be adopted to optimise the efficiency of the funds. However, lack of the needed data is considered as a reason to prevent the effectiveness. A framework should be developed to assist building stakeholders in inspecting the building, monitor the maintenance, collect and record the required information. Future research focuses on the development of case studies to test the proposed framework. Based on the information provided by the dataset and validated model, building owners and designers should pay more attention to the

components/systems that have a significant maintenance cost and best practice to adjust the current maintenance strategy toward an optimised state.

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FRAGMENTATION OF CAPITAL DEVELOPMENT PROJECTS: A TOOL FOR JOB CREATION AND SKILL DEVELOPMENT

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Unemployment of engineering and the built environment professionals has a negative influence on skill development for technical personnel at the tactical level of leadership. Reflecting on the conference theme, we suggest the use of the concept of fragmentation of mega capital projects into smaller lots and engaging multiple contractors, instead of a single contractor, as a tool to ameliorate these twin problems. This research adopted a single case study method of qualitative research and comparative analysis of the organisational structure of two mega projects (Projects 1&2) in order to examine the quantity of technical personnel engaged at the tactical level in both projects. The findings revealed that Project 1 is being executed using the single contractor concept and engages one set of technical personnel. Project 2 adopted the fragmentation of the mega project into seven lots, each having a set of technical personnel at the tactical level of leadership, resulting in seven sets of employment opportunities, which translates to the ratio of 1: 7. Thus fragmentation of capital development projects can serve as a valuable tool for job creation, skill development and other economic advantages.

Keywords: fragmentation, mega projects, skill development, technical personnel

INTRODUCTION

Unemployment and skill development are twin problems deserving attention in the engineering and the built environment industry, especially at the tactical level of leadership. Several authors have researched these subjects and proffer different solutions, especially focusing on situations in the developing economies (Moavenzadeh, 1978; Rwelamila, 2007). Ianchovichina *et al.*, (2013) advocate the use of infrastructure development as tools for job creation in the Middle East and Northern Africa countries. The development of employable professionals requires the blend of educational training and practical exposure in the real world. Specifically, in the construction industry, the workplace training for leaders at the tactical level of leadership includes ability to design project implementation schemes, scheduling, monitoring and achievement of milestones, quality control, resource management, safety and risk management, and many more (Moavenzadeh, 1978; Rwelamila, 2007;

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Kululanga, 2012). None of these competence levels can be achieved through a one-off site experience. Therefore, the project procurement system and the variant adopted will serve as vehicles for the engagement of many professionals and also guarantee repeated engagements (Awe *et al.*, 2009).

This paper is a comparative study of two mega projects being executed in a higher education (HE) institution in Nigeria, referred to as Project 1 and Project 2, with the objectives of evaluating the effects project management style on the progress of the projects and quantity of the technical personnel engaged in the construction of these projects. Project 1 is being funded from an annual capital allocation from the Federal government, planned for three consecutive years. The project was awarded to a single contractor, and the construction has been going on since 2012. Conversely, Project 2 was awarded to seven different contractors; the project was commenced and completed within the year 2013. The structure of this paper progresses from literature review which provides information on the need for training of construction workforce, the influence of the procurement system and the effect of the mode of execution on the quantity of technical personnel of a typical project. The third section explains the research methodology which was a case study approach using comparative tool for data collection. The fourth section provides information on the research findings, demonstrating how the concepts of single contractor versus multiple contractors were used in the two projects and their net effect on the project success. The final section draws conclusions from the findings and makes appropriate recommendations.

LITERATURE REVIEW

Literature review allows researchers to navigate the efforts of previous research in order to harness existing information, models and methodologies to support new endeavours. The literature reviewed here provides general information on the import of training in the development of the requisite workforce in the construction industry; the role of procurement, the applicable variant and its influence on human capacity requirements.

The Training of Construction Workforce

The role of the construction industry in capital development projects and national economic development cannot be over-emphasised. Several research efforts have suggested that productivity in the construction industry is undulating; some observe that productivity is on the decline; others suggest that it is being sustained by foreigners in some countries (Moavenzadeh, 1978; Rwelamila, 2007; Manuti *et al.*, 2015). Nevertheless, Ene *et al.*, (2016) linked productivity in the construction industry to training: “A 1 percent (1%) overall increase in training days leads to 3 percent (3%) increase in productivity and 16 percent (16%) overall productivity growth” (Ene *et al.*, 2016, 213). Training generally encompasses formal education in technical trades and practical skills. Although there is a high graduate output in the engineering and the built environment (professionals/professions), there are increasingly limited opportunities for practical training and employment for continued experience in the workplace (Rwelamila, 2007; Kululanga, 2012).

Knowledge is a critical part of the learning process. An excerpt of the definition of knowledge gleaned from Ene *et al.*, (2016, 216) suggests that knowledge is an intellectual product or something learned that is acquired by thinking, judging, reasoning, reading, observing and testing. Knowledge transfer through learning is a lifelong process of cumulative components starting with basic education which

provides the foundation for individual development, initial training in core work skills, industry-based professional competence and continuous life-long workplace learning to maintain individual skills (Ene *et al.*, 2016). The workplace training in the construction industry benefits the trainee as it increases the individual's capacity and capability as well as helping the particular construction firm in improving on its productivity and competitive advantages among peers in the industry (Manuti *et al.*, 2015). Laudable as this may be, the majority of the players in the construction industry do not want to invest in training because of the volatile nature of the construction industry and high mobility of construction workers (Awe *et al.*, 2009). However, any little contribution to the training process has significant effects in solving the twin problems of unemployment and skill development in the construction industry.

Achieving the essential project outcomes, in a typical construction project, requires consistent and structured workplace training schemes. Moavenzadeh, (1978), Rwelamila, (2007) and Ene *et al.*, (2016) identified the areas of training for the technical personnel in the construction industry in developing economies as including but not limited to:

- Construction project execution design (selecting the most suitable construction method and process);
- Project planning (scheduling, supply sourcing and developing milestones);
- Project management (effective coordination of the different construction processes, effective supervision to achieve quality, milestones, prudent resource management, achievement of company's objectives, communal social responsibilities and effective management of areas of disputes) and
- Safety (mitigate incidents that threaten the safety of workers and visitors to site, conduct safety awareness and training, identify risky situations and prevent their occurrence).

Proficiency in these areas of competence is influenced by the frequency and length of practice. Furthermore, the quantity of technical personnel that can be employed during the development of any infrastructure type is influenced by the procurement system and the variants of the system being adopted (Idoro, 2012; Ogunsanmi, 2015).

Procurement Method and Human Capacity Requirements

The level of success achieved during the execution of any capital construction project is influenced by a combination of factors which include the project procurement method, execution system and especially the quality of the project personnel (Pourrashidi *et al.*, 2017). Some common project procurement methods being used for the execution of capital projects in the public and private sector in many developing economies are the traditional design/bid/build (DBB), design and build (DB) and construction management (CM) systems (Babatunde *et al.*, 2010; Idoro, 2012). Each procurement method has different variants, enabling the client to select the one most suitable for the execution of its project. The project may be executed using a single contractor or many contractors where the project is divided into smaller lots. For brevity, the succeeding paragraphs will provide information on DBB and DB only.

The traditional method of contract procurement can be described as the process where the three phases of design/bid/build (DBB) are treated as separate tasks (Babatunde *et al.*, 2010). In managing the three separate phases, there is a fourth dimension which plays a mediatory role: the client. Adopting the DBB system requires adequate

quantity and quality of human capacity in every phase of the project, by both the client and project execution team (Escamilla and Ostadalimakhmalbaf, 2016). If the client decides to adopt the variant of using a single contractor to execute its capital project, the project personnel at the tactical level of leadership for both the client and the contractor will be one set of technical execution team (TET) from the engineering and the built environment professionals (architects, engineers, builders, quantity surveyors and others). However, if the client adopts the variant of fragmenting a mega-capital project into smaller lots, the contractor executing each lot will require adequate numbers of TET professionals for the execution of its role, while the client may maintain a set or multiple sets depending on the number of projects being executed at the same time.

The design and build (DB) procurement system integrates the fragments of design, bid and build under one contract which allows the contractor to be involved in the project from inception through to completion (Idoro, 2012). There are different variants of the DB system. Two among many variants, identified by Idoro (2012), are considered relevant to this research:

Pure DB: both the design and construction team are within the same organisation, commonly referred to as a 'consortium'.

Partial integrated DB: the consortium invites other consultants or contractor(s) to execute specific or specialised functions within the project.

An optional third variant is where different organisations (consultants and contractors) conglomerate to form a consortium, using the instrument of a memorandum of understanding (MOU), similar to the one used in alliance contracting (Jefferies *et al.*, 2014). In this regard, the collaborating consultants and contractors function in their areas of expertise. Generally, during project execution, in variant 1 a single contractor is engaged, thus requiring a single set of engineering and the built environment professionals at the tactical level of leadership. However, in variants 2 and 3, multiple contractors are engaged, and each contractor employs adequate numbers of the TET professionals at the tactical level for the execution of their portion of the project.

Project Management Style and Contractor's Performance

The project management style of any construction company has great overarching effects on the performance in a construction project. The management style includes relationship between strategic and tactical leaders, demonstration of capacity to perform, and respect for the company's image and financial management. There should be symbiotic relationship between the strategic and the tactical leaders on site in order to effectively monitor compliance with schedule, resource management and meeting of the quality goals of the project (De Carvalho *et al.*, 2015). Rafat and Ahmed (2017) emphasise the need for "project sponsors and top management to reshape their project management strategy and allow for low power distance between management and project personnel for timely completion of projects" (Rafat and Ahmed 2017, 166). In the management of project 1, it can be observed that the strategic leaders are literally distanced from the tactical leaders. This is obvious in the attendance list of critical project and site meetings, as well as the complaints of the site operatives that their leaders in the head office have not responded to their request for fund or materials. On the contrary, in project 2, (as observed from the minutes of site meetings) one strategic leader, in the rank of a Director, usually attends the site meetings and periodically visits the site and holds meetings with their TET personnel.

Periodic meetings between strategic and tactical leaders are inevitable; such meetings allow both sides to keep abreast with the realities on the construction project, deal with problem situation(s), mobilise adequate resources to the site for effective operation and allow the strategic leaders the opportunities to correlate progress reports with actual performance or challenges on site (De Carvalho *et al.*, 2015). However, when there is a disconnection between the strategic and tactical leaders, which was obvious in project 1, project performance and progress will lag behind schedule.

Alzahrani and Emsley (2013) cited a company's image as a critical attribute which influences a contractor's performance on a construction project. Although the company managing project 1 has an attractive profile, is engaged in on-going mega projects in other parts of the country, and has a history of completed projects, their image management is not satisfactory. Williams's (2015) sense of image management placed emphases on "the company's sense of locality" (Williams, 2015, 109). In this regard the organisation cares about the client being served; this produces a sense of image projection and hence a motivation to keep promises and leaves a legacy beyond the project being executed, which could encourage the client to engage the contractor for subsequent projects in the future. This feature was aptly demonstrated by the contractors that executed project 2 and not by the contractor handling project 1.

Literature is awash with information on the critical role of adequate finance in project success. The discussions include the financial capability of the contractor, financial difficulties of the client and slow payment for completed work as some factors responsible for project delay (Bagayal and Song, 2016). However, very little search light has been focused on the financial management strategy of the contractors. Two components of this financial management strategy are the willingness of the contractor to source for additional money or invest substantial portion of the earnings from each payment certificate into the execution of the project. At the commencement of each capital project, the contractors are given a mobilisation fee. Unfortunately, many contractors see this money as part of their profit and do not spend it wisely. The reality is that this is loan from the client, which will be recovered progressively from each succeeding valuation. If within the first fifty percent (50%) of the project, the contractor is not willing to source for additional funds as well as invest a substantial portion of the earnings from each certificate into the project, when the portion of mobilisation fund is removed, the net value of each succeeding certificate continues to reduce; this negatively affects progress on the construction exercise. Conversely, if the contractor sources for additional funds and invests substantial portions of earnings from earlier payment certificates, the net value of each succeeding certificate will be increasing and make positive impacts on the progress of work.

From inception, the contractor handling project 1 has demonstrated that he lacked the capacity to perform, was not willing to source for additional funds or invest any substantial portion of the earnings from each payment certificate on the project. This led to reduced performance and reduced the value of succeeding payment certificates, and thus they were not able to use substantial portions of the funds made available for the first and second year. The institution obtained a special grant of Three hundred million naira (N300 million) in 2017, in order to fast-track the execution of the project and the contractor promised a performance which will qualify them to draw a minimum of Forty million (N40 million) naira every month. But eleven months into the year, the contractor has not been able to draw more than half of the available funds. On the contrary, the contractors engaged in project 2 supplemented their

earnings from each certificate in the first fifty percent (50%) of the project with additional funds, which facilitated increased earnings in subsequent valuation and enabled them to keep pace with their project timeline. Irrespective of the funding pattern, both projects were adequately resourced; but the contractor handling project 1 has low capacity to perform. However, if project 1 had been fragmented like project 2, the project would have been completed, provided employment and training opportunities for tactical leaders and the client would have had value for the money invested in the projects.

There is sufficient evidence in the literature reviewed that capital development possesses great potential for gainful employment and the variant of the procurement system suggests where the higher quantity of the technical personnel at the tactical level of leadership lies. The focus of this paper, therefore, is to demonstrate how fragmentation of capital projects into smaller lots provides more employment opportunities for technical personnel at the tactical level of leadership, compared to adopting the single contractor approach.

RESEARCH METHOD

The single case study method of qualitative research was adopted (Yin, 2014). The case study method is seen and employed as a research strategy dealing with specific issues, it allows for intense observation, provides opportunities to study different aspects, puts each part in relation to the environment where they operate and tasks the creativity of the researcher to provide 'voice to the voiceless' (Braun and Clarke, 2006). This method is useful when holistic, in-depth investigation is needed (Green and Thorogood, 2009). The population and sample for the research was the client's representative, consultant project managers and contractors' representatives for the two projects. The data collection tools include interviews, evaluation of minutes of site meetings, and the comparative analysis of the site organisational structure. An interview guide with open ended questions was used to collect information from respondents. The analyses of the qualitative data followed the principle of content analysis (Hsieh and Shannon, 2005). The re-occurring themes which accounted for the success recorded in each project are: the project management style, the variant of the procurement method, the capacity and capability of the contractors, and the quality and quantity of the technical personnel. In order to ensure reliability and validity of data, the information, on the same subject, obtained from the consultants was correlated with the information from the contractors and the client's representatives, by adopting the principle of triangulation (Turner *et al.*, 2015). The analysis of the project organisational structure showed that in Project 1, the single contractor approach was adopted; thus the technical execution team (TET) was limited to one set of engineering and built environment professionals. Conversely, Project 2 adopted the concept of multiple contractors, with each contractor engaging an adequate number of TET professionals in their organisation. The analysis of the project site meetings revealed the capacity of the contractors and their performances in achieving the planned schedule for the execution of their respective projects. The details of the findings and analysis are laid out in the findings and discussion section.

FINDINGS AND DISCUSSION

This section provides information on the projects used for this research, and demonstrating how fragmentation and use of multiple contractors, instead of single contractor, affects the quantity of technical personnel engaged in a typical capital project.

Background of the Projects

The two projects in this research are the construction of the new administrative building, to be known as Project 1 and the construction of a phase of the faculty of Environmental Sciences, tagged as Project 2. Project 1 is a two-storey building with X, Y, Z wings and a central core, in the first phase. The second phase comprises of the construction of a generator house, supply and installation of a suitable sized generator, provision and installation of a transformer, as well as external works and landscaping. Project 1 is being funded from the annual capital budget allocation from the Federal government of Nigeria. The project execution and funding was planned for three consecutive years with the provision of 50% of the project cost in the first year, 30% in the second year and 20% plus fluctuations in the third year. The projects for phase 1&2 were awarded to a single contractor at the sum of nine hundred and seven-five million, eight hundred and thirty-six thousand, seven hundred and sixty-five naira eighty-seven kobo (N975, 836,765. 87) and commenced in March 2012. However, due to the project management style, low capacity and capability, the contractor has not being able to use the statutory and specially allocated funds timely. Project 1 is still under construction (about 65% completion) as of December 2017.

Project 2 is a phase development of the infrastructure meant for the faculty of Environmental Sciences. This is also a two-storey building, divided into seven lots and awarded to seven different contractors. Work in the seven lots started simultaneously in February 2013 and the total contract sum was six hundred and nine million, four hundred thousand naira (N609, 400. 000.00). The project was funded by a special infrastructure development agency of the Federal government of Nigeria. One of the operating clauses of this agency is that all approved projects must be completed within twelve calendar months, in order to enable the institution to access further allocation of funds for other projects. Each contractor developed its timeline; cumulatively, the project was scheduled to be completed within nine months. They worked steadily and achieved the milestones set out in the project schedule and the project was delivered earlier than the scheduled nine months, with cost savings and no compromise on quality.

Comparison of the Human Capacity

The human capacity (Technical) at the tactical level of leadership (both in quantity and quality) is very critical to the successful execution of capital development projects (Rwelamila, 2007). These leaders are the prime movers of the project, translating strategic decisions into practical realities; they coordinate the execution of the project implementation design in order to achieve the project milestones, quality and resource management (Moavenzadeh, 1978; Rwelamila, 2007; Idoro, 2012). Table 1 reflects the quantity of the technical personnel for each project at the tactical level of leadership. The Civil and Electrical Engineers in Project 1 were only on site at critical times in the life of the project. The Civil Engineer supervised the foundation works, the structural frame and roof works then left the remaining builder's works to the architect. In the same vein, the Electrical Engineer supervised the conduit works and visited the site intermittently, as the need arose; he also doubled as Mechanical Engineer. During site meetings, the most regular project personnel at the tactical level were the project manager, architect and quantity surveyor.

Table 1: Quantity of technical personnel

S/No	Project	Technical Personnel At Tactical Level						
		Civil Eng.	Mech. Eng.	Elect. Eng.	Project manager	Builder	Architect	Quantity surveyor
1	Project 1	1	-	1	1	-	1	1
2	Project 2							
	Lot 1	-	-	-	1	1	1	1
	Lot 2	1	-	-	1	-	1	1
	Lot 3	1	1	1	1	-	1	1
	Lot 4	1	1	1	1	-	1	1
	Lot 5	-	-	-	1	1	1	1
	Lot 6	-	-	-	1	1	1	1
	Lot 7	1	-	-	1	-	1	1
	Total	1 (4)	0 (2)	1 (2)	1 (7)	0 (3)	1 (7)	1 (7)

On the contrary, in Project 2 each contractor had a full complement of appropriate technical personnel at the tactical level of leadership. Lots 1, 5 and 6 used builders while Lots 2, 3, and 7 used Civil Engineers to coordinate civil, structural and building works. Each lot had an architect and quantity surveyor. The most senior technical person in each lot doubled as the project manager. All technical personnel remained in the project from inception to completion; they worked steadily with their project timeline and delivered their lots on schedule. As shown in Table 1, the technical personnel in Civil Engineering/Builder, Project manager, Architect and Quantity surveyor had a ratio of 1:7 between projects 1 and 2. Similarly, Mechanical Engineer and Electrical Engineer had a ratio of 1:4. An experience gained in each construction project adds to the learning curve of the tactical leaders.

CONCLUSION

Two critical factors necessary for effective performance in a typical construction project are the project management style as well as the quality and quantity of the technical personnel at the tactical level of leadership. The management style of each contractor will show the relationship between strategic and tactical leaders, the capacity to perform, respect for company's image and financial management. In these four indices of project management style, the contractor handling project 1 was deficient in all of them, while the contractors handling project 2 demonstrated their compliance with the four indices. This data therefore suggests that if a contractor is engaged in a project beyond his capacity, progress in the project will be behind schedule; fragmentation will be a positive consideration.

Considerable efforts are being made in many developing economies in providing formal education to personnel in the engineering and the built environment professions at the tactical levels but with limited opportunities for the practical, workplace training required for skill development. Undoubtedly, infrastructure development is a viable means of providing both sustainable employment and workplace training. Nevertheless, the procurement method and the variants employed for the execution of the infrastructure project significantly influence the quantity of the technical personnel employed in any typical mega capital development project. As shown in this research, Project 1 is being executed through the single contractor concept, which engages one set of technical personnel. Conversely Project 2 adopted

the fragmentation of the mega project into seven lots and each lot had a set of technical personnel at the tactical level of leadership, resulting in seven sets of employment opportunities. If the concept of fragmentation and good project management style had been adopted in the execution of project 1, it would have provided for more employment and workplace training. The project would have been completed and put to functional use. This would have reduced the incidence of delays in the execution of construction projects and ameliorated the effects of time and cost overrun, thus allowing client to make judicious use of dedicated or borrowed funds.

Having demonstrated the advantages of the concept of fragmentation in the development of capital building project, we recommend that this concept be adopted contextually for the execution of other infrastructure projects, such as roads, railways, and electricity generation and transmission structure. This will facilitate generalisation.

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NEGOTIATING AND KNOWING BUILT QUALITY

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This paper focus on the world of creative activity underlying structural designs and progress plans. In the world of practice, “knowing” is embodied in efforts as much as a cognitive precondition for efforts. Each worker and team have to cope with complex situations and solutions where no single contributor has full overview, neither of current and future production operations nor of current nor future functionality. Successfully creating micro-conditions for efficient operations and high quality outcomes hinges on continuous monitoring, dialogue and negotiations. Essentially, production work is an ongoing combinatorial activity, often it is a struggle against stubborn resistance offered by both people and materials. The analysis is based on original ethnographic data and shows that dealing with inaccuracies, errors and contradictions is at the very core of the production effort. Understanding better how high quality operational outcomes are achieved by processing deviations through integrative and complexity-reducing efforts, more is also understood about the potentials and limitations of formal quality systems.

Keywords: building, complexity, integration, practice, production, quality

INTRODUCTION

Building is often conceived of as essentially a straightforward assembly process. However, the simple linearity of operations that we could imagine being brought forth by freezing designs, sorting out sequential dependencies up-front, and diligently carrying out one operation at the time, cannot be realized because this would disregard even the most basic of economic considerations. Real-life construction and building must all the time cope with unforgiving economic realities. The pressures for economic efficiency transforms the production of built objects into a complex discontinuous and non-linear process where the great heterogeneity of elements, dependencies of operations, and the urgency of avoiding waste becomes the *raison d'être* both for a professionalized construction project management, and a considerable portfolio of project management tools and techniques.

This complex process is also the principle reason why administrative quality management systems themselves have to be complex (Ashby, 1958; Bertalanffy 1971). The fundamental thinking regarding quality control, however, tends to be uniform across complex and non-complex contexts. Generally, two issues are considered: First, the safeguarding that those carrying out operations have the necessary skills and knowledge and are placed in work situations wherein their skills and knowledge can be put to use in effective and economical ways (Ballard and Howell, 2003; Bølviken and Aslesen 2017). Second that a proper quality control

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system is in place. Generally, this is taken to mean that output from operations is monitored and that deviations from planned outcomes, formal quality standards and accepted norms are identified and corrected (Winch, 2010, Deming 1982).

There is a vast literature on quality within and outside the construction management research field. Built quality is an integral objective of well-known approaches to process improvement in building and construction, such as integrated project delivery, lean construction and the use of advanced building information models. Standard courses in project management deal with quality systems as a matter of course, and the International Standards Organization has been developing a systematic conceptual framework for quality management.

These approaches tend to consider insufficient built quality as deviations that should have been avoided if only work throughout the stages of a construction project had been carried out diligently and in line with accepted standards, norms and practices. This paper advances what some would say is a contrarian and slightly provocative proposal: Rather than seeing errors and contradictions during building and in the resulting built objects as unfortunate and avoidable exceptions; errors and contradictions are instead considered a basic and unavoidable part of the production processes giving form and shape to any built object. Dealing with imperfections is at the heart of what project based production of built objects is about.

The focus here is on the “sharp end” of project based production of the built environment: the actual building work on-site. One question guide the discussion in this paper, regarding built quality: If errors, deviations and contradictions in project based production of the built environment cannot be explained simply by pointing to human inability or unwillingness to carry out what is suggested in even the best pre-made designs and progress plans, then how can we account for such deviations?

THEORETICAL FRAMEWORK

In the period after the publication of seminal papers by Winch (1998) and Slaughter (1998, 2000) significant new contributions have been added to the literature on construction innovation, as well as on the general production process prevalent in modern construction. Edited books have added to our knowledge of innovation, such as Akintoye *et al.*, 2012 and Orstavik *et al.*, 2015. The particular challenge of complexity in construction has been recognized by many authors (Baccarini, 1996; Brady and Davies, 2014; Cicmil and Marshall, 2005; Gidado, 1996; Hobday, 1998). Often, however, complexity is seen as an unfortunate side effect, for example of political ambition and outside pressures (Flyvebjerg *et al.*, 2003).

Theoretical arguments can be made, that efforts to work complexity out of systems are doomed. Complexity is integral to and unavoidable in large, dynamic systems (Ashby, 1958; Luhmann, 1984). Defining a system generically as a set of related elements (Bertalanffy, 1971), the claim that both a built object as well as the construction project as such are composite systems-of-systems, should be uncontroversial. Both the construction project itself and the built object are man-made associations of artefacts thought of and designed as systems. Unsurprisingly, what is found by observing on-going construction projects in ethnographic field work is that production is carried out by work teams that are dedicated to creating each of the manifold sub-systems (such as the concrete body of the building, and the electrical system), or parts of such systems. These sub-systems either make up the overall built

object, or make up temporary arrangements that are needed in the ongoing production effort (such as scaffolding).

Complexity is a property of systems by which feedbacks and incomplete integration produces non-linearity, unpredictability and risk (Nicolis and Prigogine, 1989). As Luhmann and others have made clear, even if complexity cannot be avoided in large systems, it can be managed. Managing and modulating complexity has the obvious purpose in construction of avoiding catastrophic unforeseeable events, but also to avoid disconnections in operations that seriously hamper production flows (Ashby, 1958; Luhmann, 1984, 2000; Winch, 2010).

By being worked upon and structured, complexity can become more innocuous what regards the essential functioning of a system. Many examples of this is found in safety work in construction, where effects of unintended and unforeseen events have to be mitigated before they occur. The use of personal fall arrest systems is an example of complexity management efforts in this sense.

In the case of the many systems making up the built object, containing complexity entails at least two different efforts: First, reducing complexity by making systems and sub-systems smaller; for instance by standardizing and by reducing the overall number of elements. Second, containing complexity by structuring it. An example of this is when procedural guidelines are implemented to limit the range of variation when concrete is poured on-site. Another example is when learning by doing leads to bespoke designs or procedures implemented ad-hoc during the production process. A third example is modularization, as when prefabricated bathroom cabins are used in a new-build project.

The hypothesis that is explored in this paper is that there is significant overlap between controlling built quality and managing complexity. The interest here is not quality on the level of supplied materials, components and subsystems. The fact that hardwood flooring, tiles, ventilation systems, kitchen furniture, lifts and elevators, and so on and so forth, can be bought in diverse qualities is not considered here. Focus is instead on the production work; on the assembly process going on on-site. The argument will be made that it is in their active reigning in complexity that craftsmen and workers realize the quality of a built object.

METHODS

Background data for the analysis in this paper have been gathered in ongoing construction on-site, in collaboration with a large Norwegian constructor (Constructor V). Case study research was carried out in two construction projects in the years 2008 to 2012, here called Project M and Project S. Descriptive case-study methods were employed (Eisenhardt, 1989; Yin, 1994). The core data for the subsequent analysis, however, were gathered in the more recent Project K, by way of an ethnographic study employing standard fieldwork methods (Bernard, 2002; Miles, Huberman, and Saldana, 2013). Projects M, S and K all produced a combination of residential buildings with some commercial space at the ground floor and underground garages. Constructions were with a basic structure of poured concrete, internal dividing walls made with steel beams and gypsum boards, and outer shells made with standard timber frames, with various prefabricated materials making up the outer surfaces. Roofs were generally flat and fitted with waterproof membranes. These are typical characteristics of many current building projects in urban areas in Norway, and most likely common also in the rest of Europe. Indeed, it was found in all the projects

studied, that suppliers of materials, components and equipment generally were affiliates of international businesses, and products and standards employed reflect standards and regulations worked out on the European and international level.

For the argument of the present paper, findings from project M and S function as a background for the more intensive field work carried out in project K. The general goal of the case studies and the ethnographic field work was to lay bare the systemic nature of the construction projects and the outcomes from project based construction production.

During the fieldwork in Project K, data were gathered both outside, in the construction site among the workers there, and in the offices in which project management was located. Workers were provided with space for eating and resting, and workers were observed and interviewed also in this location. Key people were interviewed in sessions lasting between 1, 5 and to hours and all these interviews were recorded and transcribed. A significant number of meetings of various kinds taking place in the offices on-site were attended, and all of these were recorded, but only one of these have so far been transcribed verbatim. Site visits were carried out every week, often several times during a day and a week. In these visits the researcher observed, had conversations with single people or groups, and pictures were taken, sometimes in the form of short videos. These visits were all logged, and notes taken on observations and the content of conversations.

Through site visits and observation not least of work processes, a nuanced and deep understanding was gained of what was taking place in the building site, both in the production and in the administrative function of the site operations. With the data gathered in the fieldwork in Project K, data was produced for two specific analyses reported in the following. One in which the organization of the project was mapped, and the systemic nature of activities scrutinized. A second analysis was made possible having access to internal meeting minutes from the weekly meetings where foremen, team leaders and other project management representatives discussed ongoing and future work operations, and corresponding needs for managerial action. A particular interview was carried out as a walk-through of a researcher-generated log of critical tasks and observed discrepancies, based on a near-complete collection of meeting minutes from Contractor V that were distributed after meetings during the fieldwork period (about 7 months). In this interview, the significance of discrepancies and contradictions were investigated, reasons for their emergence reflected on, and the ways chosen to mitigate them described and discussed.

Project K Activities and Outputs

In this section, findings regarding the organization of production on-site will be related in terms of activity areas (division of labour) and work groups (that we characterize as activity systems).

Division of labour and the nature of outputs

Researching ongoing production work by way of non-participant observation in the ethnographic fieldwork, it was found that the fundamental principle of the division of labour in project K was systemic. This finding was corroborated by observations of near identical work organization carried out during the case study research carried out in projects M and S. The built objects are created by distinct work teams that are each responsible for creating specific sub-systems of the built object. In project K, the contractors and suppliers involved nearly always had their own dedicated work teams

doing on-site assembly work. This is shown in Table 1, where the right half of the table is the continuation of the left half of the table. There are 3 columns: the contractor or supplier is identified by an acronym (FA, V, etc.) in column 1. Most of the acronyms from column 1 reappear in column 3, specifying what firm actually carried out the relevant on-site work. The middle column is used to explain the area of activity in general.

Table 1: Division of labour

Contractor or supplier	Activity area	On-site assembly by	Contractor or supplier	Activity area	On-site assembly by
Machine Contractor (FA)	Foundation	FA	Door supplier (SW)	Doors	V
Main Contractor (V)	Concrete	V	Membrane specialist (IS)	Roof covering	IS
Formwork supplier (RA)	Concrete	V	Electrical contractor (P)	Electrical system	P
Scaffolding supplier (RA)	Various	RA	Plumbing contractor (T)	Water	T
Manpower Services (AD)	Concrete	AD	Sprinkler subcontractor (S)	Sprinkler	S and T
Steel supplier (NS)	Concrete	V	Ventilation company (BR)	Air circulation	BR
Steel producer (SS)	Concrete	V and SS	Plasterboard builder (GP)	Internal walls	GP
Various suppliers	Concrete	V	Masonry contractor (MM)	Façade, wet room	MM
Main Contractor (V)	Timber	V	Tinsmith company (VK)	Tinsmith work	VK
Sub-contractor (MB)	Timber	MB	Painting contractor (BU)	Surfaces	BU
Timber supplier (SAG)	Timber	V and MB	Flow-floor supplier (AB)	Floors	AB
Various suppliers	Timber	V and MB	Flooring supplier (BA)	Hardwood flooring	BA
Window supplier (LI)	Windows	V	Kitchen supplier (HT)	Furniture	HT
Door supplier (SW)	Internal doors	V	Lift supplier (SC)	Lifts	SC

A key point brought forth from this analysis of specific domains and work operations is that all outputs on-site have systemic properties. Workers relate elements into specific subsystems. Importantly, not only technical subcontractors (plumbing, electrical, ventilation, lifts) produce systems, but that also, for example, the concrete structures, the internal walls, facades and surfacing and foundations have systemic properties: they are designed and created as sets of functionally related elements. A few firms act as pure suppliers of materials, tools, etc. Often, it is the project owner, Contractor K that receives these deliveries and use them in their own work on-site.

Another key finding is that work teams are social groups, often well integrated into collectives marked by high levels of trust and solidarity, but still consisting of people with specialized skills and knowledge. The groups form activity systems, in the sense that the skilled group members deal with specific materials and tools that they themselves generally bring to the site and know well how to handle. The work groups have their own professional informal norms and formal rules pertaining to their

specific domains. Generally, the systems that are created in one activity system (or group) are made from prefabricated, mass produced standard parts, with known properties. There are often well-defined methods for connecting elements into complete, bespoke systems tailored to the particular built object in which it is being created.

Being made from standardized parts and made into well-trying complete systems architectures, there are generally few surprises in the functioning of the completed systems. Provided, of course, that assembly work has been carried out adequately. This, however, is not always a given. Errors and sub-standard assembly in this sense, is always a possibility, and can create functional failures and dysfunctions when the completed system is made operative. For this reason, administrative quality assurance systems are common. These are in part devised, implemented and followed up by the work-teams themselves. Some oversight, however, is being effected by high level administration in Contractor V, by way of corporate safety and quality systems imposed on the project top down and via project management. These are generally based on controls effected by management, in weekly inspections or in connection with completion of specific task; when what has been created is “taken over” and accepted as completed by the contractor.

Communication, negotiations and production flow

Even though the systems based nature of output does allow for work group independence to some extent in day to day operations, project-based production does not allow teams to work independently over longer periods. In varying ways and degrees, teams depend on other teams in their operational activities. The basic reasons are two: The first is that sub-systems are entangled in the built object; either because space is scarce and physical contact (or near-contact) unavoidable; or because there is actual interpenetration between diverse sub-systems, as when electrical power and/or electronic automation functions are applied to water systems. The second reason is that there are numerous dependencies between operations and, hence, between work groups.

There is, as information in Table 1 serves to highlight, much variation in terms of work-involvement times on-site. Some suppliers are staying there only briefly, for example to unload goods, while other firms remain as service providers for long periods, even for the entire production period. For example; in project K, the technical subcontractors P and T stay on-site nearly as long as Contractor V does. For such reasons, some work teams are much more closely integrated into the project organization, than other firms are. They take part in intra-project communication and ongoing negotiations (in formal, scheduled meetings as well as in informal talk) regarding issues such as production coordination and flow. Still, all work teams on the site have to communicate with project management and often with other teams directly, to handle practical issues that are not made explicit in any structural design drawing or progress plans.

Coordination is a technical issue concerning the actual building process, but it is also a timing issue concerning many other issues than the technical. For example, remuneration in Project K is generally based on production work done and documented. The effect of this is that work groups have a primary interest in production flow - as experienced by own team members. Unpaid waiting caused by others is detested, while there is notable motivation for high-intensity work in the cases when project management accepts piecework pay.

Complexity in Building

The observations done in projects S, M and K indicate that well-assembled subsystems of the built object generally has limited complexity. An exception from this seems to be the poured concrete structure of the buildings. Interviews with gang leaders and managers, as well as observation of several incidents and problems during production work, indicated notable complexity both in the course of the production runs as well as in the emerging concrete structure.

A second area where high complexity could be observed, was in the integration of subsystems in certain locations in the built object. An example of this in project K was unanticipated effects of enmeshing of several systems inside an internal wall, making the wall - itself a system with a sandwich structure and a hollow core - unstable and losing its shape under high-humidity conditions.

The dominant form of complexity, however, as observed in Project K during the field work, was clearly in the construction project itself, where activities are divided into operational work packages and organized temporally and with respect to intra- and inter-elemental dependencies. This, of course, is the functional essence of standard project management tools. These are able to model how work teams and their activities are to run alongside in the course of the project. The project model represents a framework for coordinating the dynamic production system of the construction project.

What was found in the ethnographic study is that this administrative framework, even though essential for the outcome of the project, is only “scratching the surface” of what is actually going on in the production work. Real-life efforts have to deal with a level of detail that cannot be replicated in the project model. Observations indicated that neither the designs (in project K in the form of conventional paper drawings) nor the progress plans had much to say about the everyday working out of practical solutions that could make production flow and the built object emerge in line with overall plans.

To explain why this is so, one could metaphorically describe the everyday problem-solving as going on at a “level of reality” existing "beneath" the progress plans and design drawings created by architects, engineers and project managers. Obviously, it is on this detailed level of tangible reality that energy, skills and creativity are employed to effect the transformation of materials and components into the built object. It is here that discontinuities and contradictions are hit upon and the processes of finding solutions have to start. There are numerous observations recorded in the observation log from the fieldwork that document examples of this. For example, it was observed in one case that parts of iron did not have the right measures for a support wall and re-ordering of correct parts would take too much time and have serious ripple-on effects; in another case that architect's drawings contained errors due to omitting the inclusion of fire inhibiting materials; in a third case that different drawings were incompatible because designers had failed to communicate and agree on a single design, and in a fourth case that people fell sick and did not show up for work. Such seemingly trivial examples are interesting here, because they represent situations in which complexity becomes obvious and complexity management is essential to keep up production flow and avoid having to backtrack and rework.

There were, however, also more subtle efforts to cope with complexity that were observed during field-work and found to be common occurrences. As mentioned in the discussion of methods earlier, an analysis of the handling of discrepancies,

contradictions and imperfections was made based on an in-depth interview in which problems made explicit in meeting minutes were discussed. Extract 1 contains excerpts from the interview with management team member X in project K.

Extract 1: Knowing and negotiating floor elevations

The elevation of floor surfaces [in one story in a building] is like a game. A very scary game, it is. (...) It all depends on the progress plan, but you know, stairways and balconies (...). Sometimes the stairs come first, at other times the balconies are poured first. (...) So this is challenging and you really have to proceed cautiously. Where you place windows, where you position doors, where you place kit and caboodle ... because everything can become crazy expensive. (...) Everyone [in the industry] is struggling with this. (...) Sometimes you have to plan a doorstep to make it (...). And sometimes, if you have to put in a prefabricated bathroom cabin (...) then that is put on top of the concrete floor and then you have a doorstep that has to flush with the cabin door. And if you also have sliding doors then the floor has to flush perfectly with that and with the balcony outside, and then you might have to pour a bit less here because this surface is to be tiled, and there, and here because of the hardwood flooring.. Foreman Y has been extremely competent, he has taken this as the point of departure (...) and has said to the lads pouring the balconies that they should use that as a reference at least in front of the door, which is the most important. Then we have made a detail drawing, and shown how to proceed with that. For example, with these flats: [pointing in the drawing]; one, two, three, four and five, we have said here is the door, here is the door, here is the door, here is the door. Then we have proceeded in this way: this is the level of the stairs; this line is the line indicating this level; here it should be 1 cm under this line. Then we have tried to adjust and to calculate the height difference relative to that line, all the way, tried to adjust everything, and said, like, hey, here there is the possibility to gain 5 millimetres. And then we have talked to the float-floor people and said you can make the floor with this level here. And over time, the [float-floor guys] (...) became so good at this that they could see themselves what was needed and what doors we could use, to create a level difference of maybe 5 millimetres on the floors [and succeed in keeping within the tolerance in over the whole story].

Interview with X in the project K management, January 31, 2018. [Author's translation]

This is but one example of several possible in the observation material, and is presented here to show how production work is a complex and creative reality underlying the level of structural drawings and progress plans; and for other reasons than that errors are made. X focus only on the technical systems; it is the mutual adjustments that have to be made between several elements, and the possibility of ripple-effects that have to be controlled. As for built-quality-as-realized-in-production, this is the essential integrative effort that construction workers and their management on-site have to accomplish. This in itself is a complex issue, since so many work teams are involved and need to communicate, negotiate and agree, for a workable solution to be found and economical working procedures established.

In terms of complexity management in the real-life activities underlying structural models and plans, this is far from all, however. The people involved have to deal with a number of other systems than the technical, and at the same time. Most obviously, work has to be done economically - all involved are conscientious about their remuneration and what has to be done, to avoid negative economic effects. Another issue is safety; those involved are aware of the safety guidelines and regulations that they have to comply with. And as a matter of course, they are concerned with maintaining their relations to other workers and teams, in particular maintaining or improving their place in the social system of the work group that they are part of.

Sorting out the technical issues, therefore, is far from only a technical issue. Non-technical considerations normally play a significant role for the ability of workers to realize acceptable built quality on-site. This was observed and documented during the ethnographic fieldwork in Project K, where an overarching concern of the project management was to “keep the lads happy”; by balancing administrative demands and requirements with the need to keep a positive tone in the project organization.

CONCLUSION

The question was posed at the introduction how can we account for the many deviations and for the insufficient built quality encountered in many building projects, when errors, deviations and contradictions in project based production of the built environment cannot be explained simply by pointing to human inability or unwillingness to carry out what is suggested in pre-made designs and progress plans. The argument has been made here that managing complexity is a significant factor in safeguarding built quality as realized in project based production. There is a significant overlap between enhancing built quality and work-based managing of complexity. Complexity cannot be avoided in large systems, but it can be managed. Part of this complexity management effort is handled in decentralized administrative quality control systems, as when routines are implemented by plumbers to sign off on batches of work and document what has been done with pictures stored in their own project documentation archive. But another significant part of the quality management is carried out by workers in everyday project practice, in informal ways.

Further exploration of existing data and also further empirical research would be needed to expand the analysis presented here; to more systematically document how various systems complexities are managed, what the positive role of administrative quality systems can be in the overall context of practice, and how such systems ought to be designed not to interfere negatively with workers’ own complexity management efforts.

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COUPLING INNOVATIVE TECHNOLOGY, SPACE MANAGEMENT AND BIM PROCESSES WITH SMART CITY MANAGEMENT: CONGESTED CONSTRUCTION SITES IN URBAN CENTRES IN CAPE TOWN SOUTH AFRICA

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This paper examines the issue of limited space on congested building construction sites in the Cape Town urban centre. It is argued that the use of Building Information Modelling (BIM) and innovative technology will mitigate the problem of space during construction. The slow uptake by construction firms in using this technology is due to a lack of demand for digital information by clients. Building information generated during and after construction coupled with smart city development will provide the incentive for construction firms to invest in these technologies. Smart city management and big data-infrastructure is becoming increasingly important in world cities like Cape Town. The increase in demand for digital information will require building construction firms to focus more on models that encompass an entire city rather than just building-focused models. Quantitative survey methods are used to obtain information from building project managers, registered contractors as well as consultants within the central business district of Cape Town metropolis. The data obtained was analysed using SPSS statistical software. A lack of space was identified as the most significant challenge during building construction projects in the urban centre of Cape Town. The safe movement of materials on site, limited storage space for materials and restricted access for delivery of materials were found to be the most challenging aspects. The suggested ways of dealing with these issues are 'just-in-time' delivery of materials, lean construction methods and the use of innovative technology. Innovative technology includes location awareness equipment, point cloud laser scanning, bar coding, aerial drone imagery and closed circuit TV. The process of using BIM for generating and managing digital information was highly recommended for all stages of the building project from initiation to planning, execution, monitoring and finally closing. Despite the enthusiasm shown by construction personnel construction firms remain reluctant to invest in these technologies. This relates to a lack of demand by clients resulting in the risk of over capitalising and unnecessary development of personnel skills.

Keywords: space management, BIM, smart city, congested construction sites

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INTRODUCTION

Building construction firms in the developing world have been broadly criticised as not embracing innovative technologies during construction. This is particularly evident on congested construction sites in urban centres where technology can significantly mitigate problems associated with space (Pinfold, 2015). The reason for not investing in new technologies is the risk of over capitalising and the unnecessary training of personnel (Jin *et al.*, 2017). During the procurement process the client's needs underpin the objectives of the project. If there is no need for technologically advanced construction processes then there isn't an incentive for a construction firm to introduce them. The main priority when procuring building construction projects is early completion of the project, price competition and risk mitigation.

One of the advantages of BIM is sharing building information and providing virtual simulation of construction processes (Isikdag, 2015:34). BIM encourages collaboration between project team members which means the project is more likely to achieve a successful outcome. Therefore, from a contractor's perspective, BIM and related technology should present an opportunity for better success in a project. However if construction firms are not interested in engaging with BIM and related technology they're not going to advise the client to use BIM. The South African BIM institute conducted a survey in 2016 investigating why South African building construction firms are reluctant to implement BIM.

The survey revealed that construction firms are following trends rather than taking the lead in BIM implementation. A large percentage of respondents in the survey (81%) were concerned that there is no local mandate by the National Department of Public Works concerning BIM standards (Harris, 2016:4). In South Africa BIM implementation has had some success however is not yet an industry standard. The potential use of BIM in today's construction industry is gaining momentum and will reach a tipping point sometime soon. Contractors, subcontractors and suppliers who want to tender for projects that include BIM must understand the requirements of BIM and related technologies and have the capacity to implement it. Construction firms that do not embrace new technology will lag behind and lose their competitive edge (Pinfold 2015:58; Hardie 2010:387).

This paper examines the issue of limited space on congested building sites in the Cape Town urban centre and to what extent construction firms are using BIM and related technology to address space issues. The author argues that the use of BIM and related technology can mitigate the problem of space during construction. A survey was conducted to establish what construction personnel considered the most significant challenges on congested building sites in urban centres and what broad-minded management methods are being used to mitigate these challenges. Finally the author considers future developments of BIM and the influence it will have on construction firms. It is suggested that construction managers embrace the digital revolution gripping the construction industry and couple innovative technology, space management and BIM processes with Smart City Management.

INNOVATIVE TECHNOLOGY

According to Pinfold (2015:1) the use of innovative technology can significantly mitigate problems related to the management of space on a construction site. Location awareness technology for instance identifies position in real-time using Global Positioning System (GPS) and Wi-Fi technology. Location awareness technology

consists of indoor and outdoor location sensors that can be downloaded on mobile handheld devices such as cell phones, tablets, data loggers and watches. Location awareness technology allows both onsite and offsite monitoring of materials (Razavi *et al.*, 2012:239). Aerial photography using drones is an effective method to monitor space outdoors. Weekly surveys can be done quickly and cheaply to identify problem areas. CCTV cameras can be used inside and outside the building to provide explicit recognition of conditions on site.

Manual Data Collection and Barcode Scanning

Manual data collection on-site is a task that is nearly impossible when recording on-going construction work (Yun-Yi Su 2010:4). As a result only approximate estimation of work can be collected with undesirable accuracy. Barcoding of materials, machines and tools provides real-time information about their status. Personnel can scan the barcode using a smartphone camera to access information from an inventory database via an internet application. When an item is 'on the move' the inventory can be consciously updated to reflect its current location, when it is expected to arrive on site or where it is. Material tracking provides critical information needed by the construction supervisor in order to manage delivery. Crane time (crane waiting) can be better managed so that materials are immediately hoisted to their required location on arrival rather than having to be stored on site.

Efficient material monitoring enables 'just in time' delivery of material which can reduce the need for material storage. A barcode attached to an item or packaging can be updated by personnel on site by scanning the code and entering new information in the inventory such as its new GPS coordinates. Knowing the rate at which materials are arriving and the rate at which the materials are being used is an important aspect of lean management. Yun-Yi Su (2010:7) highlighted the importance of timely and accurate feedback information which describes actual operational data on the construction site. Without timely and accurate feedback, the accuracy of the updated project database is effected hence many critical decisions cannot be made (Davidson and Skibniewski 1995). The monitoring of materials and optimising supply chain management is critical in managing the delay between procurement and its arrival on site. The rate at which material is received is seldom the same as the rate at which the material is used. Barcode scanning in this case is useful for balancing surplus and demand of items.

Monitoring and Measuring on Site

Unnecessary movement of material on site constitutes wasted time. Multiple moves of stockpiles or clearing materials out of the path of machinery is a result of a poor site layout and space management. Location awareness technology, CCTV cameras, drone imagery and barcode scanning technology can be effectively used to monitor and make sense of unnecessary movement. Another cause of wasted time is waiting for design details from engineers, architects and construction personnel. Becker (2015:66) identified laser scanning as one of the most exciting technologies to have emerged in the construction industry. It is widely accepted that laser scanning is useful for measuring existing building structures that are difficult to get to (Gleason 2013:2; Tuttas *et al.*, 2014:341; Kim *et al.*, 2013). The use of laser scanning can result in large and complex datasets that need to be deciphered by skilled personnel. Isikdag (2015:34) refers to BIM as a methodology related to sharing of information in real-time over the internet. BIM can be used as a space linker that links macro and micro spaces. With the use of location awareness technology fully interactive BIM

can be introduced on site. BIM allows the flow of 3D spatial, financial and material information to be seamless between the field and office.

Futuristic Development of BIM and Digital Technology for Building Construction Projects

Construction projects stall and falter without information. When implementing BIM on a building project it creates a vast amount of free flowing standardised information that can be utilised by other related infrastructure projects such as transport systems and utilities. Technology available today can produce vast amounts of useful information generated on building construction sites either for batch processing or real-time processing. Data mining of pre-existing databases provides knowledge that can be effectively used to organise resources. Vast amounts of real-time data are first stored then processed in Big Data repositories and infrastructure before being streamed for use by the construction firm.

Ismail (2016:1) refers to the so-called “5V” in Big Data: volume, variety, velocity, veracity, and value with an emphasis on volume, variety and velocity. Volume, variety and velocity indicates huge amounts of data acquired constantly which become very difficult to store and process. If Big Data is used and communicated in a disciplined manner then decisions made will be enhanced based on multiple data sets that are current and accurate. At present a single BIM model used for design, evaluation and planning cannot make use of unstructured information and Big Data infrastructure. However if BIM is expanded from a single building model to include buildings and infrastructure in an entire city, where geo-referenced buildings and real-time information are linked, then BIM models can be converted and contribute to Smart City models.

Khemlani (2015) refers to the expansion of BIM to include infrastructure with the next logical step being City Information Modelling or Smart City Modelling. Khemlani describes City Information Modelling as the connection between BIM (buildings) and other related city infrastructure such as roads and public spaces (open data), streetlights (sensors) and even people (social media). A BIM model is traditionally centred on information while a Smart City model is centred on the flow of information. The author believes the extension of the BIM model to a Smart City model in South Africa is not far-fetched and suggests that building construction managers should be looking beyond BIM level 1 and 2 to BIM level 3, smart city management and Big Data analytics. BIM level 3 is the integration of electronic information with full automated connectivity and web storage. BIM Level 3 proposes a construction industry that is smarter and more digitally-enabled than BIM level 2.

THE CAPE TOWN URBAN CENTRE SURVEY

Design, Methodology and Approach

In 2015 a quantitative survey was done in the Cape Town city centre to investigate to what extent construction personnel support the use of innovative technology on congested construction sites (Pinfold, 2015). The sample consisted of building project managers, registered contractors as well as consultants working on three construction sites in the Cape Town city centre. The three building sites included the Standard Bank Towers worth 500 million Rand, Cape Town Convention Centre worth 832 million Rand and Portside worth 1.6 billion Rand. The building projects were all in their final year of construction.

In 2018 a similar survey was done to investigate to what extent BIM and related technologies are being used on building construction sites in Cape Town. The sample for the survey consisted of building project managers, registered contractors as well as consultants working on the Dido Valley Multipurpose Building Project in Simon's Town in the Cape Town Metropolis. The project is worth 168 million Rand and is in the first stage of construction. The selection of the Dido Valley Multipurpose Building Project was based on the scope of work and the relationship the Department of Construction Management and Quantity Surveying at the Cape Peninsula University of Technology (CPUT) has with the contracted construction firm. The construction firm is considered progressive in its management approach and regularly employs students and degree graduates from the Department. These students/graduates are well rehearsed in technology and BIM capability. Respondents were asked if they had any experience using these technologies in the past and if they intended using them on this project. The objective of the survey was to reveal any uptake in the use of technologies that were identified as useful in the 2015 survey. Respondents were also asked to indicate to what extent space influenced production on congested construction sites and how they managed it. Twelve challenges identified during the 2015 survey were listed on the questionnaire that might influence production on a congested construction site. Five management strategies identified during the 2015 survey were also listed on the questionnaire.

The Perception of the Usefulness of Innovative Technology

The technologies identified in the 2015 survey included BIM, point cloud scanners, remote sensing imagery obtained from a drone, location awareness technology, bar code scanning and CCTV monitoring. Respondents were asked how effective these technologies are during construction. A sample of 139 questionnaires was obtained from construction personnel in the city centre. BIM was perceived to be the most useful technology across all five building production processes. Although construction personnel believed that BIM and other technology significantly enhances building production processes only a few believed it was a good investment for the firm they worked in. Respondents blamed the lack of BIM standards in the construction industry as a major stumbling block for BIM implementation. Respondents agreed that the construction industry needs to be encouraged to convert from paper documentation to digital information systems (see Table 1).

Table 1: Perceived usefulness of innovative technology. Source Pinfold 2015

Innovative Technology	Process groups in building production management				
	(a) Initiating	(b) Planning	(c) Executing	(d) Monitoring	(e) Closing
1. BIM technology	Y	Y	Y	Y	Y
2. LAT technology	N	N	Y	Y	N
3. Point Cloud technology	N	N	Y	Y	N
4. Barcode Scanner technology	N	N	Y	N	N
5. UAV technology	N	N	N	N	N
6. CCTV technology	N	N	N	Y	N

The Use of Innovative Technology

The 2018 survey included 22 construction personnel currently employed on the Dido Valley Multipurpose Building Project. The distribution and collection of questionnaires was facilitated by selected practitioners. The 22 respondents consisted of 4 (18%) females and 18 (82%) males, their ages varied between 45% above 50, 18% between 40 and 50 and 36% younger than 40. Respondents were asked to what extent each technology was being used on site and if they had used the technology before. A five-point scale was used where 1 = 'not at all', 2 = 'sometimes', 3 = 'often', 4 = 'generally', and 5 = 'almost always'. Of the respondents 27% had often used CCTV on building construction sites, 9% occasionally and 64% never. 18% of respondents said BIM was more often than not used for construction projects, 18% said it was seldom used and 64% said it was never used. 18% had used location awareness technology, 27% occasionally and 55% never. 9% had occasionally used barcode scanners and 82% had not. 18% had used a laser scanner however 82% had not. None of the respondents had used or seen a drone being used on site (see Table 2).

Table 2: The use of innovative technology on congested sites in the Cape Town central city

Innovative Technology	Scale1	Scale2	Scale3	Scale4	Scale5
CCTV technology	64%	9%	27%	0%	0%
BIM technology	64%	18%	18%	0%	0%
LAT technology	55%	27%	18%	0%	0%
Bar Code Scanner technology	82%	9%	9%	0%	0%
Laser Scanning technology	82%	18%	0%	0%	0%
UAV technology	100%	0%	0%	0%	0%

The Challenges Experienced on a Congested Construction Site

Respondents were asked to indicate what challenges they had on congested building sites, using a five-point scale, where 1 = 'not at all', 2 = 'sometimes', 3 = 'often', 4 = 'generally', and 5 = 'almost always'. Safe movement of materials on site, limited storage space for materials and restricted access for delivery of materials were found to be the most challenging aspects (see Table 3).

Table 3: Challenges experienced on congested construction sites in Cape Town central city

Challenges on a Congested Site	Scale 1	Scale 2	Scale 3	Scale 4	Scale 5
Safe movement of materials around site	0%	0%	9%	91%	0%
Limited storage of materials on site	0%	18%	18%	64%	0%
Restricted access for delivery of materials	0%	18%	27%	55%	0%
Coordination management issues	0%	9%	82%	9%	0%
Locating material on site	0%	18%	73%	9%	0%
Health and safety issues	0%	0%	64%	36%	0%
Congested space on site	0%	9%	64%	27%	0%
Restricted access for delivery of materials	0%	0%	55%	45%	0%
Difficulty communicating on site	0%	27%	55%	9%	9%
Damage to material on site	0%	36%	55%	9%	0%
Personnel in close proximity to machinery	0%	36%	36%	27%	0%
Overcrowding of personnel	0%	82%	18%	0%	0%

The Management Response to the Challenges on a Congested Construction Site

Respondents were also asked to indicate how often construction management methods were used to deal with challenges on congested sites, using a five-point scale, where 1 = 'not at all', 2 = 'sometimes', 3 = 'often', 4 = 'generally', and 5 = 'almost always'. The suggested ways of dealing with these issues are 'just-in-time' delivery of materials, lean construction methods and the use of innovative technology (see Table 4).

Table 4: Management response to the challenges on congested construction sites in Cape Town central city.

Management Methods	Scale1	Scale2	Scale3	Scale4	Scale5
Just-in-time delivery of materials	0%	0%	27%	73%	0%
Lean construction methods	0%	27%	64%	9%	0%
Knowledge management	0%	9%	45%	27%	18%
Prefabrication	0%	27%	36%	36%	0%
Use of innovative technology	0%	36%	27%	36%	0%

FINDINGS

The 2015 survey showed that construction personnel believed BIM and related technology have the potential to mitigate challenges experienced on congested construction sites. However the 2018 survey shows that BIM and related technology are seldom used. Construction personnel identified movement of materials on site, limited storage space for materials and restricted access for delivery of materials as the main challenges on congested construction sites. Just-in-time delivery of materials, lean construction methods and the use of innovative technology were identified as the main management strategies used to mitigate these problems. Despite the enthusiasm shown in the 2015 survey there is little evidence that BIM and related technologies are being implemented on building construction projects in the Cape Town Metropolis urban centres.

CONCLUSIONS

The core underlying issue that was identified as being problematic on a congested construction site is the lack of space and overcrowding of workplace. This is consistent with other surveys where space management is widely accepted as the most critical aspect on congested sites (Tommelein and Zouein 1993; Spillane *et al.*, 2011:143). The 2015 survey found that BIM was highly recommended for all stages of a building project from initiation to planning, execution, monitoring and finally closing while other innovative technology were believed to be useful only at certain stages in a building construction project. However the 2018 survey indicates limited use of BIM and innovative technology on construction sites in the Cape Town metropolis. The suggested ways of dealing with congested space is through 'just-in-time' delivery of materials and lean construction methods. The surveys indicate that construction managers acknowledge the potential of BIM and innovative technology however underutilise it for management during building construction projects.

The author suggests in this paper that construction managers should be aware that BIM is gaining momentum in today's construction industry and that construction firms need to build capacity to enable them to tender for building projects that are required to utilise BIM processes. BIM should not be seen as a single model but as multiple models incorporated in a Smart City model. It is suggested that Big Data and Smart City infrastructure developments will be the catalyst needed to encourage

construction firms to invest in BIM in the long term and to contribute to its trajectory from its predominantly building-focused models to models that encompass an entire city. The South African government needs to follow this trend and invest more in Big Data infrastructure if it is to keep up with this digital revolution.

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CONCEPTUALISING BEHAVIOURAL AMBIDEXTERITY AND THE EFFECTS ON INDIVIDUAL WELL-BEING

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‘Knowledge work’ in the contemporary business landscape typically demands behavioural ambidexterity: the ability to simultaneously demonstrate creativity and compliance. However, the effects of behavioural ambidexterity on the well-being of individual employees are not well known. We examine the relations between work design, behavioural ambidexterity and perceptions of well-being, conceptually drawing on a review of the three strands of literature. Our focus is on well-being, after a well-established holistic definition based on healthcare, philosophy, psychology and sociology literatures, which have converged on three core dimensions of well-being: psychological (happiness), physical (health) and social (relationships). We highlight the influence of personal circumstances and the role of agency in work design as two key antecedents of well-being outcomes, and suggest a preliminary framework for further studies of behavioural ambidexterity and well-being in the construction industry.

Keywords: behavioural ambidexterity, well-being, happiness, health, relationships

INTRODUCTION

Knowledge work is characterised by ambiguous task boundaries, need for expertise and innovation, continuous learning, and quality [and quantity] of the outputs. Knowledge workers are the people in organisations and projects whose main capital is knowledge. In construction work, this includes for example architects, designers, engineers, accountants, quantity surveyors, contracts and project managers, and any other party whose line of work requires them to "think for a living".

Trade-offs, compromises and adjustments are an integral feature of organisational life, management practices and individuals’ experiences of knowledge work. These include negotiations regarding work design and well-being. Contemporary research on work design advocates meaningful work and worker autonomy as key antecedents of wellbeing (Boxall and Macky, 2014). There is evidence for a positive connection between perceptions of the meaningfulness of work and the performance and satisfaction of the worker (Humphrey *et al.*, 2007; Wood and de Menezes, 2011; Wood *et al.*, 2012). Indeed, satisfaction is a key well-being outcome at work (Boxall and Macky, 2014). Knowledge-based professional work is frequently considered

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highly rewarding and self-fulfilling due to its embeddedness in the lives of the workers. Technological advances allow such work to be carried out anywhere and at any time (Gallie *et al.*, 2012; Ford and Collinson, 2011), which can increase flexibility and a sense of autonomy. However, it can also threaten work-life balance and well-being, especially in employees whose work is central to their identity.

For knowledge workers, conflicts between compliance and inspiring creativity may arise when organisations seek to adopt behavioural ambidexterity. Behavioural ambidexterity, from the perspective of the organisation, is that their employees simultaneously demonstrate exploitation and exploration across an entire business unit (Gibson and Birkinshaw, 2004: 209). At the level of the individual this means that employees must simultaneously comply with organisational norms and procedures, thereby ensuring that the organisation can continue to exploit the formulated business strategy; whilst also exhibiting creativity and thus ensuring that new situations are responded to positively and every opportunity is taken to explore how to develop the business. Although there has been growing interest in the performance outcomes of behavioural ambidexterity (see for example Patel *et al.*, 2013; Ahammad *et al.*, 2015), little is yet known about the effects of organisational demands for ambidextrous behaviour on individual well-being.

Based on a critical review of relevant literature, we develop a conceptual framework for examining the well-being outcomes of behavioural ambidexterity in knowledge workers. We highlight the influence of personal circumstances and the role of agency in work design as two key antecedents for positive well-being outcomes.

WORK DESIGN-AMBIDEXTERITY-WELL-BEING

Our conceptual model draws together literatures on work design, behavioural ambidexterity and well-being as shown in Figure 1.

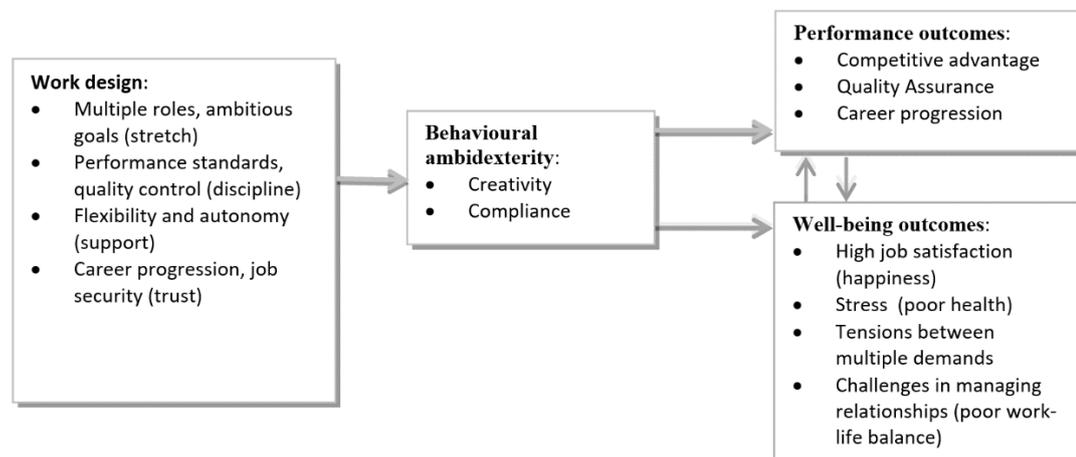


Figure 1: Conceptual framework (after Gibson and Birkinshaw, 2004; Simsek, 2009; Van de Voorde *et al.*, 2012; Patel *et al.*, 2013)

The core argument is that behavioural ambidexterity mediates between organisational contextual characteristics (a combination of stretch, discipline, support, and trust) and performance (Gibson and Birkinshaw, 2004). Here we build on the input-process-output view of ambidexterity (after Simsek, 2009) by examining how work design, as the key contextual influence that seeks to produce behavioural ambidexterity at the level of the individual, is associated with performance and well-being outcomes. We

enhance the understanding of behavioural ambidexterity by adding a consideration of well-being outcomes.

Ambidexterity

In organisational research, ambidexterity refers to an ability and desire of an organisation to simultaneously pursue two different, often conflicting, aims: exploration and exploitation (Simsek, 2009); alignment and adaptability (Gibson and Birkinshaw, 2004); efficiency and flexibility; or integration and responsiveness (Birkinshaw and Gupta, 2013). There are three forms of ambidexterity in organisations: temporal ambidexterity, structural ambidexterity and behavioural ambidexterity (the latter is also sometimes called contextual ambidexterity) (Gibson and Birkinshaw, 2004). In temporal ambidexterity, exploitation and exploration are sequential, i.e. an organization switches from one mode to the other depending on organisational and environmental requirements (Swart *et al.*, 2016). For example, a period of rapid organisational change may be introduced by the actions of a competitor. An organisation that uses structural ambidexterity to manage conflicting demands will have “dual structures” in place where certain business units focus on exploitation while others focus on exploration (Gibson and Birkinshaw, 2004). So, an organisation may have a separate research and development (R and D) unit that continually explores (adapts) the organisational offering (aiming to meet demand and supply in the future) while the mainstream operations exploit (align) their provision to current market needs.

Behavioural ambidexterity is the capacity to simultaneously demonstrate exploitation and exploration across an entire business unit. It is about the multitude of ways in which organisations manage the tensions involved in doing two different things at the same time (Birkinshaw and Gupta, 2013).

Behavioural ambidexterity has become a popular concept because it is progressive and versatile (Birkinshaw and Gupta, 2013), as well as closely associated with contemporary notions of employee engagement and high-performance work systems (Patel *et al.*, 2013). Organisations that aspire to behavioural ambidexterity encourage their employees to make their own judgments about how to manage the conflicting demands for exploitation and exploration (Gibson and Birkinshaw, 2004: 210). Although individual employees and their choices are central to behavioural ambidexterity, worryingly, research examining the concept at the level of the individual is sparse (for notable exceptions see for example Audia and Goncalo, 2007; Burgess *et al.*, 2015; Caniëls and Veld, 2016; Brem, 2017).

Burgess *et al.*, (2015) highlight the importance of the role of agency within particular contextual circumstances. Audia and Goncalo (2007) integrate psychological theories of individual creativity (and constraints) with organizational theories of exploration versus exploitation to examine the relationship between past success and creativity over time, predicting that successful people are more likely to generate new ideas, but that these ideas will tend to be less divergent as they favour the exploitation of familiar knowledge at the expense of the exploration of new domains. Caniëls and Veld (2016) in turn examine whether and how innovative work behaviour and/or specialisation is related to explorative and exploitative activities, and find that a high-level balance of innovative behaviour and specialisation is conducive to innovative work. Finally, Brem (2017) develops a framework within which individual level 'opening' and 'closing' behaviours facilitate organisational exploration and exploitation.

This body of research shows that when the employees of an organisation collectively engage in creative, innovative and open behaviours, the organisation benefits from opportunities for exploration. Creativity is a common theme, and thus a useful label for this group of individual level behaviours. Constraint, specialisation and closed behaviours in turn facilitate exploitative activity within organisations. We label this group compliance.

Work Design

In our suggested model, work design depicts the organisational contextual characteristics: a combination of stretch, discipline, support, and trust relevant to knowledge work. Patel *et al.*, (2013: 1422-1423) identify that:

Stretch occurs when employees are given goals that “raise the bar”, encouraging the attainment of more and more ambitious goals

Discipline exists when employees understand what is expected of them, are provided with the skills to meet those expectations, and are held accountable for their actions

Support refers to the resources, care and autonomy provided to employees, and

Trust is influenced by perceptions of equity, organizational leadership and level of involvement offered to employees, and it can be enhanced through career progression opportunities and job security.

These conditions are viewed as enabling for behavioural ambidexterity in that they facilitate the relationship between work design and performance.

Performance Outcomes

The anticipated performance outcomes include measures that achieve high status and individual success (competitive advantage), together with organisational citizenship, the aggregation of which ensure the career progression of individual employees.

Achievement of such performance outcomes collectively leads to organisational competitive advantage: for example, successful project outcomes on time, cost and quality; client satisfaction; employee satisfaction, development and retention; sustainable profit margins; esteem and reputation; market share and repeat business; return on investment; and possibly also social value.

Well-Being Outcomes

The well-being outcomes in the model derive from a well-established holistic definition of well-being based on healthcare, philosophy, psychology and sociology literatures, which have converged on three core dimensions of well-being: psychological (happiness), physical (health) and social (relationships) (Grant *et al.*, 2007: 52). In the following, each is described further.

Happiness refers to the psychological well-being of employees. Key issues here are satisfaction with work and with life in general, with focus placed on subjective experiences and functioning at work (*ibid.*). Van de Voorde *et al.*, (2012) also consider commitment as a key aspect of happiness at work, noting that this differentiates between the foci of attention: i.e. satisfaction is related to the job, whereas commitment is targeted at the organisation.

Health refers to the physical and psychological well-being of employees in terms of experiences of strain or work-related stress and outcomes such as cardiovascular disease, hypertension, sleeping problems, mental health issues and workplace accidents (Grant *et al.*, 2007; Van de Voorde *et al.*, 2012; CIPD, 2015).

Relationships are a more contemporary addition to considerations of employee well-being (Grant *et al.*, 2007; Van de Voorde *et al.*, 2012). This category differs from both happiness and health, the two categories above, in that happiness and health both focus on the individual, whereas relationships relate to the interactions and quality of relationships between people, both within the workplace and in their personal life beyond work. Recent models of work design also include social characteristics as an important consideration in the modern workplace (see for example Humphrey *et al.*, 2007; Oldham and Hackman, 2010). A key aspect of relational well-being is work-life balance where work has the potential to enrich or conflict with personal life and enhance or detract from the quality of personal relationships.

The work design literature suggests that well-being outcomes are often varied: for example, enriching jobs may increase stimulation and challenge, and thus increase job satisfaction, but at the same time cause physical strain and/or stress (Grant *et al.*, 2007). Demanding or greedy jobs also often take away time from family and friends, and therefore can cause tensions in the relationships dimension of well-being. Moreover, opportunities to gain support as well as respite from work are reduced when people are physically or psychologically absent from family and friends.

Knowledge workers tend to enjoy high job satisfaction (happiness), but may suffer from stress (poor health) and challenges in managing relationships (poor work-life balance). We have added ‘tensions between multiple demands’ as a distinct consideration due to its relevance to our discussion about work design and as a causal reason for stress. The demands of knowledge work are open-ended and, as such, have strong potential to engender time-based and strain-based conflict between work and personal life. Knowledge workers are also typically deeply involved in their work and often over-committed to the job role, which can increase the potential for time-based and strain-based work-life conflict and psychological distress. The high level of autonomy may lead to ‘enabled intensification’ whereby increased flexibility can further threaten work-life balance and recovery processes rather than facilitate them (Kinman and Jones, 2008).

THE CONNECTIONS: WORK DESIGN-AMBIDEXTERITY-PERFORMANCE-WELLBEING

We derive the anticipated relationships between stretch, discipline, support and trust with performance and well-being from the work design literature, which suggests that jobs that combine variety with autonomy and flexibility produce positive behavioural (performance) outcomes, but varied well-being outcomes (see for example Hackman and Oldham, 1980; Dorenbosch *et al.*, 2005; Humphrey *et al.*, 2007; Oldham and Hackman, 2010). Therefore, we argue that it is critical to gain insight into the well-being implications of the work design-ambidexterity connection, just as it is important to understand the relationship between work design and performance outcomes.

This research adds to the well-being literature by providing some insights from knowledge workers operating within an environment characterised by increasing intensity and conflicting demands on the one hand, and whose successful performance, on the other, is highly dependent on both organisational and individual behavioural ambidexterity.

Behavioural Ambidexterity in Construction

Extant research identifies that engaging in ambidexterity tends to vary according to knowledge workers positions within an organisational hierarchy (Swart *et al.*, 2016),

and that most of the time ambidexterity is considered at the organizational level which may not apply at project level (Liu *et al.*, 2012). Drawing on the broader literature on project management, professional roles, and innovation, we develop a projection about ambidexterity in construction work at project level, as follows.

Off site is where we anticipate most creative work to take place. Contracts managers, designers, architects, company directors, and other parties involved at the front end of project planning and strategic level decision-making need to and have the freedom to engage in creative work. It is knowledge work at this level that aims to secure the continuity of the business over the longer-term by making decisions about the kinds of work the organisation wishes to bid for, their strategic approach to resource allocation, vision, mission, and values among others. The decision-makers must consider 'the product' (or service) carefully and position the organisation in the marketplace.

More specifically, Raisbeck and Tang (2009) report on the design of projects highlighting how architects and engineers create designs which integrate the different systems which comprise a project, and that these designs then also need monitoring, co-ordinating and managing as construction proceeds with other professionals, contractors and subcontractors. The design engineer or architect may gather data and information from clients, regulatory authorities, the physical environment, user groups, or other sub-consultants (*ibid.*) and balance the requirements for design solutions (creativity) with constructability, regulations, budget constraints, etc. (creativity and compliance). Ultimately, however, they act as "agents of innovation" (*ibid.*) exhibiting two forms of knowledge-based innovation: innovation in compliance and creative innovation. Creative innovation refers to immediate new project domains, and entails search work, variation, experimentation, and activity to solve project-specific problems; while innovation in compliance concentrates on developing generic organisational infrastructure to refine and improve the efficiency of the firm operations to nurture capability for future activity (Lu and Sexton, 2006).

At the same time, Caven and Raiden (2010) reveal significant concerns over maintaining a satisfactory work-life balance among architects, and Sang *et al.*, (2007) note a high risk of poor health and well-being due to long working hours, job insecurity, poor work-life balance, low professional worth and temporary teams in the profession. Although this group of knowledge workers exhibits most creativity, it seems to be at a cost to their wellbeing.

Project managers make up the middle tier in construction organisations, leading specific projects. Their work is particularly demanding in that the requirements for both compliance and creativity are intense. It is an imperative that they supervise the various parties on the project to deliver the product to precise specification. On a daily basis they are presented with complex social and material problems that necessitate creative and innovative thinking and contextual problem solving (Feghali and Raiden, 2016). They manage the everyday on site and form a connection with the strategic aspects of the organisation. They have autonomy in their job and tend to be self-empowered (Lau and Lew, 2011). This approach to work has been depicted as "muddling through"; and Sandberg *et al.*, (2016) identify that such reactive behaviour is not sustainable. It has been shown to lead to stress and hinders the on-going development of management in construction organisations. In addition, long and inflexible work hours are the most consistent predictor of work-life conflict among project office workers (Lingard *et al.*, 2007).

On site, it is the setting out engineers, craftsmen and foremen, who tend to occupy the lower levels of the organisational hierarchy of knowledge workers, who often use more compliance oriented behaviours. Their tasks and areas of work tend to be more neatly defined. Project-based quantity surveyors may also fit into this category. Work is focused at point of delivery: task completion to given specification and/or supervision of daily work. When task uncertainty is low, the classical 'plan-execute-control' approach works well, and the management focus is typically on fine-tuning and making the most of existing capabilities (Liu *et al.*, 2012). Innovation is focused on incremental improvements and adaptations, rather than on creation of new and different solutions. Bowen *et al.*, (2013) found that workers at this level tend to experience less stress than their colleagues at higher levels of the organisational hierarchy.

In summary, at lower levels of the organisational hierarchy, construction workers tend to use compliant behaviours. The more senior and the more entrepreneurial knowledge workers in construction are, the more they tend to use creativity. This is not surprising; however, what research does not identify is that creativity must build on judgement and experience, as well as resources and support. Rarely is there a harmonic and wholesome balance between creativity and compliance; instead, there is a continuous pull and push, at the level of an individual, between the individual's desires and the institutional demands and within their wellbeing domains. Tensions arise that crave mental and physical energy and intellectual effort to resolve.

CLOSING REMARKS AND CALL FOR RESEARCH

Our discussion implicates conceptualising ambidexterity in construction (and in other professions) in that we build in a consideration of wellbeing outcomes together with performance outcomes.

Indications from extant research in construction suggest that the contextual characteristics of construction work result in wellbeing concerns; we identify a connection between creativity and negative wellbeing outcomes. This could be simply a product of limited research; hence, we call for studies that investigate the relationships between work design, behavioural ambidexterity and the performance and well-being outcomes across all knowledge workers involved with construction projects. Studies are needed to examine the contextual characteristics of construction work as well as to compare and contrast findings with other sectors in order to develop a holistic understanding of behavioural ambidexterity.

Studies should also examine whether management practices need to focus on enhancing the creative aspects of ambidextrous work design in order to enhance the workers' feelings of empowerment in construction, or whether an overt focus on creativity is likely to continually predict negative well-being outcomes. In many professions, the current and sometimes dramatic moves to formalise, rationalise and standardise processes and procedures, as well as to increase transparency, have resulted in pressures and often contradictory changes in work processes and practices, resulting in an overly keen emphasis on compliance by the knowledge workers. In construction, this may ease knowledge workers pressure to be creative, allowing them to take advantage of their capabilities more effectively.

As Patel *et al.*, (2013), drawing on Gibson and Birkinshaw (2004), warn: behavioural ambidexterity is not created through organisational practices, no matter how well-intentioned, but rather "*through the flexibility of allocating the time and attention of*

human resources toward exploration and exploitation". To be effective, behavioural ambidexterity has to function on three levels: the organisation, the project, and the individual.

Finally, we build on Litrico and Lee's (2008) work on balancing creativity (exploration) and compliance (exploitation) in alternative work arrangements, which suggests that there are patterns that allow creativity and compliance to mix or become counterbalancing; they need not always compete (1016). Since this balance is a fragile equilibrium and stressful to manage (ibid.), we argue that behavioural ambidexterity cannot be considered only in the organisational context (in relation to work design and performance outcomes); a consideration of the well-being implications must be included in future work.

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HOW DO INFRASTRUCTURE OWNERS BUILD CAPABILITIES TO REDUCE OPERATIONAL FAILURE?

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There are limited studies that have focused on understanding the causes of operational quality failure, which is recognised to be a significant and costly problem for owners. This paper investigates why assets handed over to owners have failed during operations, and proposes new ways that capabilities can be distributed to reduce potential operational problems from arising. This study identifies and measures quality cost failure in five projects within a single client organisation. This is achieved by means of preliminary Delphi reviews on operational problems and 19 in-depth interviews with an expert sample from five specific infrastructure projects. The interviews included those involved with project delivery and operational use of the asset. Empirical data was gathered using card sorting and semi-structured interviews. The preliminary findings indicate the importance of quality cost failure and the fragmentation of capabilities in addressing operational failure. By identifying and measuring quality cost failure, owners will learn and be able to procure more integrated failure-mitigating capabilities for reducing failures.

Keywords: failure, operational capabilities, quality cost, mitigating capabilities

INTRODUCTION

The construction industry is making clear their commitment to move away from transactional, cost driven procurement to embrace the creation of value through integrated collaborative owner, contractor and supplier alliances. However, all too frequently projects deliver failures in critical operational outcomes, put operations at risk, constrain future investments and jeopardise innovation. At every level of the construction supply chain the prices tendered by companies include allowances for the management, overhead and corrective cost of failures, all of which is avoidable. Delivery to time, cost and quality has perhaps remained the mantra of the construction industry, although failures post completion is still highly recurrent (Razak *et al.*, 2016) with little focus on the failure implications (Hall and Tomkins, 2001; Barber *et al.*, 2002). Capable owners assume that projects will integrate with operations. Some place significant weight on the capabilities of contractors and suppliers in understanding how this is done, but research perhaps shows, owner's project and operational capabilities are the key (Davies *et al.*, 2016) and understanding of the operation must be distributed across an inter-organisational network of suppliers. These capabilities need to be simultaneously managed (Davies and Brady, 2016) and

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this study will focus on those capabilities needed to reduce the cost of operational quality failure. Within the project-based organisation (PBO) literature, there is a need to understand how the distribution of capabilities create lasting performance (Brady and Davies, 2004) that collate and integrate knowledge and skills. Owners and operators must advance their capabilities (Winch and Leiringer, 2016), both strategic and operational capabilities (Helfat and Peteraf 2003 and Mora *et al.*, 2008). More specifically, owner's capabilities are needed in managing operations in responding to poor quality and performance and addressing non-conformance to owner needs and requirements.

Capabilities facilitate problem solving and can be used to structure resources (Schreyogg and Kliesch Eberl, 2007). However, projects are built on multi-organisational capabilities that dynamically embed value that is transmitted through resources and people (Davies and Brady, 2016, Flynn *et al.*, 2010). Whilst there has been much talk of the capable owner in these processes, little has been written about their capability in supporting a project that is ready for operation. Some have identified the value lost from rework (Barber *et al.*, 2002), defects or product non-conformance (Hall and Tomkins, 2001), but rarely has been explored on quantification of operational failure. This research aims to explore quality cost failure from the perspective of the capable owner. Capturing integrated capabilities across a multi-organisational network to test if this could assure operational success. This study has appraised the operational cost of quality within a single owner organisation to understand the distribution of capabilities across an owner's multi-organisation network within project-based organisations.

Distribution of Capabilities within Project-Based Organisations

There has been a move from traditional strategies to project based organisations (PBO) to address increasing complexity, uncertainty and risk (Melkonian and Picq, 2010). The complexity and uncertainty of a project can be explained as “temporary coalition”, “multiple project” or “intra-organisation” environment that extended beyond the boundary of single firm (Hobday and Davies, 2005; Söderlund and Tell, 2015; Sower *et al.*, 2007; Brady and Davies, 2004). In different organisations, capabilities are developed through organisation resource allocation that is embedded in individual structures (Schreyogg and Kliesch-Eberl, 2007), thus project organisations conceive a distinct behavioural pattern that is complex in nature of building the project coalitions. Davies and Brady (2016) suggested capabilities based on multiple short term projects need to be integrated to continuously add value in competitive projects.

Capabilities require resource investment, and define how resources should be allocated, coordinated and deployed (Schreyogg and Kliesch-Eberl, 2007 and Ethraj *et al.*, 2005) also representing a repository of historical experiences and organisational learning (Winch, 2016). Capabilities distributed during the strategic stage play a significant role in delivering operational and project outcomes (Eisenhardt and Martin, 2000 and Mora *et al.*, 2008), however continuous investment is needed to build new resource configurations, and to respond and adapt capabilities to the external environment. Comparatively little attention has been devoted to how distribution of capabilities will impact project operational failure.

Research by Davies *et al.*, (2016) shows the importance of the owner requirement and capability integration role. As project participants often focused on their own interests and managing their own project risks, rather than on the operational realisation of the

owner's objectives (Hughes and Murdoch, 2003). This can lead to the misalignment of project capabilities. Capabilities are shaped and adapted by different organisational decision makers (Flynn *et al.*, 2010; Davies and Brady, 2016), although the capability role of the owner is unclear, particularly as suppliers move to operate and maintain facilities (Davies *et al.*, 2016), the balance between owner and supplier operational capabilities need further investigations.

Operational Quality Failure Cost and Capabilities

Operational capabilities may not be easily obtained as they are generally firm specific skills, processes, and routines (Flynn *et al.*, 2010) that are developed within the operations management as a continuation of project capabilities. Research shows limited understanding of capabilities in the project lifecycle that explains the fundamental source of firm heterogeneity (Helfat and Peteraf, 2003). In operation management, operations strategy places equal importance on strategic management as operational failure may be a consequence of project processes, poor management of performance or poor quality (Love *et al.*, 2018). Operational failure can occur either during the process or within the final product of the construction project. Although, much research has shown the implication of failure and its effect on quality cost (Love and Irani, 2010), few have focused on post-operations quality cost (Hall and Tomkins, 2001).

Ethiraj *et al.*, (2005) argued capabilities reflect on the evolutionary process of considering firm specific investments that results in heterogeneity of firms and its consequent is differences in their performance. However, the challenge of diversity in capability towards innovation and uncertainty (Davies and Hobday, 2005) may be apparent, but the effect on project failure may be less evident (Morris and Hough, 1987). Every failure may be quite different from one to another, and so the causes of project failure may be a contingent to the project life cycle (Pinto and Mantel, 1990). Therefore, project management literature has suggested a better understanding towards the organisational structure and project-based management in managing capabilities (Söderlund and Tell, 2015) and the quantification of quality cost (Hall and Tomkins, 2001).

Given the difficulties in addressing construction quality costs have been discussed by many (Hall and Tomkins, 2001; Jafari and Rodchua, 2014), operational quality failure costs are determined as the most significant and difficult to evaluate (Sower, 2004; Snieska *et al.*, 2013) among other cost in construction projects. Although some studies looked at owner management (Davies *et al.*, 2016; Winch and Leiringer, 2016) but none has comparatively discussed the relationship of owner and its supply chain capabilities impact on operational problem. It is therefore necessary that the evaluation of these quality costs should be initiated with the identification of potential failure and causes, in which embedded within the organisation of capabilities in the project lifecycle. By far, the quantification of failure cost frequently used to transfer the effects of poor quality into monetary terms (Hwang and Aspinwall, 1996) that can be used to visualise and assist management in preventing and improving operational failure.

METHOD

A multi-project case study approach has been used within a single client organisation to understand the distribution of quality failure cost reduction capabilities. A case study protocol was used to help ensure reliability and used a mixed-method approach. The case study research method included card sorting and semi structured interviews

with a selective expert sample. An expert Delphi technique was used to identify the most suitable case study project and in selecting all experts during four stage of a preliminary study. The first stage of interviews with project managers (n=7) lead then through snow balling to a selective sample (n=12) across the five project specific case studies.

A card sorting method was used to aid the participants in selecting the cost elements incurred in each specific case, the estimated cost, the factor that influences the cost of those selected elements and those involved with the operational issues. The combination of these methods showed what is known about the causes of operational quality failure cost within the complex multi-organisation project structures and context. This method was then repeated across all interviews (n=19) with operational teams. Assessments were made in face-to-face interviews and a multi- representative workshop to further advance and generalise the findings. Note, memo, documents and voice recording were used to capture qualitative data, along with interviews which were professionally transcribed. All data was collected, displayed, reduced and verified using a thematic method that progressed through several rounds of coding transcribed interviews, case-by-case to abstract and transform data into emergent pattern codes and later categories. These categories and their respective themes are further explained, analysed and discussed in the following sections.

ANALYSIS AND FINDINGS

Appraising the Quality Cost

Preliminary studies within the owner organisation identified five projects with a range of operational issues that differed according to project context and environment. The studies indicated operational issues were not quantified, thus causes of failures were not understood, learned from and so improvements were frequently not made.

Table 1 demonstrates numbers of quality failure cost elements selected by the experts during the exploration of the case studies. All elements were selected more than once in almost all projects. One element ‘early obsolescence’ was only selected in two projects (C and E). Environmental cost was selected least of all the elements.

Table 1: Cost of quality failure elements selected in project specific case study.

Quality cost elements	Project A	Project B	Project C	Project D	Project E	Total no. selected
1. Insurance cost	6	1	1		2	10
2. Latent Defect Cost	7	1	6	2	7	23
3. Safety cost for operator	4	1	3	1		20
4. Asset availability costs	2	2	7	3	7	21
5. Energy use costs	1		2	1	2	6
6. Maintenance costs	6	4		2		31
7. Environmental costs	3	1	1		1	6
8. Lifecycle performance costs	4	2	5	2		21
9. Functionality costs	2	2	1	2	2	9
10. Unadaptable costs	1		2	1	3	7
11. Early Obsolescence costs			2		4	6
12. Reputation/ brand cost indirect consequential losses	5	1	5	2	5	18
13. Operational training/ readiness costs	6	3	6	1	4	20

A particularly important element is ‘maintenance cost’, overall this has been selected 31 times. Different projects show a different range of quality cost incurred with different awareness on quality cost selected. Project B shows the lowest selection among all quality cost elements and Project E has more range on the selected quality cost with average 2-11 times. Following on to the selection of case specific quality

cost failure elements, experts then estimated their real costs. To generalise across projects of differing scales, the failure costs were divided by the total cost of the project to show the cost of failure as a proportion of the total. The proportion of project failure was described as a percentage (%). This indicated that the cost of operational quality failure ranged from 0.1% (£40,000) to 13% (£5,000,000) of the total project cost, demonstrating the significance.

Capability within the Supply Chain to Address Quality Failure.

Empirical data from all project cases show the importance of strong capabilities within the supply chain during execution. Figure 1.0 mapped the cause and effect of considering the lack of value placed on technical expertise during executions that led to the operational failure such as the use of non-confirming product, poor material performance and projects overrunning the schedule.

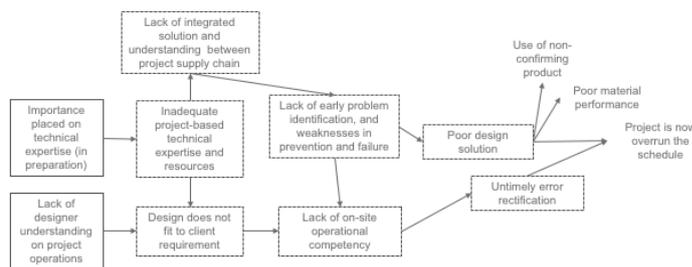


Figure 1: Cause-and-effect of technical capabilities within project supply chain

Figure 1.0 indicates there are two obvious causes from the effect of inadequate technical expertise in a project; that is lack of competency on site-operations and lack of integrated solutions and understanding between the project supply chains. In most cases, poor competency on-site operations meant that problems were not identified early. Therefore, the operational failure was not prevented and adequately appraised. In most projects, the owner assumes the contractor is more responsible, thus client technical expertise was less valued by the project team assuming the contractor has fully understood the owner operational environment. In project B, the team faced difficulties to fulfilling demanding requirements, with insufficient information and knowledge on operating of the new asset. Project C and D showed complex design and technical problems that were not understood and resolved by the contractor due to limited capabilities. The project indicated operational capabilities were not integrated during the project execution and led to the project not performing. Moreover, in some cases, less emphasises on the technical expertise role create low-motivation among the technical experts and has indirectly influenced poor capabilities of learning; because of each specialist tending to work according to individual assignments rather than integrating the systems. Some of it may be due to time constraints as projects need to be completed on time thus effecting project decisions where top management were frequently influenced by ‘getting the asset complete’.

Capabilities within the Contractor to Address Quality Failure

Although capabilities are usually firm specific, owners need to carefully understand contractor capability as it may affect the successful operation of project presentation aspects. Technically, the contractor is pertinent to the execution, but may not be fully involved in the operations of the asset thus not aware of the owner’s unique operation’s environment. As shown in figure 2.0, there was inadequate technical expertise in the project especially in operational capability. The owner was perhaps overly reliant on a ‘competent’ contractor and supplier thus the contractor who had

limited opportunity to influence the design, did their best to construct the complex design.

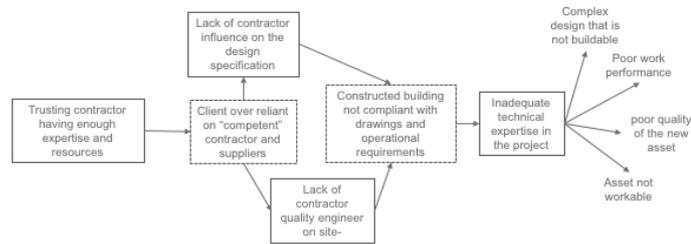


Figure 2: Cause-and-effect of capabilities within the contractor

Figure 2 demonstrates the contractor who has less quality involvement from engineer may have difficulties in complying with client requirement due to inadequate information from a technical expertise perspective. In project A and C, quality was given less emphasis due to limited time and non-integration of capabilities between the team. Project A was built with poor quality performance, while project C showed an unsuitable use of materials. These have led to both project non-compliance and owner dissatisfaction. What was evident, was the owner trusted the contractor could comply with the quality standard. However, the operational complexity implies continuous quality support from all parties to ensure the project will meet all parties' expectations.

Capabilities within the Owner to Address Quality Failure

In project A, the designer may have designed the project according to owner's needs but has limited buildability capabilities. The complex design was less integrated with contractor capability thus hindered effective quality control as the contractor was only driven by the owner's critical completion date. Frequently, design was only developed later by contractor thus poorly emphasis on the construction and functionality side of it. Mostly, projects show owner assumed contractor to have the competence capability, but supply chain shows limited influenced on design and quality executions have only led to non-compliance to design and quality for operations. Supply chain always believed that owner should provide insight when they needed, but sometimes owner focuses more on the limited time and cost, forcing contractor to work out of order thus quality was always less prioritised. Figure 3 demonstrates cause and effect mapped to show examples of how owner capability effects project performance. Commonly, projects have complex interrelated systems of systems. In some cases, data shows the owner's choice of procurement route was effected by the complexity with complex projects and are either critical to time as the project is needed to be compliant to demanding regulations, interdependence to another project or the need to avoid an operational penalty.

The owner may have selected a preferred contractor due to past experiences or long-term relationships to reduce project uncertainty. In project a, due to stronger relationship between supplier and client, the main contractor was not able to contribute to material selection. Early involvement did not occur to create integration and to align the contractor with the selection of materials' decision, thus this increased the risk of the project for the owner. Four of five projects showed that critical time significantly influence operational issues with one project abandoned. In the majority of these cases, the complexity of the project and focus on completing the project led to the quality of execution being less prioritised.

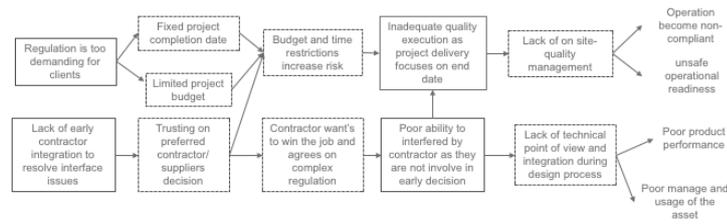


Figure 3: Cause-and-effect of capabilities within the owner

DISCUSSIONS

A previous study (Razak *et al.*, 2016) showed low maturity in how cost of quality failure is perceived and the limitations of quality management systems during the complex and multi-organisational project process. However, the study showed high awareness of operational quality issues with owner and supply chain, but the expertise and the responsibility for resolving them to reduce failure was doubted. Owners have significant influence in dealing with operational failure, although the quality costs resulting from operational failure were intertwined within complex multi-organisational arrangements. The question is who should take a share in the risk and who pays for resulting operational failures? The finding showed quality cost failure range from 1%-13% from total cost of quality, this illustrates the range of quality cost failures that capable owners could significantly reduce. Through for example project integration, risk sharing (rather than transfer) and the distribution of capabilities across the multi-organisational owner-supplier network.

Capabilities that are embedded in different organisations (Söderlund and Tell, 2009) may influence project culture and behaviour as each unique organisation has individual expertise, but the integrated capabilities need stronger management from owner. Davies and Brady (2016) suggested, relationship between dynamic and operational capabilities need to be reciprocal, recursive and mutually reinforce. This research showed integrating project and operational capabilities will aid the project team in knowing how and when the project needs to structure their capabilities that influence the operational necessity. From the empirical case studies, integration on technicality aspects from the owner to the supply chain could better prevent the occurrences of failure. What this has shown is the need for integration capabilities between the owner and supply chain, to mutually support and share capabilities in fully understanding the project process and plan according to operational technical necessity. This shows the equal value of balancing and distributing project risk among the project stakeholders.

Empirical data demonstrated capabilities were not integrated. Resulting in project and operational quality and performance being partially not delivered. Assets as a result were not workable, design was partially unbuildable and not ready for operation. Operational integration is achievable through early and long-term contractor and supplier engagement and clear skill, training and working practices guidance from execution to handover (Ordanini and Rubera, 2008). What is evident is early engagement of the contractor helps greater understanding of project capabilities that responses to project operations thus increase the competencies among the project team to provide fair solutions and prevention of failure. Therefore, integrating capability will make the sure project is executed and operationalised. The analysis showed integrating contractor capabilities with project operations could reduce failure as they would share responsibility for project risk thus having more opportunity to provide

greater quality realisation by working together with designer and suppliers in mitigating failures.

This study has shown that it is important for a capable owner to apply system integration (Davies and Mackenzie, 2014). They must understand the full network of supplier capabilities and how these contribute to failure through design, execution and the operation of projects. Although, many teams will exhibit different behaviour when put under pressure (e.g. limits of time and budget) as demonstrated by the case studies. Quality is important during the strategic stage (Hernandez and Aspinwall, 2008), but quality at the operations stage is seldom investigated. New multi-organisational quality assurance processes must therefore withstand pressures of budget and time. By providing stronger management on integrating capabilities project risk will be shared among the owners and supply chain thus quality execution will be more assured. This instance the necessity of contractor capability to influence the design and construct project process as according to owner quality expectation.

The owner's long-term relationship with the contractor and suppliers should help the owner to better distribute the right capability, based on past-experiences and understanding of how the contractor works. The research showed that the procurement route used by the owner significantly influenced project operational quality delivery. The owner awarded contracts on a lowest project cost basis; however, all cases showed additional work during operations. The cost of quality failure was therefore not shared from the beginning, but transferred or absorbed by some parties. Additionally, poor selection of contractors who did not have adequate capabilities, increased project risk and led to project abandonment. By distributing and integrating the capabilities of various project participants, failures could be foreseen, prevented and addressed at an early stage, rather than contributing to operational failure. Love *et al.*, (2018) reports that quality failures may not only effect owners but significantly impacts the profitability of contractors. Thus, it is imperative that owners and their supply chain address quality failure so that this capability can be engendered to improve construction projects and reduce failure.

CONCLUSION

This research started with the need to appraise, explore and understand the causality of post-completion quality cost failure. Literature on capabilities within owners and the supply chain in project-based organisation concepts were synthesised to describe and characterise the divergence of capabilities in a project based-organisation. This provided a useful means of understanding the multi-organisational case study environment from the perspective of a capable owner. The case studies showed the diversity of capabilities of the owner and its supply chain and the influence on the occurrences of failure. Empirical data revealed a lack of operational capabilities within the project supply chain which influenced the existence of operational failure. The long-term relationship between the owner, contractor and suppliers provided opportunity to capture and use the capabilities to address operational failures. Data also showed project procurement routes drove different behaviour and culture with significant variance in how project teams used their own capability in responding to quality issues. Capabilities were embedded and intertwined in these complex infrastructure projects. A strong capable owner requires understanding on this diversity to better distribute capabilities.

Capable owners must create collaborations and proactive approaches between the supply chains to access the capabilities of their supply chains. With greater access,

owners and suppliers can work together to balance the emergent and dynamic capabilities of the supply chain and better identify root causes and cost effective failure mitigating solutions. Therefore, by integrating capabilities between owner and its multi-organisations in projects will reduce the risk of operational quality failure. Capable owners need concerted effort in agreeing project goals between parties, thus encouraging better identification and measurement of quality issues to address failure. The findings revealed that learning capabilities were not fully attained and distributed by the project team and operational stakeholders, therefore further work is needed to clearly identify and fairly distribute failure mitigating capabilities.

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FIELD DIAGNOSIS OF CHALLENGES AND FACILITATORS TO THE ADOPTION OF GREEN BUILDING PRINCIPLES IN MULTI-PURPOSE OFFICE FACILITIES

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The study is a qualitative investigation of the implementation of green building projects, and the identification of the facilitators regarded as the most important to enhance the adoption of green building. To realise a robust outcome, case studies were conducted on purposive selected green building projects based in Cape Town, South Africa. The primary data were obtained using a semi-structured interview, and respondents included consultants, and contractors' management teams registered with the Green Building Council of South Africa (GBCSA). Regulatory factors were identified as key challenges to implementation of green building projects. The study also identified some key facilitators that enhance the adoption of green building. These include attributes of adopters such as skill, experience, and reputation of firms to undertake green building projects, green policy framework, incentives, and financial support from financial institutions. Design and construction firms should institute a mechanism for evaluating performance periodically, and identify challenges encountered in respect of green building projects they are involved in. Early identification of challenges and taking proactive steps to rectify problems are likely to ensure survival in the industry. The findings of this research contribute to a better understanding of the challenges of constructing green building, and the factors that engender the implementation of green building projects.

Keywords: professional, developing country, facilitators, green building

INTRODUCTION

Green building is defined “as a high-performance property that considers and reduces its impact on the environment and human health” (Yudelson, 2010: 13). Green building is viewed as a long-term business opportunity since it continues to influence construction in both developed and developing economies (Jones and Mandyck, 2016). A global study conducted by Dodge Data and Analytics reveals that some international firms, including architects, engineers, contractors, specialist consultants, and property developers, are focusing on sustainable design and construction, as at least 60% of their projects will be ‘green’ by 2018, an increase from 28% in 2012

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(Jones and Mandyck, 2016). For example, it is anticipated that the percentage of construction firms in South Africa incorporating green practices in their business is expected to increase from 27% in 2015, to a planned 61% by 2018 (Jones and Mandyck, 2016). Thus, South Africa emerged as one of the countries with the highest green share among all the survey participants, indicating a market conducive to green building (Jones and Mandyck, 2016). Despite this development, however, significant impediments persist, erected by the inertia of the building professions and the construction industry and compounded by the difficulty of changing building codes (Osec, 2010). Industry professionals, including consultant team members, contractors, and developers are generally slow to adopt change and tend to be risk-averse. Similarly, amendments to building regulations are inherently difficult to pursue, and fears of liability and litigation over the performance of new products and systems pose appreciable challenges (Osec, 2010). Hence, the research problem statement states that significant challenges of implementing/constructing green building persist in the South African construction industry as a result of overly prescriptive and conflicting building codes, slow / resistance to change, lack of information and incentives, inadequate technical skills, litigation over the performance of new systems and green products, cost of green building and the lack of collective vision and guidance in terms of decision making for adopting future green building projects. This raises the following questions that the study aims to address: what is the most significant challenge affecting the implementation of green building projects, and which facilitators are regarded as the most important to enhance the adoption of green buildings? The purpose is pursued by analysing qualitative data obtained from three case studies based in Cape Town, South Africa. The structure of this paper summarises and presents brief discussions with regard to the extant literature relative to the challenges of implementing green building and facilitators that engender the adoption of green building. This is followed by the methodological approach adopted for collecting and analysing the data. Thereafter, the findings from the case studies are presented and discussed. The final section presents the conclusions of the study.

LITERATURE REVIEW

Overview of challenges of implementing green building

Many researchers have identified the underlying reasons responsible for the inertia in implementing green building projects (e.g. Isaksson and Linderoth, 2018; Häkkinen and Belloni, 2011; Djokoto *et al.*, 2014). According to Isaksson and Linderoth (2018), the first reason for the sluggishness in implementing green building is costs. Hankinson and Breytenbach (2012) revealed that clients / developers would have to incur an additional cost between 10% and 20% in order to implement green innovation in construction. Besides, the cost to be borne by built environment stakeholders is prohibitive for the first green building of a client or the consultant team members and contractors since the design and construction process is often characterised by significant learning curve costs, and design schedule problems including late and costly change orders (Kats and Capital, 2003). The second significant challenge that the industry is confronted with regarding the implementation of green building is skills shortages and lack of industry skill with regard to green design and construction (DST, 2014; Hankinson and Breytenbach, 2012). According to Jones and Mandyck (2016), the high level of activities related to green building may contribute to the fact that one of the biggest challenges is finding sufficient skilled professionals. Regulatory and steering barriers are also key challenges in implementing green concepts. According to Häkkinen and Belloni (2011), different

types of instruments are used for steering. However, the lack thereof or wrongful steering may rather stifle the growth of green building whilst on the other hand; green building may also be promoted at least to a certain extent with the help of regulations (Djokoto *et al.*, 2014). The fourth key challenge hampering the implementation of green building is organisational culture. Djokoto *et al.*, (2014) opine that the construction industry is conservative and presents itself as an industry which is slow to adopt to change specifically with regard to construction techniques practiced and building materials used. The construction industry has traditionally been a slow adopter of new technologies in general, mainly due to the perceived associated risks (DST, 2014).

Facilitators of green building

There are many facilitators that could help to ensure a successful project implementation and overcome a range of challenges inhibiting the adoption of green projects. Firstly, improving the availability of reliable information and knowledge relative to the benefits of green building would better inform stakeholders and the general public and help to diminish misperceptions (Darko *et al.*, 2013). Khoshbakht, *et al.*, (2017) opine that the accumulation of diverse cost-benefit variables is imperative for a full package of economic evaluations, and that it should be communicated to various stakeholders in the green building industry. Secondly, the implementation of green building, thus, requires a joint team effort by uniting a wide range of different professionals who possess the right mix of skills. According to French *et al.*, (2008), the most outstanding attributes of members of high-performance teams have the right mix of skills, including technical skills, problem-solving and decision-making skills, and interpersonal skills (Sanderford *et al.*, 2015). Thirdly, developing enablers for green building could be one of the significant steps toward creating a holistic view of the complexities of the construction sector, as it serves as a guiding principle for the government to develop policies as well as instigating more actions amongst stakeholders within their own realm of responsibility (Abidin *et al.*, 2013). Numerous enabling factors have been identified to ensure a successful implementation of green projects. The main enabling factors were found to be: changes to regulatory framework; provision of monetary and non-monetary incentives; ensuring sufficient financing; involving appropriate experts, and embracing partnerships (Majdalani *et al.*, 2006; Choi, 2009; Kapur *et al.*, 2011).

METHODOLOGY

The research was undertaken by conducting an empirical study using a qualitative approach in conjunction with a literature survey. To achieve the purpose of the study, case studies were conducted among selected firms in the Western Cape Province to investigate how and why challenges of implementing green building persist and how the enablers could be used to encourage the adoption of green building. According to Yin (2009), a case study allows researchers to explore individuals, organisations, communities and programs, to test research mechanisms and techniques. Yin (2009) further asserts that there is no ideal number of cases that should be undertaken. To date, there are a total of 63 certified green building projects in the Western Cape Province. Out of the 63 certified projects, 22 are green star office buildings. However, purposive sampling method was adopted to select three green star office buildings based in Cape Town. These projects were selected on pragmatic considerations, namely their availability. Purposive sampling consists of handpicking purportedly typical or interesting cases (Blaxter *et al.*, 2001). The following parameters were used in selecting the three cases, the type of project and facility type,

whether the buildings had been certified as green by the GBCSA, the date of certification, and ease of access to information. In total, three (3) respondents were interviewed (thus one respondent from each firm). Interviewees included environmental specialist, junior site manager, and an architect who were directly involved in the construction of green buildings. A semi-structured interview questionnaire as described below and a site visit approach (visual inspection) were adopted in the data collection. The survey participants from the three selected firms were interviewed face-to-face. A three part questions guided the interviews. Section 1 - Relates to general information regarding the green building project. Section 2 - Explored respondents' opinions regarding the challenges encountered during the construction of green buildings. Section 3 - Relates to lessons learnt from the project and successful corrective solutions to faced challenges. The qualitative data were analysed using content analysis. The analysis of the qualitative data consisted of transcribing and conceptualising the data obtained from the interview that were deemed to be relevant to the topic under investigation.

FINDINGS

Preparation of Interview

Prior to conducting the interview, the respondents were contacted by phone and informed about the purpose of the interview. Thereafter, the semi-structured questionnaire was sent as an attachment with the email and this provided the interviewees an opportunity to prepare in advance for the interview. With respect to project A, the contractor's environmental specialist / transformation manager was interviewed. The interview was conducted in the environmental specialist's office and lasted 1 hour 30 minutes. Concerning project B, the interview was held on site with the junior site manager and lasted 30 minutes. With regard to project C, a half-hour interview was held with the architect in the office. All the discussions were tape recorded using a tape recorder.

Case Description: Analysis of Project A

Project A was 32 floors, comprising 3 floors of basement, upper and lower ground floor as retail area, 7 structured parking levels, 19 floors of office space, 2 floors of dedicated plant room and 1 sky plaza with over 52000m² of office space. The level of certification of the project was 5-star. The respondent stated that the most significant green features that were used for the building include: Design so that over 95% of the total façade can be disassembled; LED lighting scheme; electric car and electric bicycle charging points, and cycle racks.

Challenges Encountered During the Construction of Green Building

Lack of materials and certification / testing of materials

According to the interviewee, there were two difficulties with respect to materials and certification of materials during the execution of the project. One of the challenges according to the interviewee was sourcing green materials / products with low percentage of volatile organic compound (VOC) content, low environmental impact and recyclable. The second issue that confronted them was the high cost of green materials with low VOC values coupled with the cost of testing these materials. The interviewee lamented that the cost of testing green materials is more expensive than standard materials. The interviewee stated that:

The green building council is very stringent when it comes to the use of formaldehyde. Formaldehyde minimisation is one of the things that really cause a pain. For instance, there is a premium for the formaldehyde content in terms of the joinery work. That is

there is a price for the formaldehyde, is actually very high. There are different board types and typically they will prefer the E1 board type which must be tested and the test is very expensive. For items such as the boards and paints, there is a premium to be paid specially to have the formaldehyde and zero VOCs. And if you go for IEQ13 test for instance, which is mostly what pushes up the price, hence the cost implication of the project. Hence, we are obliged to look for local within say 15km radius but elsewhere it will cost less.

Financial barriers

With respect to financial challenges, the respondent expressed concern regarding the high percentage premium associated with the certification process of green building, coupled with the cost of green materials. The respondent further stated that there is a system in place for monitoring purchasing of materials from suppliers other than BEE suppliers. The respondent argued that this system act as a barrier as it has an impact on the company's BEE scorecard. The respondent lamented that:

High percentage premium and prices of the raw materials, as well as the impact on our BEE scorecard with buying from suppliers other than BEE suppliers. For instance, the premium as a percentage of the total cost of the building for gaining green certification was 17%.

Capacity barriers

The respondent also expressed concern in relation to the lack of capacity as far as the green building industry is concern, although the respondent was of the opinion that most of the consultant team members were experienced enough to ensuring the success of the project judging from their previous experience. However, the uniqueness of this very project posed lots of challenges to the design team members as well as the contractor. The respondent also highlighted that:

The contractor and other consultants were on the learning curve, as a result, there were a lot of design related and site related rework which escalated the cost of the project and subsequently affected the duration of the project.

Regulatory barriers

The respondent stated that the main regulatory barrier encountered with respect to this project was the time spent in getting the green building project certified and the difficulty in adhering to green certification requirement such as recycling, and dumping of waste materials. The respondent cited examples such as:

Slow rate of progress of certification delayed the commencement of the project. The way we look at our waste, did the truck dump the waste at a responsible place? Is easy for me not to bring to the GBCSA attention because is going to make life easier for me on site, how' if I say I diverted 80% of waste from landfill, they still send it to landfill, but they used it to build road.

Lessons learnt

The interviewee stated that the push behind going green should be based on certain parameters including perceived benefits from green building, the extra cost of green building material and technology, the operational costs of green building, availability of green technologies, availability of green materials, and availability of consulting and project management expertise. The respondent emphasised that these parameters will ensure the success of the project and encourage stakeholders within the built environment to go green.

In my opinion, more emphasis should be placed on the impact of current methods, and the benefits of going green should be sold more aggressively with real financial incentives and affordable to all.

Successful Corrective Solutions to Faced Problems

Liaising with consultants on a regular basis, do things while the building is on, constant follow-ups, and two-way communication. Holding back payments of certain subcontractors, regular inspection of the actual materials used, and regular checking of the drawings.

Case Description: Analysis of Project B

The second case study that is project B consisted of a 5-storey office complex (approximately 23.8m high) with a total site area of 23755m², with a building footprint of 7195m² and landscaped areas of 7280m². The level of certification of the project was 5-star and the total cost of the project was R 218,206,912.37. Some of the innovative technologies used for the project include biometric readers' system (BRS). Therefore, each floor can only be accessed by biometric readers, and the occupants need to be on the system to have access to a particular floor. The BRS also controls all the electronics and water supply to the building.

Challenges Encountered During the Construction of Green Building Capacity barriers

According to the junior site manager, one of the biggest mistakes on this project was the appointment of subcontractors with inadequate skill or know-how with regard to how green principles should be implemented. This situation resulted in time overrun and increased in the cost of the project due to rework. The respondent opined that:

Firstly, this is our first green building endeavour, so you need to make sure that those that you employ such as your subcontractors and their workers have the skills and the know-how of what is required. And not just the skills and knowledge but also channels of communication are important. That was a huge issue on the site and I think that is one of the downfalls that is why we are still here today.

Another example cited by the respondent with respect to appointing sub-contractors was in the case of the landscaping work.

There were palm plants in the pond to be planted, so we have this subcontractor who does mostly civil works. But for this specific job he decided he's going to tender for civil and landscaping because he can do landscaping for some reason. It will be his responsibility to supply and plant the water lilies in the pond. And water lilies are water plants and not a refill so they have their own compost or certain compost that need to be used and he was adamant that he would supply it, try and get it sorted. Now, two-three weeks later we have dead water lilies in our pond, and we told him how to do what he was supposed to do and he did not.

Regulatory barriers

The respondent stated that the major barrier encountered was that their firm has limited knowledge with respect to green strategies. This was evident during the implementation stage of the project where they failed to comply with green certification requirement such as recycling of material.

But when we came to doing as built for the green building to get our certification, we noticed that there was a regulation for how much OPC needed to have been in the cement, how much of it was like a re-use material that they had used to comprise that made up our cement. I think someone overlooked that when we started with the building project and when we came to the end, there is the building standing and we not going to get a point, and that was like 2 point. I think we overlooked that regulation.

Cultural barriers

The cultural barrier that was apparent in the interview was organisational culture. The respondent argued that some of the role players would want to do something their way that they know that the end result will be satisfactory, but not a green building way.

An example will be the outside of the building was finished with face brick and that in old days how you will clean face brick is to do it with diesel and it will get rid of the white resin that comes out on the outside of the face bricks and it will make the bricks look very nice, it brings out the redness in the brick. This is one of the things that was suggested that we should use in cleaning the facing bricks but we can't. Obviously on a green building you can't use something like diesel to be cleaning face brick, because is flammable and is one of the big no on a green building.

Lessons learnt

According to the respondent, the most important lessons are that green building is a good thing, thus good initiative; it should be low maintenance if it is done right the first time. The interviewee stated that:

The initial cost is very expensive but very worth it at the end of the day, if you look at how it saves and helps the environment and the staff that are occupying the building. More so, communication in general is a big key especially in green building. There is so much information and if you don't have people that are on board, then that can lead to lost in translation and then you end up where we ended up.

The interviewee opined that a lot of rework ensued since "*this was their first green building endeavour*". Therefore, the respondent suggested that:

The experience and knowledge base of contractors and sub-contractors are very vital during the construction of green building. The respondent was also of the view that design team members should also have the necessary skill, experience, and reputation in undertaking green building projects as these characteristics are important to ensure the success of green building projects.

Case Description: Analysis of Project C

Project C consisted of a 2-storey building, the total floor area was 3800m². The level of certification of the project was 4-star and the total cost of the project was R 24,000,000.00. Some of the innovative technologies used for the project include: PV / off grid energy and black water recycling system.

Challenges Encountered During the Construction of Green Building

Regulatory barriers

The respondent was asked to explain some of the regulatory barriers, according to the respondent, overly prescriptive and conflicting building regulations resulted in difficulty and unnecessary delays in obtaining green certification and permits for the green building project. The interviewee maintained that:

The process of obtaining green building certification was a very lengthy process and a bit tricky. It was prohibitive, and after we have done the one, we said we wouldn't be doing it again. At the same time, we looking at drawing up easy to use guidelines that we can implement the principles and strategies without having to register. We are not going to get the star rated building but we going to be using a good practice, is not ideal if you want the star rating. And I think the way we could achieve that is by having internal green consultant which we don't have, the consultant will do the process for us, and we might be able to achieve it and then run alongside us with the project and do the work involved with the council. I worry that Green star has become more of a 'tick box' to compliance. This is something I have noticed considerably in the last few years. Consultants are not given the opportunity to provide valuable advice on the design of projects. It is very prescriptive, in my view.

Financial barriers

When questioned about financial barriers and how it affected the project, the architect expressed concern about high percentage premium associated with the certification process of green building and the cost of green consultants.

Percentage premium, and in fact we are implementing the principles but not going through the process of registering at the green building council, because of the work load and cost of appointing consultants; the green building consultant is a costly element. We find that very prohibitive. Then a matter of finding the finance to employ a group of green building consultants or the core workers to get the building certified was a great concern. But the additional issue is the line department has to be prepared to pay the percentage premium as well.

Lessons learnt

Experience of consultant team members is very important to ensure a successful implementation of green building.

Practical training: People who have not studied in a long while cannot in any way be motivated to suddenly study to be accredited for green building profession. However, I believe they can be motivated to do some practical training instead, to be accredited for green building profession. This is worth a try to get the 'old' professionals in the construction industry aware and comfortable with green building practices in the construction industry.

The architect lamented that there should be a green policy framework in place that will fast track the permit process and reduce the time involved in obtaining green certification from the GBCSA. The respondent also stated that there is inadequate system in place for facilitating the adoption of green building and that various incentives schemes should be provide to encourage developers and consultant team members to take up green building projects to assist the nation to achieve its sustainable goals. In addition, financial institution should also come on board to assist in providing financial support to encourage developers and client to adopt green building.

DISCUSSION OF FINDINGS

Challenges: The result of analysis shows a consensus of opinion that there are challenges associated with the implementation of green building. These factors include: lack of materials and certification and testing of materials; financial barriers; capacity barriers; regulatory barriers, and cultural barriers. All respondents also identified regulatory factors as key challenges to adoption of green building. Most of the respondents view financial and capacity factors as major challenges to adoption of green building. In accordance with the review of literature, respondents' perception of risk associated with green building adoption has a negative effect on attitudes. These findings are consistent with green building studies that found how multiple layers of risk and risk aversion by professionals' cause resistance to transitioning to alternative approaches to green building (Häkkinen and Belloni, 2011; Hankinson and Breytenbach, 2012)

Benefits of green building: According to the qualitative analysis, two of the professionals interviewed believe that the push behind adopting green building should be based on the benefits accrued to green buildings. Two of them viewed operational cost savings (low maintenance cost) and reduced percentage premium relative to the cost of going green as major benefits of green building. One of the respondents perceives environmental benefits as one of the benefits of green building. These

findings are akin to previous studies conducted by Park *et al.*, (2014); Darko *et al.*, (2013).

Attributes of adopters: The case study analysis revealed that major attributes revolved around skill, experience and reputation of firms to undertake green building projects. For instance, one of the respondents disclosed that a lot of rework ensued since it was the first green building endeavour. Hence, the need to engage contactors and consultant team members with the necessary skill, experience, and knowledge cannot be overemphasised. This is in alignment with the findings in the literature that, the attributes of adopting firms and contractors were found to exhibit significant direct effects on adoption of high performance building products innovation and green building (Sanderford *et al.*, 2015; French *et al.*, 2008).

Enablers: The respondents affirm the need to employ other means through which green buildings can be promoted to encourage its adoption. Some of the respondents highlighted the need for a green policy framework as this will fast track the permit process and reduce the time involved in obtaining green certification. This finding aligns with previous study undertaken by Majdalani *et al.*, (2006) who opine that changes to the regulatory framework are considered to be the most effective means for a behavioural shift in transforming the green building sector. Two of the professionals agree that more incentives should be provided to enhance the adoption of green building. Similar findings emerged in research study conducted by Choi (2009) who found evidence for the use of incentives as measures to enhance the adoption of green building. Notably, one of the respondents stated that financial support from financial institution will undoubtedly encourage developers / client to adopt green building. This is corroborated by Kapur *et al.*, (2011) who opine that financial institutions are playing a role in creating financial resources and instruments in facilitating energy efficient investment such as green buildings. One of the respondents also suggested the need for practical training to get the old professionals in the construction industry aware and comfortable with green building practices in the construction industry.

CONCLUSIONS

This study investigated the challenges that built environment stakeholders encounter in their quest to implementing green building, and the facilitators that will create an enabling environment for adopting green building. In all the projects, it was found that challenges to implementation of green building include: lack of materials and certification and testing of materials; financial barriers; capacity barriers; regulatory barriers, and cultural barriers. However, all the respondents identified regulatory factors as the most significant challenges to implementation of green building. The results of the study reveal that although there are risk factors involved in implementing green building, there are also factors that engender the adoption of green building. It should be noted that all the respondents highlighted the need for a green policy framework as this will fast track the permit process and reduce the time involved in obtaining green certification. It was also mentioned that more incentives should be provided to enhance the adoption of green building.

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THE IMPLEMENTATION OF STAKEHOLDER MANAGEMENT AND BUILDING INFORMATION MODELLING (BIM) IN UK CONSTRUCTION PROJECTS

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The implementation and usage of Building Information Modelling (BIM) on construction projects affects procurement and the supply chain activities. The BIM process is changing the traditional modus operandi of the construction industry where many projects have failed to achieve their objectives due partly to ineffective stakeholder management. An on-going PhD study is exploring how to mitigate delays and conflicts between stakeholders on BIM implemented projects in the UK. However, the scope of this paper is limited only to the role BIM can play in managing stakeholders. This paper is based on a critical literature review and primary data collection through five semi-structured interviews. Findings from the literature review show that BIM publications such as PAS 1192-2:2013, Employers Information Requirements (EIR) and BIM Execution Plan (BEP) set out clear requirements for the coordination and collaboration process that will facilitate the use of the BIM model. This inadvertently strengthens communication and mitigates conflicts among stakeholders. The findings from the interviews which were analysed by content analysis show that BIM can help project teams to proactively satisfy stakeholders by engaging them early on in the construction process and seek solutions that avoid or minimise delays and conflicts. The paper concludes that BIM has a huge potential to manage stakeholders on construction projects. Communication, collaboration, stakeholder engagement, trust, common goals, technology and people are at the core for managing stakeholders within BIM projects.

Keywords: BIM, communication, conflict management, stakeholder management

INTRODUCTION

Missonier and Loufrani-Fedida (2014) postulated that projects fail due to ineffective social interactions between the project stakeholders rather than lacking or ineffective project management practises. Numerous studies by various authors such as by: Aaltonen *et al.*, (2008), Schepper *et al.*, (2014), El-Gohary *et al.*, (2006) show the essence of stakeholder management. Ineffective stakeholder management on construction projects can have dire consequences such as cost overruns, significant delays and in worse cases project closure. So it is highly important for any

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organisation to manage stakeholders effectively in order to achieve their project's goals.

Stakeholder management has been researched a lot in the context of projects delivered by traditional means. However it has not been researched on Building Information Modelling (BIM) implemented projects. BIM affects the overall traditional modus operandi of organisations in the delivery of projects. So it is important to investigate how stakeholder management is changing on BIM implemented construction projects. Moreover, BIM has been explored a lot in its technical domain, for example, in the aspects of 3D visualisations, energy analysis, clash detections, 4D, 5D, among others. However how BIM can assist in stakeholder management has not been explored. So a PhD study is being carried out to fill this gap. Moreover, this will act as an additional pull factor for organisations to adopt BIM on their projects. The following sections, based on the study, will briefly discuss the critical literature review, methodology, data analysis, discussion, conclusion and outstanding work consecutively.

Literature Review

Building Information Modelling (Bim)

The concept of BIM originated at Georgia Institute of Technology and was developed in the mid-1970s by Eastman and was originally called Building Description Systems (Cao *et al.*, 2015; Rokooei, 2015). There is no universal consensus on the definition of BIM. However, for this research the definition proposed by Succar (2009) is adopted which described BIM as “a set of interacting policies, processes and technologies that generating a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle” (p.357). This definition promotes the holistic nature of BIM that also incorporates project management related tools and processes in addition to the software that enables 3D modelling and input of information. From this perspective BIM is viewed as a tool for more effective project management (Bryde *et al.*, 2013).

Rokooei (2015) argued that BIM helps to foster communication among stakeholders in several ways, for example, BIM models allow the input, modification and analysis of data which makes stakeholders to communicate with each other more effectively and thus reduces disputes between them. BIM provides project managers opportunities to improve and promote collaboration among stakeholders (Bryde *et al.*, 2013) because different models prepared by different parties are federated into one model, so that all parties have to work simultaneously as a team on one big model (Rokooei, 2015).

PAS 1192-2:2013, EIR and BEP

In the paper: PAS 1192-2:2013, Employer's Information Requirements (EIR) and BIM Execution Plan (BEP) are discussed in the context of the stakeholder management only. PAS 1192-2:2013 provides guidance for information management during the construction phase of a project. It explains the EIR and BEP, among other issues. EIR is a pre-tender document which becomes a part of the tender documents for the procurement of design and construction teams. BEP has two parts i.e. pre-contract BEP and post-contract BEP. The pre-contract BEP provides guidance on how the requirements set by the employer in the EIR will be met. Once the contract is awarded, the post-contract BEP will specify everything in detail. It is basically a refined and more detailed version of the pre-contract BEP. PAS 1192-2:2013

provides a good guidance for both the BEPs. All these three documents are interrelated.

PAS 1192-2:2013 and EIR are coherent documents in terms of providing guidance for stakeholder management on BIM implemented projects. PAS 1192-2:2013 provides an overview of what should be included in the EIR. For example (related to stakeholder management), PAS 1192-2:2013 states that EIR should specify requirements to bidders for the management of coordination, clash detection and collaboration processes. It also states that training requirements (if required) should be included in the EIR. The EIR takes this to the next level by specifying in more detail the requirements from the bidders. EIR has explicitly categorised its contents into three parts, namely, technical, management and commercial. The EIR highlights the key areas for which the bidders have to fulfil the requirements. For example, for the collaboration process it asks the bidders to specify how frequently they will collaborate, details of model review workshops and other collaborating working practices, among others. For roles and responsibilities, the EIR highlights the guidance documents to be followed. PAS 1192-2:2013 also provides guidance on the roles involved in a BIM process.

The guidance provided in these documents will make project stakeholders to overcome the boundaries in other procurement approaches (for example, traditional procurement approach) and contractual barriers and make them to collaborate and coordinate with each other (Singh *et al.*, 2017) because they have to increase collaboration and coordination to devise plans to specify in the BEP.

Stakeholder management

The APM Body of Knowledge (2006) defined stakeholder management as “the systematic identification, analysis and planning of actions to communicate with, negotiate with and influence stakeholders” (p.20). Many researchers have proved that project stakeholder management is one of the most critical factors to make a project successful (Offenbeek and Vos, 2016; Travaglini *et al.*, 2014) because the project’s success or failure significantly depends on the perceptions of every individual stakeholder backed by their ability and willingness to act either in favour or against the project (Bourne, 2005).

METHODOLOGY

A constructivism philosophical orientation underpins the empirical research which is a sequel to the (foregoing) review. This orientation believes that individuals develop subjective views about objects or phenomenon from their experience. In this paradigm, a researcher would seek the complexity of the views developed by individuals (Creswell, 2014).

Semi-structured interviews were conducted to collect data and discover the experiential world of the interviewees within topical dimensions. Semi-structured interviews allow an interviewer freedom to diverge slightly from the script (McIntosh and Morse, 2015).

Purposive sampling was adopted for selecting the interviewees because it allows the selection of participants based on their specific characteristics such as experience, perspectives, expertise (McIntosh and Morse, 2015). Specifically the participants targeted are working on BIM implemented projects. The sample size of 5 is too small to represent the whole construction industry but more interviews are planned.

The interviews were conducted face to face except the interview No.4 which was conducted using a webinar. The average interview time was 58 minutes. The interviews were recorded using both a phone and Dictaphone simultaneously. The interviewer played a major passive role and a partial active role while conducting interviews. The questions were asked and prompts were provided only when an interviewee was diverging from the topic. The interviewer did not suggest ideas while interviewing. The interviews were transcribed exactly word to word where the “oTranscribe” tool was used. The interview transcripts were uploaded to the “NVivo” software which was used to analyse the data in a process explained by McIntosh and Morse (2015).

Data Analysis

Conventional content analysis was adopted for analysing data. Conventional content analysis is an inductive approach in which the researcher develops categories from the data to make new insights to emerge (Hsieh and Shannon, 2005). It is usually used in research where the aim is to describe a phenomenon. Thematic analysis could be adopted for analysing data but content analysis provides opportunity for quantification of the data. It means themes or categories in content analysis can be presented as a frequency of appearance. However, quantification in this regard requires extreme caution because one theme could appear more frequently in one interview and less in others. This can erroneously make a theme or category to look more predominant (Vaismoradi *et al.*, 2013). Due to the limited number of interviews, the quantification of data is not considered in this paper.

Initial themes were generated from the data and coded. As the analysis progressed, more themes were generated, some were merged with others, and thus the analysis progressed as an iterative process.

Information about Interviewees and Their Background

Data from five of the interviews conducted so far have been analysed. The paper is based on this limited analysis. The profile of interviewees and their organisation is shown in table 1. For confidentiality reasons, the identities of the interviewees have been anonymised as A, B, C, D and E.

Table 1: Profile of interviewees and their organisation

Interviewee	Experience	Role	Length of using BIM (organisation)	Organisation's BIM maturity level	Organisation sector
Interviewee A	1 year	BIM coordinator	2 years	Between 1 and 2	Infrastructure (highways)
Interviewee B	17 year	Divisional engineering manager	10 years	Level 2	Infrastructure (geotechnical)
Interviewee C	30+ years	Design manager	2 years but has been using BIM for 4 years	Between 1 and 2	Infrastructure (highways, airfields, rail)
Interviewee D	20 years	CEO	20 years	Level 2	Software firm
Interviewee E	10 years	BIM manager	6 years	Level 2	Infrastructure (schools, prisons), housing sector

The objective was also to investigate who are the key stakeholders on BIM projects as perceived by the construction industry. The interviewees perceived stakeholders as usually those with whom they liaise with on a daily basis (shown in table 2). For instance, interviewee B treated stakeholders as those who have financial input to the project i.e. people who are more linked to the client, their supply chain, employees and, sub-contractors. However, interviewee B further acknowledged that if it is a big project like High Speed 2 (HS2) then members of the public would be key

stakeholders as well, as permission would be required from some of them to access their lands to do site investigation.

Table 2: Entities perceived as their stakeholders by the interviewees' organisations

Interviewee	Stakeholders
Interviewee A	Designer, client (infrastructure), all office colleagues
Interviewee B	Client (infrastructure), supply chain, employees, sub-contractors, public
Interviewee C	Asset managers, contractors, local councils
Interviewee D	Owner, teams that are creating 3D models
Interviewee E	Architects, structural engineers, MEP engineers, supply chain, sub-contractors, internal team, client, client's representative, technical advisor, end users

The Role BIM Plays in Stakeholder Management

Common goals and problem solving

BIM models hold the potential to assist in solving problems between different construction stakeholders. This is due to the inherent property of the BIM models which allows data to be added, modified and then to be verified against real life scenarios. This unique property of BIM models assists in reducing disputes among different project stakeholders (Rokooei, 2015).

This was noted by one of the interviewees on a motorway construction project where one of the stakeholders objected to the construction of a gantry because of the fear of glare from the gantry into their window during night. This stakeholder approached the project team and raised the concern. The project team then put the exact location of the house, fence and gantry into the BIM model and showed them that if the fence of their house was 3 metres high then light would not glare into their window. The organisation presented the result to the concerned stakeholder in a visual way by using the BIM model and this convinced the stakeholder. According to interviewee A:

The stakeholder was satisfied with the result otherwise we have to stop the construction of that gantry because that stakeholder didn't want it.

There are other ways as well in which this issue could have been demonstrated to this concerned stakeholder e.g. by using simple maths or theodolite. However, BIM provided a ready basis through visual representation which was comprehensible to the stakeholder and it addresses stakeholder's concern.

Pre-planning

BIM helps in pre-planning the activities to be carried out in much advance and provides opportunity to stakeholders for providing feedback. The project team then can work on this feedback to implement required changes (if demanded by stakeholders). This makes stakeholders to feel that their concerns are being addressed by the project team and eventually helps in setting common goals (in favour of a project) among all stakeholders. For example, interviewee A illustrated traffic management signs on a BIM model (on a highway project in the UK) to client, police and other stakeholders eight months in advance to get their feedback. According to interviewee A:

We showed to police and client and lots of other stakeholders and got feedback from them and we will change it before that.....and get the same thoughts and things.

Interviewee B also noted that BIM assists in pre-planning activities. If the stakeholders are not agreed then the plan can be changed digitally. Interviewee B stated,

adjust things digitally so that when we turn up on site, all we do is implement the plan.

Clarifying intentions

Emmit and Gorse (2003) argued that in the construction industry when one party fails to convey its intentions to another party, it engenders dispute between both the parties.

This was noted by interviewee B that BIM helps in clarifying intentions about the project programme to the construction stakeholders. If intentions are made explicit among all the stakeholders then they will all know what is needed to be done. It often happens that not all stakeholders understand the intentions of project teams equally. So the time when a task is required to be executed, some stakeholders may perceive things differently. According to interviewee B:

It [BIM] increases I think their confidence that they understand our intentions and sometimes they don't agree with our intentions and that's absolutely fine....at least if everybody understands our intentions even if half of them wouldn't agree with it and then they can say alright lets discuss what your plans are and we can come to an agreement.

Collaboration

Liu *et al.*, (2017) investigated how BIM made project stakeholders to meet frequently which resulted in generating higher trustworthy environment and strengthening their relationships.

This was echoed by interviewee E who explained that their organisation organised BIM workshops where all the design teams could collaborate with each other. It helps in taking much better informed decisions because everybody is working together. No one is working in silos and no one can hide anything. Accordingly;

...rather than doing things individually we bring everyone together. So everyone in the room can collaborate. It's a much better way of working. (Interviewee E)

Communication

Communication is highly important for the execution of complex projects performed by teams. This is extremely pertinent to the construction industry where stakeholders need to exchange information in order to execute projects successfully (Dubas and Paslawski, 2017). Communication helps stakeholders to establish trust and foster empathy among themselves (Emmitt and Gorse, 2003). Digital tools such as BIM can assist in improving communication with construction stakeholders (Dubas and Paslawski, 2017) in many different ways. Three common themes (common language for communication; facilitates communication with non-technical stakeholders; effective communication of complex ideas) related to communication emerged from the interviews are discussed below.

Common language for communication

According to interviewee D there is a huge potential of miscommunication on construction projects due to disconnected data sources. Moreover, project stakeholders come together for one project and then their teams are disbanded. This factor further contributes to miscommunication. The objects in BIM models can retain the data attached to them. This property of BIM helps to avoid miscommunication among stakeholders by providing a common language for communication.

...for us to say that you know there is an object that certainly can take data and have a path right the way through from a section to right the way through the in life you know facility. That's a very valuable thing. So what role does it play in stakeholder management? It integrates and it helps to improve the communication between people. (Interviewee D)

Facilitates communication with non-technical stakeholders

BIM improves communication with stakeholders who cannot understand 2D drawings. The reason for this is that 3D models are easy to understand than 2D drawings. In 2D drawings, a person has to analyse the drawing first and then to visualise what a structure would look like in 3D. Moreover, different stakeholders may visualise them in different ways. This may create confusion among various stakeholders and could have detrimental impacts on the project (Fazli *et al.*, 2014).

It is helping in communication by showing them the models is better than just standing in front of them and talking and saying we are going to do this and that. But if you show them the model like we have done with the traffic management signs, they can actually visually see it as you are explaining to them. So it's better communication for them because they can visualise what you are talking about. (Interviewee A)

Interviewee C had similar perception that 3D models can play a key role in explaining what a project is about to the public or stakeholders with less technical knowledge.

Interviewee E had a similar perception that BIM models make stakeholders understand what is going to be built. This interviewee E gave an example of one of their project where stakeholders came to the room straight away, picked 2D drawings from the boards and said they hate these drawings because they could not visualise from these.

Effective communication of complex ideas

Clash detection in BIM enables early risk identification and communication (Zou *et al.*, 2017). Interviewee B noted on one of their projects that digital tools can assist immensely to communicate complex ideas to stakeholders. While carrying out one of the geotechnical projects, an owner of the existing asset under the ground approached interviewee B's organisation with a concern that they may damage their asset. Interviewee B's organisation performed clash detection in a BIM model and presented the real results to the owner of that asset.

...what we need to do is to give them confidence that we are not gonna damage their asset, and to give them a cup of tea and say don't worry it will be fine, doesn't cut it. Whereas we show them a 3D model and say let's start, here is your asset and here's an inclusion zone we are putting around it and here's where we have designed the ground anchors to go and here is the zone of tolerance around where they could end up and that still doesn't clash with your exclusion zone - are you happy with that..? and they go well that's better. (Interviewee B)

Visual scoping of work

Interviewee D's organisation has developed a software which assists in developing the scope of work in a visual way. It assists in assigning roles to the stakeholders relative to the time when those roles are required to be performed. It further assists in managing the information requirements at all the project stages, the level of information required, assigning responsibilities to manage that information, updating progress, among others. As all this happens in a visual way, it helps all stakeholders to understand their (and others') responsibilities in a very engaging way and monitoring the progress. Stakeholders can visually see who is required to do what and take mutual decisions. This can help in assisting stakeholders who are lagging behind in their roles. So it promotes collaborative ways of working.

Challenges with BIM and Scope of the Paper

The implementation of BIM on projects has some challenges. For example, training the supply chain on its use, unwillingness to learn new things and unwillingness to adapt digital ways of working are some of the hindrances against the adoption of BIM. However, the current paper is not focused on the challenges but on the role BIM can play in enhancing stakeholder management.

DISCUSSION

The interviewees perceived stakeholders on BIM projects as those who are generally involved in the process. These were usually internal stakeholders (table 2).

Stakeholder engagement is a key aspect in managing stakeholders. It can help in resolving conflicts effectively among stakeholders and setting common goals among them (Singh *et al.*, 2017). BIM provides the opportunity to engage concerned stakeholders by using visual means. This promotes trust and acceptability of project results by stakeholders and aligning their goals. Pre-planning activities provides opportunities to stakeholders for providing feedback. When stakeholders' feedback is incorporated into the project, it enhances their trust in it. This eventually helps in aligning their goals with those of the project. Moreover, when there is a mutually agreed plan, then there is a common goal for all the stakeholders to achieve. Clarifying intentions in advance enables the avoidance of conflicts later on in projects. Conveying intentions to stakeholders and then liaising with them if they are not agreed is a part of stakeholder engagement. This facilitates mutually agreed decisions which engenders trust among stakeholders, and gives rise to common goals.

According to Yong and Mustaffa (2013) communication should not be focused only on tasks or words, it should rather be focused on fostering relationships among stakeholders. Effective communication is a critical tool to maintain existing relationships (Chinyio and Akintoye, 2008; Khafaji *et al.*, 2010). BIM helps in fostering communication among stakeholders whether they possess technical background or not. By providing a common language for communication, it eradicates the probability of miscommunication which may leads to issues at a later stage. By facilitating communication with non-technical stakeholders, it allows them to understand the project in a better way. This enables stakeholders to resolve any confusion digitally rather than doing so on-site. When things are uncertain (especially when the projects are of geotechnical nature), BIM can assist immensely to resolve issues and communicate the results by using visual means to the stakeholders concerned. This helps in engendering trust among stakeholders by mitigating their concerns.

Conclusion, Limitations and Outstanding Research

Setting common goals with the stakeholders is the key to managing them effectively. If stakeholders have different goals then these must be aligned with the project's goals. Stakeholder engagement is the key to setting common goals with them. This is due to the reason that it allows stakeholders to provide feedback to the project activities. Furthermore, it also assists in making them to speak out their concerns related to the project. Their concerns can then be tackled and feedback provided by them can be worked on to set common goals between the project and its stakeholders. This makes stakeholders feel satisfied and their trust is generated in the project.

Communication plays a key role in engaging stakeholders with the project. BIM has a huge potential to facilitate communication among different stakeholders by various means, for example, it facilitates in making communication more visual.

Furthermore, BIM fosters collaboration among stakeholders as well. Both these factors assist in facilitating and fostering stakeholder engagement.

In summary, BIM has a huge potential to manage stakeholders effectively on construction projects. Even the roles that are not directly/indirectly related to BIM can benefit from increased and better communication and collaboration.

Communication, collaboration, stakeholder engagement, trust, common goals, technology and people are at the core of managing stakeholders within BIM projects.

This paper is based only on five interviews and the interviewees' do not reflect the entire spectrum of stakeholders. The research interviews are currently on-going and it is hoped that a diverse range of industry professionals will be interviewed. Therefore, the current conclusions are temporary and might change with further data collection.

This paper has presented the findings from the first five interviews related to the role BIM can play is stakeholder management. These findings are treated as preliminary findings. This research is also looking into other aspects which are outside the scope of the current paper e.g. the challenges which organisations face while managing stakeholders on BIM projects and the techniques used to manage stakeholders on BIM projects.

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VISTAS OF STRATEGY-MAKING WITHIN NORTHERN IRELAND CONSTRUCTION FIRMS: HOW SME'S DIFFER FROM LARGE FIRMS

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The Northern Ireland (NI) construction sector endured a more austere deterioration from the 2007 economic recession, compared to the rest of Great Britain (GB). Indeed, the sector experienced a consistent downward trajectory in output from 2007 to 2013, with a moderate recovery ensuing during 2014 and 2015. Consequently, construction firms, both large and small, responded to this cacophony of environmental change; scrambling to capture market power and preserve competitive advantage. Extant empirical research has shown that the pressure on chances of survival in an industry is far greater for smaller firms than for larger ones, and furthermore, that start-up firms fail at a higher rate than their larger rivals. Within the general management domain, there is a serious paucity of research investigating episodes of strategy-making within small and large firms during a period of economic contraction and growth; hence the emergence of this topic. To address this research gap, two comparative case studies with different macro-level outcomes, were used to examine episodes of strategy-making within NI construction firms during the period 2007 - 2015. Resonating under the strategizing praxis theme, the results suggest that large and SMEs differ substantially in their responses to industry environments, and subsequently in their strategy-making philosophy and approach. The large firm's generic strategy-making philosophy was based on deliberate and purposeful activities, while the SMEs philosophy was founded on the emergence of strategies non-deliberately. Lastly, the findings will enable top managers to recognize and reflect on how 'strategy is actually made', and how this relates to macro strategic change over time.

Keywords: Northern Ireland, organizational turnaround, SME, strategy-making

INTRODUCTION

Across the extant literature, there is much debate regarding the effects of firm size on strategic response to environmental change. Indeed, the literature suggests that small and large firms possess fundamentally different resources and capabilities (Shama 1993). Despite the wealth of 'isolated' strategic management empirical work of both the 'large' and 'small' research streams, the body of 'comparative' research remains modest, particularly in the realm of construction management. Furthermore, within the general management domain, no comparative research (as far as we are aware) has

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been performed on episodes of strategy-making within small and large firms, particularly during a period of economic contraction and growth. In this study, we address this gap by exploring episodes of strategy-making within large and SME NI construction contractors during the period 2007 - 2015.

To put into context, economic activity in NI peaked in Q4 2006 and subsequently deteriorated until Q2 2013; representing an 11% decline (NISRA 2017). As such, this decline equates to an extremely severe recession, where the peak-to-trough decline in output exceeds 10%, and is subsequently known as a depression (Claessens *et al.*, 2009). In a similar vein, construction output peaked in 2007 at £3.4 billion and then contracted for six consecutive years, reaching a trough in 2013, valued at £2.1 billion (NISRA 2017); representing a 38% decline. Since 2013, a recovery in the construction sector ensued, with construction output figures for 2015 reaching £2.6 billion. On the basis of these changing economic conditions, the study draws on two exploratory case studies in order to explore their generic strategy-making philosophy, whilst also exploring episodes of strategy-making within the practices of internationalization, domestic reorientation, cost/asset retrenchment, and tendering/procurement.

THEORETICAL BACKGROUND

Given the considerable overlaps and affinities between the strategy process (SP) perspective and the more recent strategy-as-practice (SAP) approach, a number of authors have recently tried to conceptually distinguish between both notions (see for example, Kouamé and Langley 2017, and Tsoukas 2016). Indeed, both approaches seek to answer the same conundrum: how do organizations make strategies? Also of concern in the SP and SAP domains is the lack of explicit connections with macro-level phenomena, such as strategy outcomes and performance outcomes (Johnson *et al.*, 2003; Seidl and Whittington 2014). On this basis, Kouamé and Langley (2017) suggested using cross-case comparative logic to bridge the link between micro-processes and macro-outcomes.

Strategy-Making

Similar to the blurred lines between SP and SAP, disorientation also seems to exist between 'strategy-making' and 'strategizing' (Jarzabkowski *et al.*, 2007). Indeed, Tsoukas (2016) argues that a clear distinction should be made between 'strategy-making' and 'strategizing'. He further contends that strategy-making can occur in both deliberate and non-deliberate ways, while strategizing, which is an intentional and conscious activity, generally involves deliberate actions. Vaara and Whittington (2012) also make similar distinctions, describing strategy-making as a plethora of activities that lead to the creation of strategies, and strategizing as more or less deliberate strategy formulation (i.e. strategy work or the doing of strategy). On this basis, strategizing is situated under the higher-level term 'strategy-making' (Vaara and Whittington 2012; Tsoukas 2016). However, with regard to the strategizing conceptual framework developed by Jarzabkowski *et al.*, (2007), if praxis is based on the notion of emergence then the central concept of 'strategizing' does not really align with the descriptions depicted above. Indeed, at this juncture it becomes clear on how these two terms have become conflated in the extant literature.

The SAP field is underpinned by the 'what', 'who', and the 'how' - known as 'practices', 'practitioners', and 'praxis', respectively (Jarzabkowski *et al.*, 2016). According to Vaara and Whittington (2012, p.290) 'praxis refers to the activity involved in strategy-

making'. Indeed, strategy-making has also been described as a dichotomy of strategy activities, entailing inductive and deductive approaches (Regnér 2003), while more recently this has extended to a trichotomy, involving inductive, deductive and abductive approaches (Tansey *et al.*, 2018). It is this inductive or non-deliberate element of strategy-making (i.e. strategy without design) that aligns particularly well with the Heideggerian views of Chia and Holt (2006, 2009). The authors depict two modes of strategy-making - the conventional and dominant 'building mode' based on purposeful strategic activities, and the basic 'dwelling mode' that is based on the emergence of strategies non-deliberately throughout everyday practical coping (De La Ville and Mounoud 2016). Chia and Rasche (2016) have further developed this view, indicating that practical coping requires forms of tacit knowing; phronesis (prudent practical wisdom) and metis (practical intelligence for escaping puzzling situations); which are acquired through experience and the immersion of embedded social practices.

Firm Size and Strategic Response

Empirical research has shown that the pressure on chances of survival in an industry is far greater for smaller firms than for larger ones (MacMillan 1980). Indeed, across the extant literature, there is much debate regarding the effects of firm size on strategic response to environmental change. Some scholars argue that firm size dictates competitive advantage, which is a derivative of economies of scale, scope and learning effects (Bain 1956; Porter 1980). Scholars have even argued that smaller firms many exhibit increased flexibility, resilience, and adaptability in terms of organizational structure and processes when responding to reduced environmental munificence (Chen and Hambrick 1995; Carr *et al.*, 2004).

Both large and small firms face different economic environments depending on their market power and target markets. In fact, the literature further suggests that firms' responses are generally dictated by the competitive advantages available to them (Latham 2009), given that small and large firms possess fundamentally different resources and capabilities (Shama 1993). For instance, large size firms have been seen as garnering competitive advantages such as; economies of scale and scope, and learning effects (Ghemawat 1986). On the other hand, small firms are limited in their product and geographical scope and may have limited learning effect advantages (Latham 2009), however, they possess a number of competitive advantages such as; increased sensitivity to both customers and the market (Dean *et al.*, 1998), and increased flexibility in production (Fiegenbaum and Karnani 1991). In terms of market power, larger firms usually have higher proportions which helps them during times of economic decline. Smaller firms, on the one hand can have a protected market niche which helps them during recessionary periods, while other small firms who are unable to attain finance, can sometimes be forced out of business (Shama 1993). Regarding resources, larger firms are often associated with abundant slack resources (Singh 1990), which may give the firm an increased ability to attack competitors (Chen and Hambrick 1995). Conversely, smaller firms with less resources, potentially possess more sensitivity to changing market needs than their larger counterparts (Latham 2009).

RESEARCH METHOD

Based on methodological recommendations of Eisenhardt and Graebner (2007), two cases with different macro-level outcomes (turnaround vs non-turnaround) and at two different extremes (large vs SME) were deliberately chosen for cross-case

comparison. On this basis, the research method adopted consisted of two exploratory case studies of NI construction contractors. Given that the collection of information concerning strategy-making is very sensitive (Regnér 2003), and also that the approach involved an in-depth exploration concerning 'how' type research questions (Yin 2014), a case study approach was deemed appropriate. Indeed, several proponents of the SAP perspective have favoured qualitative methods in their research (e.g. Balogun *et al.*, 2003; Johnson *et al.*, 2007). More specifically, given that theorizing in the SAP field is at a relatively 'early stage' (Kouamé and Langley 2017), exploration of the respective phenomena are particularly relevant for in-depth qualitative inquiry (Graebner *et al.*, 2012). On the premise of the foregoing theoretical background, the central research question formed for empirical work was thus: How did vistas of strategy-making differ between large and SME NI construction contractors during the period 2007 - 2015?

Selection of both case firms was broadly based on a criterion sampling strategy related to annual turnover that aligns with the requirements set out by the European Commission (2005). Considering this, the 'large' firm had an annual turnover greater than €50 million in 2007, while the 'SME' had an annual turnover of less than €50 million. With regard to firm types, both cases were predominately civil engineering / building companies. In relation to the empirical inquiry, field data was drawn from semi-structured interviews (with senior management), and was supplemented with company documents and archival data. Semi-structured interviews fill the spectrum between the two extremes of unstructured and structured interviews (Fellows and Liu 2008) and allow an in-depth investigation of the phenomena. A semi-structured interview instrument was thus utilized to assess two main areas - general company information and turnaround strategizing practices (episodes of strategy-making) during the period 2007 - 2015. The second stage of the interview initially utilised strategic themes (emanated from a review of key empirical strategic management studies) for broader level questioning. Subsequently, more focused questions were used to drill down at the micro-level, thereby generating episodes of strategy-making.

Interviews were conducted on-site at the firm's headquarters, and lasted between 90 and 130 minutes. Each interview was subsequently recorded (with the respondent's permission) and transcribed verbatim. To confirm accuracy and to ensure construct validity, transcripts were verified by the participant's (Yin 2014). A three stage qualitative coding process as recommended by Saldana (2013) was adopted for the research and consisted of: first-cycle coding, second-cycle coding, and lastly the post-coding and pre-writing stage.

DISCUSSION

A total of 16 categories emerged from the qualitative data analysis, however due to space restrictions, the scope of the discussion will be focused on episodes of strategy-making within the practices of internationalization, domestic reorientation, cost/asset retrenchment, and tendering/procurement. Before exploring vistas of strategy-making, the firms' generic strategy-making philosophy is firstly examined.

Firms' Generic Strategy-Making Philosophy

The large firm's strategy-making philosophy was based on a deliberate approach, while the SMEs course tended to be non-deliberate and emergent in nature. Indeed, the case data confirmed that the large firm develops three-year strategic plans which are reviewed and updated on an annual basis. Additionally, the firm utilises an

external facilitator for their strategic review days with the board of directors, and also for the preparation of the strategic documentation. Each year the updated (or new) strategic plan is presented to the whole business at their strategy forum, where the CEO (Chief Executive Officer) outlines their strategic objectives (corporate and business unit), work types, geographical areas of work and respective value sizes. Considering this, strategizing is thus an intentional and conscious activity, involving deliberate strategy formulation (cf. Tsoukas 2016; Vaara and Whittington 2012). This also tends to resonate with Chia and Holt's (2006, 2009) 'building mode', which is based on purposeful strategic activities.

In contrast, the case data illustrated that the SME didn't intentionally strategically plan, yet they non-deliberately created strategies in order to deal with the banks and to ensure their survival. Interestingly, in late 2007 the SME decided to use an external solicitor that they knew, as a sort of business consultant; to help them deal with pressing banking issues. Moreover, both directors of the firm met with the solicitor every Friday afternoon and went through critical actions that needed addressing. As such, they proactively created short-medium term strategic plans for the bank and therefore dealt with the immediate pressing problem of sustaining their business and servicing their loans. The SME acknowledged that at the time of negotiating with the bank and creating solutions, they didn't realise that they were inadvertently creating a strategic plan to survive. These findings thus concur with Bruton *et al.*, (2003) who established that financial institutions very often apply extensive pressure on firms in decline to take decisive actions. Strategy-making in this case aligns with Chia and Holt's (2006, 2009) 'dwelling mode', which is based on the emergence of strategies non-deliberately throughout everyday practical coping (De La Ville and Mounoud 2016).

Episodes of Strategy-Making

A number of practices will now be examined, with particular emphasis on praxis i.e. the activity involved in episodes of strategy-making.

Practice of internationalization - Resonating under the strategizing praxis theme, the results show that the large firm who already had extensive international experience, actually reduced its international expansion intensity, and undertook a more cautious approach during the period. In contrast, the SME tended to diversify into mainland GB markets, such as England and Scotland. Indeed, for the large firm, its level of resources (including knowledge structures) and path dependency triggered its entry into the US market. More specifically, given the high mobility of their prevailing human resources and the firm's path dependency of similar work in South America, the firm were in a position to tender for and subsequently win work in the US. On this basis, internationalization was abductive in nature and was partly achieved through the exploration of new markets (inductive strategy making), but more through the exploitation of established resources and knowledge structures (deductive strategy making) (cf. Regnér 2003).

Practice of domestic reorientation - With regard to new GB markets, the large firm increased its emphasis on English and Scottish markets in 2008, while the SME waited until 2014 to increase its emphasis. The SME perceived that they could maintain themselves in NI, and therefore put all their resources and effort into attaining work locally. During 2014 and 2015, the SME acknowledged that they were forced to evolve and to seek other markets, particularly given the increased competition and various supply-chain issues encountered in NI. Moreover, the firm

reported that there was a serious lack of quality subcontractors left in NI; with most of them leaving for London and Dublin.

The case data for both firms provides some thought-provoking episodes of strategy making within the practice of domestic reorientation. For instance, the SME utilised its stakeholder relationships to augment diversification into the London market. More specifically, the commercial director contacted architects and engineers in NI whom they had long-term relationships with, and who were already operating in the GB environment. Regarding one particular architectural firm from NI, the SME got the opportunity to tender for a private building project in London, and also another one in the north of England. Interestingly, they resourced all the GB projects with their own core management teams from NI, whilst also relying on some NI subcontractors. This resourcing decision was triggered by their relational assets, in that, a Republic of Ireland (ROI) contractor who they joint ventured with in NI, and whom had successfully established themselves in the GB market during the recession, advised them on how to resource such endeavours. In contrast, the large firm was able to enter more sophisticated sectors like the private 'energy from waste' sector; mainly because of its strong balance sheet and ability to procure performance bonds. However, given that the firm was relatively unknown in England, it took them four years to get established in this particular market. This entailed the firm having to employ a business development executive to find opportunities and build new relationships, and also a marketing person to start profiling the business. With these resources (human and financial) embedded, the firm started a marketing campaign in GB in 2012, and as such, started entering awards like, company of the year, investors in people, and various health and safety awards; just to try and build their profile.

Within the practice of domestic reorientation, strategy making for the SME tended to be deductive, while for the large firm, strategy making was more inductive in nature. More specifically, for the SME, strategy making was characterised by the exploitation of prevailing resources and industry networks, while for the large firm, strategy making was achieved through the exploration of new markets and the establishment of new knowledge structures (cf. Brown and Duguid 2001).

Practice of cost / asset retrenchment - Regarding cost retrenchment, the large firm tended to freeze salaries and reduce employee numbers over a short period of time, while on the other hand, the SME froze salaries and reduced employee numbers for longer periods. Indeed, the case data confirmed that the large firm froze salaries during a two year period (2011 - 2012), while the SME froze salaries over a 5 year period (2008 - 2012). Moreover, the large firm reduced its employee numbers by 33% during the period 2010 - 2012, while the SME had to dramatically scale down its workforce by 49% over the period 2008 - 2014. In relation to the notification of imminent cuts across both case firms, different mechanisms were utilised by management. Exploring the episode of strategy making within the large firm, praxis entailed the company CEO briefing the whole business by visiting each of its three main regions (Northern Ireland, England, and Scotland) over one week. Depending on numbers in each region, a hotel or main office was used as the location for each of the briefing sessions. Deciding to be honest and upfront with staff, the CEO conveyed that there was going to be redundancies, a removal of bonuses, and a freeze in salaries. The firm was very insistent that these retrenchment actions were to be implemented within a six month period - before its end of year strategic review. In contrast to this, the SME conveyed such measures through unplanned informal encounters (e.g. verbally told each individual) - form of sensegiving (cf. Gioia and Chittipeddi 1991).

In relation to asset retrenchment, the SME had to sell off a significant portion of its land portfolio given its 'high severity' situation. Indeed, this decision formed part of the overall strategy that was agreed with the banks. On this basis, the bank exerted high influence over the contracting firm through network based power (cf. Pajunen 2006). This is also consistent with Robbins and Pearce (1992) who found that the only way to achieve improvements in performance for firms in severe turnaround situations, was to supplement cost retrenchment with asset reductions. In contrast, the large firm didn't have to initiate any asset reductions mainly due to its robust and healthier financial position. For both firms, the strategy making episode was deductive, in that, deliberate cost-cutting measures were implemented in order to stem the pressing problem of organisational decline (also found by Tansey *et al.*, 2018).

Practice of tendering / procurement - In relation to below cost tendering, the large firm made a conscious decision during the period of not going below cost in order to chase turnover, or to keep experience for future pre-qualifications. On the other hand, for the SME, the only way of securing work was by tendering below cost. Indeed, the SME started tendering below cost in 2008, however by the end of 2015 the firm made a conscious decision that they were no longer going to buy work. Interestingly, the SME revealed instances of aggressive below cost tendering in certain sectors of the NI construction industry. For instance, on one particular public works framework contract, firms had to make their adjustment to the schedule of rates. The SME went in at -5%, however, a contractor with rates of -45% won the contract. Soon after starting the contract, this firm went bankrupt, thereby leaving the next contractor in line (at -30%) to start. In a similar vein, they also went bankrupt, with the project now being constructed by a contractor at -15% rates. These findings thus align with those of Hillebrandt *et al.*, (1995), who found that firms will often have to bid below cost or at cost in order to secure work during recessionary periods.

In comparison to the SME, the large firm tended to formalize most of its tendering/procurement practices during the period 2007 - 2015. For instance, the large firm actually reduced the volume of projects that they tendered for, and started to be more selective. In the past, the firm would generally tender for most projects, and would often get half way through a tender before realising that the project was not suitable for them. On this basis, the firm ceased its 'scatter-gun' approach and spent more time focusing on projects that they actually wanted and that were strategic for the firm. To aid this new approach, the firm brought in a formalized 'stop-go' methodology for its tendering practice in 2012. This 'praxis' entailed the new business development executive devising a weekly opportunities report for the board. Every Tuesday the senior management team (head office and operations) would meet and make a 'stop or go' decision on each opportunity using a rational assessment framework.

Subsequently, if the firm prequalified, they would adopt the same methodology with regard to proceedings to tender. To further strengthen this new practice, the large firm substantially increased personnel in its tendering/procurement departments. In contrast, the SME decided to reduce personnel in their tendering department as part of its cost-cutting measures. Not surprisingly, the SME acknowledged that they made a huge mistake by not replacing their bid writer who left during the turbulent period. With regard to changes in procurement methodologies, a stark difference was also apparent between both cases. More specifically, the large firm started to consult more with its supply chain at pre-tender stage, thereby securing better prices and pre-deals. This ensured that the submitted tender price was robust and that all the risk was closed

off at an early stage. In contrast, the SME tended to focus on supply-chain cost reductions at a latter, post-tender stage. Once the firm acquired a project (usually below cost/at cost), they would only then start splitting up supplier packages in order to try and achieve cost reductions.

Within the practice of tendering/procurement, strategy making for the SME tended to be deductive and was solely based on cost minimizations and efficiencies. For the large firm, strategy making was more inductive in nature, and was based on the addition of new resources and the 'trying out' of new knowledge structures.

Performance Outcomes

Based on the suggestions of Kouamé and Langley (2017), the SAP micro-processes discussed above were bridged with turnaround macro-outcomes. On this basis, the large firm achieved 'turnaround success', while the SME attained only 'partial turnaround success' during the period 2007 - 2015. More specifically, for the large firm, profit and turnover levels recorded for 2015 exceeded pre-downturn (2007) levels of performance, while for the SME, profit and turnover levels were significantly less.

CONCLUSIONS

This study explored episodes of strategy-making within large and SME NI construction contractors during the period 2007 - 2015. This responds to recent calls by Kouamé and Langley (2017) to use cross-case comparative logic to bridge the link between micro-processes and macro-outcomes in qualitative strategy process and practice research.

The results suggest that large and SMEs differ substantially in their responses to industry environments, and subsequently in their strategy-making philosophy and approaches. The large firm's generic strategy-making philosophy was based on deliberate and purposeful activities, while the SMEs course tended to be founded on the emergence of strategies non-deliberately. Across the practices depicted, episodes of strategy-making for the large firm were realized mostly through an inductive approach, while for the SME, it was typically through a deductive path. More specifically, for the large firm, inductive strategy-making was mainly achieved through the exploration of new markets, addition of new human resources, and the establishment of new structures. In contrast, for the SME, deductive strategy-making was primarily realized through cost minimizations, and the exploitation of prevailing resources and industry networks.

Given the restriction of the empirical data to two cases, caution is therefore required in making generalizations. Despite this limitation, the findings will potentially enable top managers to recognize and reflect on how 'strategy is actually made', and how this relates to macro strategic change over time. Additionally, the findings provide a platform for further qualitative strategy process and practice research.

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IMPACT OF CONTRACTOR INTERNAL TENDERING PROCEDURE GOVERNANCE ON TENDER WIN-RATES: HOW PROCEDURES CAN BE IMPROVED

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Construction contractors normally, though not always, pursue tenders with the expectation of winning and subsequently making a project profit. Corporate governance (CG) constraints, risk appetite, and selected tender strategy impact contractors' tendered prices and any associated qualifications. Therefore, failure to win may not constitute 'failure' in senior executive's eyes. Increasing CG within some jurisdictions has led to more complicated contractor internal tendering procedures (ITP) with layers of management reviews and risk committee sign-offs. The question arises as to whether these changes make any difference to tender win rates and subsequent project outcomes. A series of qualitative semi-structured interviews were undertaken with 25 high-profile Australasian based construction contractors (11, either directly or via parent companies, operate internationally - Europe, Africa, Asia and North America), providing a mix of publicly listed and privately owned companies, as part of a wider research program investigating the efficiency and effectiveness of contractors' ITP. Moving beyond previous research limitations of smaller contractors (often sub-AUS\$100m turnover) this qualitative research looks at much larger contractors. Content analyses of the interview transcripts found that, while contractors talked equally about 'win' and 'lose', most did not see losing a tender as 'failure'. Only a quarter felt their changed ITP made a difference to their tender win-rate. Somewhat unexpectedly interview findings suggest that approximately three-quarters of contractors have ITP that do not formally require lessons learned (LL) from previous tenders nor projects to be inputs in subsequent tender pursuits. Larger contractors (over AUS\$500m turnover) were twice as likely to discuss LL, indicating different governance approaches to tender outcome expectations. Informal LL approaches were applied to clients' reputations (particularly payment) in bid/no-bid decisions. Interviewee suggestions of processes by which contractors can improve resultantly their LL procedures, as part of their CG, are also presented.

Keywords: contractor, corporate governance, failure, lessons learned, tender

INTRODUCTION

Good corporate governance (CG) involves codes and voluntary practices designed to facilitate effective management towards company long-term success (BEIS 2017). Major publicly listed contractors must comply with and report against listing rules, eg UK's Corporate Governance Code (Financial Reporting Council (FRC) 2016) or the

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Australian Securities Exchange's (ASX) Corporate Governance Principles and Recommendations (ASX 2014). Legislators are increasingly keen that similar CG requirements be adopted by significantly sized private companies to keep pace with business expectations (BEIS 2017). These rules require public disclosure of a contractor's risk management approach and viability (solvency and strategic planning for ongoing success). Contributing components of contractors' CG are their internal tendering procedures (ITP), as a board must determine "the nature and extent of the principal risks it is willing to take in achieving its strategic objectives" (FRC 2016: 5) and hence its internal control principles. An obvious question is whether a claim to causality may exist (Whyte 2015) between more elaborate ITP requirements and a contractor's tender win-rate, and subsequent project performance success.

Twenty-five semi-structured qualitative interviews were undertaken with major high-profile publicly and privately owned civil construction contractors operating in Australasia, to facilitate a more detailed quantitative survey into ITP efficiency and effectiveness. As 11 of these contractors also operate outside Australia, and/or are subsidiaries of international construction companies, the findings may be argued as being reflective of contractors facing similarly legislated CG requirements in other (wider 'commonwealth-of-nations') countries. Contractors' responses about how they addressed lessons learned (LL) within their ITP provided a few, somewhat, unexpected results that will require further investigation (under separate cover).

LITERATURE REVIEW

Increased CG has the potential to further increase contractors' ITP requirements. Major Australian contractors can spend more than 10% (some over 15%) of their tender hours addressing their tender review requirements (Urquhart *et al.*, 2017), significantly more than the 6-9% UK contractors were spending (Laryea 2013). Increased governance, such as the pending UK governance changes (BEIS 2017), may lead to similar tender review time increases, particularly for larger and/or publicly listed contractors, meaning improved efficiency in ITP processes is essential.

As civil infrastructure projects often experience cost blowouts (Flyvbjerg 2009; Whyte 2015; Love *et al.*, 2017) it is reasonable to assume contractors do not always get their tender prices right. With most construction companies delivering only 2-4% profit margins (Schleifer 1990) they are over represented in company failure statistics (Coggins *et al.*, 2016). Given contractors' greater dislike for losses than equivalent gains (Han *et al.*, 2005) their ITP are often more focused on not winning a 'loss making' project ahead of winning the tender (Urquhart *et al.*, 2017). Cost overrun risk does not vary by project type or contract value - it only diminishes for the contractor if it is contractually protected from the risk (Love *et al.*, 2015). With increased risk transfer to contractors, especially with growing bespoke contract use (Whyte 2015), ITP governance is more focused on tender project selection, especially given the high potential for wasting time and money pursuing the wrong prospects (Bagies and Fortune 2006).

Contractors may tender a project for strategic reasons other than to win (Drew and Skitmore 1997). Individual project pursuit decisions can significantly influence a contractor's short-term profitability and long term strategy and performance (Hillebrandt, as cited by Bagies and Fortune 2006). Contractor decisions on a tender position are developed through (attempted) rational decision making at short discrete review events within its management hierarchy (Smyth 2017). Resulting decisions still occasionally lead to contractors winning projects that lose money (Coggins *et al.*,

2016). As strategic decision making is dependent upon measurement of performance (Jin *et al.*, 2013), the question arises as to whether increased ITP governance, involving iterative decision steps through progressive management levels over a project pursuit life cycle (Urquhart and Whyte 2018a), makes a real difference to win-rates and project outcomes. Success depends on how effectively a contractor manages its internal and external knowledge (Switzer, as cited by Shokri-Ghasabeh and Chileshe 2014).

Delegations of authority and risk appetite statements (e.g. not accepting process risk or consequential loss) can be included within CG and ITP rules. ISO 9001 certified procedures are a form of rule based knowledge retention (Kieser and Koch 2008). However, given the humanistic nature of tendering (Urquhart and Whyte 2018a) ITP rules do not achieve the same repeatable success rates as process and manufacturing quality assurance (QA) procedural rules. Winning one in every five (Yean and Liu 2005) or six (Laryea and Hughes 2008) tenders while following its ITP are hardly repeatable QA success rates a contractor would want when, for instance, incrementally launching a bridge. Past versions of ISO 9001 were prescriptive in their tendering and contractual review processes requirements. ISO 9001:2015 adopts a less prescriptive risk focused approach and does not even mention “tender”. To be certified to ISO 9001:2015 contractors should be adjusting their ITP, and other procedures, to this risk-based approach. Common sense derived from experience and expertise, i.e. learning, can constructively inform decision making (Smyth 2017) and thus be included within ITP. However, LL benefits within QA rules may be overlooked. Brooks and Spillane (2017) suggested some contractors only obtain ISO 9001 accreditation to meet client imposed tendering pre-qualification requirements, arguing no significant correlation between ISO 9001 certification and business improvement.

The qualitative study undertaken is an early step in a wider program to address an identified construction contractor need for research into the efficiency and effectiveness of ITP (Urquhart and Whyte 2018), especially within countries experiencing increasing legislated CG controls.

RESEARCH METHODOLOGY

Semi-Structured Interview Process

Twenty-five contractors, with a predominant focus on infrastructure construction, were purposefully selected to be interviewed in an early qualitative data gathering stage of the wider research program. Purposeful selection enabled a cross-section of high-profile privately owned (Private) and publicly (or subsidiaries of) listed (Public) contractors, with a range of annual turnovers, to be involved. While 24 of the selected contractors are Australian based, seven also operate internationally and another four are subsidiaries of international contractors (these 11 covering Australasia, Europe, Asia, Africa, and North America). The interviews, lasting 1.5 to 2.5 hours and held between November 2016 and January 2018, consisted of three parts:

Part 1: Company and interviewee demographics (summarised in Table 1). Contractor selections were weighted towards very large companies by turnover, when compared to Shokri-Ghasabeh and Chileshe (2014) - their main response source (85.2% <AU\$100m pa) was reflective of a construction industry dominated by small contractors (Drew and Skitmore 1997) rather than companies captured by stricter CG requirements. Contractors selected for this study were more likely to be

representative of those subject to current or pending CG obligations (ASX 2014; FRC 2016). Table 1 uses contractor categories (Cat A to Cat D) for convenience in this paper only. The open ended AU\$10+b Cat A is presented to avoid possible contractor identification, as the category includes a number of the largest operating companies in Australia. Eighteen of the contractors secured 80-100% of their work by competitive tender and the other seven 60-80% competitively. Interviewees held positions from Chief Executive Officer/Managing Director to Pre-Contracts Manager/Estimating Manager. Importantly, all had direct knowledge of and experience in (Love *et al.*, 2015) their respective companies' tender development and review processes. Their industry experience ranged from 10 to 40 (average 23.8) years.

Part 2: Involved 'rating scale' and 'check list' questions (Fellow and Liu, 2008) regarding management and decision structures associated with tender selection and review approvals that are beyond this paper's current scope.

Part 3: Semi-structured discussions on aspects of the contractor's approach to, and opinions of, its ITP and wider tendering processes. After using general questions to develop a rapport with the contractor deeper probing questions, informed by a detailed literature review, were pursued (Fellow and Liu, 2008). Nineteen contractors agreed to their discussion being audio recorded, while only handwritten notes could be taken for the others. Typed interview notes or transcripts, as applicable, were returned to the relevant participant to review/approve, or if necessary adjust/correct (Fellow and Liu, 2008). Questions relevant to this paper's scope related to:

Timing of changes to their ITP; and, whether the contractor felt these changes improved tender win-rates and project outcomes - an opinion based assessment as none of the contractors had specific data to hand to suggest a causal link. The nature of their project outcomes was not asked, recognising there may be strategic reasons, other than profit, for pursuing/winning a project (Drew and Skitmore 1997).

How contractors addressed LL (internal and client feedback) from previous tenders and projects. No direct questions were asked about reporting, analysis, recording, retention, or how LL were applied to tenders, to avoid guiding interviewees on what was being sought - i.e. how LL feed into ITP efficiency.

Table 1 - Number and demographics of contractors interviewed by ownership and turnover

Contractor Category / Annual Turnover	Overall Numbers	Public Ownership (includes subsidiaries)	Private Ownership
Cat A – AU\$1 – \$10+b	6 (24%)	5 (20%)	1 (4%)
Cat B – AU\$500 - \$999m	2 (8%)	0 (0%)	2 (8%)
Cat C – AU\$100 - \$499m	9 (36%)	4 (16%)	5 (16%)
Cat D - <AU\$100m	8 (32%)	4 (16%)	4 (16%)
Totals	25 (100%)	13 (52%)	12 (48%)

Analysis of Interview Data

Returned transcripts were coded in NVivo 11 for content analysis on a systematic qualitative level, seeking progressive development of response themes, and a basic quantitative assessment, around specific word counts (Leedy and Ormrod 2013). Word counts were made on contractors' use of 'fail', 'learn', 'lesson', 'lose', 'profit' and 'win' and associated derivatives. Text surrounding these words was coded considered reflective of the different CG and tender outcome expectations. Coding analysis of word usage against contractor ownership and turnover categories enabled

identification of trends in ITP changes; views on how those changes impact tender/project performance outcomes; and, approaches to LL.

FINDINGS FROM THE INTERVIEW DATA

Contractors' Perceptions of the Impact of ITP on Their Tender and Project Results
 Cat D Private Contractors mentioned 'profit' the most, perhaps for survival, followed by Cat A Public, which may be a function of ASX performance expectations. All groupings had near equal usage of 'win' and 'lose' and rarely used 'fail' in their discussions. So no further conclusion could be drawn in that regard. An indication of the frequency at which contractors were changing their ITP could be obtained from qualitative statements made (it was not a specific quantitative survey question) (see Table 2). Twelve (48%) of the contractors made ITP changes within the last three years, while six others (24%) were making changes. Public contractors showed a higher propensity to make changes, often to address CG including delegations of authority. Of the remaining seven (28%), several had not changed their ITP in five years. While not asked at the time, reasons may include their ITP already reflecting ASX's third edition of CG requirements (ASX 2014).

The 18 contractors indicating they recently (<3 years) had made, or were making, changes to their ITP were asked if their changes improved tender win-rates and project outcomes. One of the other contractors also provided an unsolicited comment in this regard. Responses, extracted from the transcripts, are presented by contractor category in Table 3. Responses of 'no difference' or 'could not tell' were considered to reflect the same position, i.e. 'no discernible difference'. While not asked, five contractors (4 Public, 1 Private / 3 Cat A, 2 Cat B) stated it was the people involved, not the ITP that really made the difference. The humanistic issues of tendering are investigated further in Urquhart and Whyte (2018a). Contractors with more stringent CG obligations (i.e. larger and Public) were the ones more likely to comment about the importance of people on tender results. As the impact of people over ITP process was not an interview question (though now identified for the later quantitative survey), the number of contractors holding this opinion is considered a lower bound - the others may hold similar, but unstated, views.

Table 2 - Timing of contractor changes to ITP

Made ITP changes	Totals	By ownership		By annual turnover			
		Public	Private	Cat A	Cat B	Cat C	Cat D
Changing now	6 (24%)	4	2	1	1	2	2
<3 years	12 (48%)	6	6	3	1	4	4
>3 years	7 (28%)	3	4	2	0	3	2
Totals	25 (100%)	13	12	6	2	9	8

Fewer contractors made comments on whether their ITP changes led to improved project outcomes. At the time, this was not investigated further but noted to be included in the later industry quantitative survey on contractors' views on the impact of ITP and people on tender win-rates. It cannot be concluded there is causality between ITP changes and tender win-rates - tender teams may not always comply with their ITP as they seek time efficiency (Love *et al.*, 2016) during constrained tender periods, where limited information may be available.

Table 3 - Perceived impact of ITP changes on tender win-rates and project results

Impact of ITP changes on	By ownership		By annual turnover			
	Public	Private	Cat A	Cat B	Cat C	Cat D
Tender win-rates						
Made a difference	3	2	1	0	3	1
No discernible difference	5	9	2	2	5	5
Project outcomes						
Made a difference	3	3	2	0	2	2
No discernible difference	4	3	2	0	3	2

Representative responses of divergent views obtained during the interviews are:

You can have the best system in the world but if you have inexperienced people it will never work. Public, Cat A

Where we have undertaken mid-tender reviews that has definitely improved our bid and come up with solutions that helped win the bid. Public, Cat D

I think often the win rate would be more dictated by market constraints. Often the procedures would lower our win rate because they are designed to get us to a position where we understand the risk. Private, Cat C

Contractors' ITP Requirements for Inclusion of Lessons Learned into Tenders

During the interviews, contractors were asked how they addressed LL from previous tenders and projects. Content analysis of interview transcripts indicated most contractors operate either informal LL structures or, at best, a low level of formally documented LL retention (see Table 4, where turnover groupings are >AU\$500m and <AU\$500m due to the limited meaningful responses). Only three contractors (two Public) specifically mentioned linking LL to tendering, while three others (1 Public, 2 Private) considered LL in bid/no-bid decisions - e.g. clients and payment reputations. This was despite many others recognising the need for better treatment of their LL. Word counts, normalised by category, indicate contractors with turnovers >AU\$500m were twice (1.9 times) as likely to mention LL as those with turnovers <AU\$500m.

Table 4 - Contractor comments on their approach to lessons learned and its use in tenders

Approach to LL	By ownership		By annual turnover	
	Public	Private	>AU\$500m	<AU\$500m
Formal procedures in place (2)	1	1	1	1
A documents form applies with varying rigour (7)	6	1	3	4
Informal use, especially for input to tenders (5)	2	3	3	2
Number of meaningful responses (14)	9	5	7	7

Of the 14 contractors that provided an outline of their approach to LL, only two had a formal LL procedure while seven (6 Public, 1 Private) claimed a less formal documented approach. A further five (2 Public, 3 Private) operated an informal approach. While a number of the contractors did not raise/discuss LL it does not mean they do/do not have or operate formal LL procedures. Discussion was not be drawn out to avoid indicating surprise that expected levels of formal LL incorporation into ITP were not occurring, and it was not the original research focus. However, this low use of LL procedures is consistent with Shokri-Ghasabeh and Chileshe's (2014) findings that, despite contractors believing LL were important, only a third actually retain such information and use it when selecting subsequent tender opportunities.

Representative views on the importance, or otherwise, of LL are:

Best practice would be absolutely having a lessons learned feedback loop and a system that demands that lessons learned being captured at the end of each project. Public, Cat A

It is a great buzzword and everyone wants to do lessons learned but it is how you implement that into the next tender. Public, Cat A

Past lessons can often be rationalised out..... It is not commercially competitive to add money for the past lesson of what may have gone wrong. Private, Cat A

Some lessons learned will be documented, though the majority of lessons learned remain in heads. Public Cat D

Another problem in the industry is that sometimes lessons get hidden in the top levels of management Private. Cat D

These responses reflect an industry dominated by personal past experiences: Where word of mouth prevails over structured learning (Maqsood *et al.*, 2006); and, important project knowledge often remains only in the minds of the key people involved (Kazi and Koivuniemi 2006, cited in Shokri-Ghasabeh and Chileshe 2014) and not fed back to contractors' tendering teams. While the temporary nature of project teams may be argued as a contributing reason for restricted learning (Jin *et al.*, 2013), contractors' tendering teams are more permanent. Structured LL retention and re-use for tenders should be possible.

With consistent structured incorporation of LL seeming to remain an industry failing/challenge, contractors' suggestions (see quotations below) on how they sought to improve LL capture are worth considering. However, none of them proposed a governance directive that formal LL procedures be applied as part of their ITP. This suggests long ITP review processes involving layers of management in sequential events (Urquhart and Whyte 2018a), while being of questionable value, may remain in favour. From a tendering efficiency perspective, if contractors fail to evaluate whether their actions are yielding their sought after results, then, like other strategic plans, they will merely expend tender teams' time and energy (Simu 2017). Organisational learning must capture individual knowledge (a challenge on highly transient major projects), retain it and then transfer/re-apply it when needed (Argote 2011) on later tenders. Effective LL information should be progressively captured, not left until job closeout reports, which are invariably rushed or not completed as the project team member's move onto their next project(s).

Monthly project reports now include a section on innovations and lessons learned. Public, Cat D

[Proprietary customer management system] enables lessons learned to be captured. Private, Cat B.

[A] refresher that you do once a year and can be tailored so that if you are doing road projects you can learn the current issues and trends. Public, Cat A.

Perhaps drawing from Cummings (2004), who suggested external knowledge sharing within structurally, rather than demographically, diverse groups provides for greater performance improvement, some contractors were actively seeking LL from competitor sources. They visit projects lost at tender to compare construction methodologies the winning tenderer is using with the methodologies they based their losing tender on, e.g. use of incrementally launched rather than precast bridges.

From these interviews it was clear that for most contractors LL is still not a mandated formal activity within their ITP. High-profile/status contractors that do not have LL

procedures within their ISO 9001 certified quality management systems are unlikely to adequately embrace LL and incorporate them into subsequent tenders.

CONCLUSIONS, LIMITATIONS AND FURTHER RESEARCH

There exists an identified need for improved efficiency in contractor internal tendering procedures (ITP) (Urquhart and Whyte 2018). As an early stage, to facilitate a wider ITP research program, this study draws on information gained from a qualitative assessment of data from semi-structured interviews with 25 Australasian based construction companies, of which 44% have international exposure through operations and/or parent companies. Of the interviewed contractors, 72% had made, within the last three years, or were making changes to their ITP to address increasing corporate governance (CG) obligations - a matter now facing larger UK based contractors (BEIS 2017). However, only a quarter of those 72% of contractors felt the changes resulted in better tender win-rates and even fewer thought they produced better project outcomes. This identifies a need for further research into whether ITP changes are focused in the right areas.

An unexpected finding from the interviews, given the high-profile nature of the contractors, was the indication that clear realistic capture, storage and subsequent re-application of lessons learned (LL) into later tenders remains an area requiring real attention within the industry. Improved LL should be a governance focus ahead of more bureaucratic multi-layered tender review processes that appear to commonly apply in larger construction companies (Urquhart and Whyte 2018a), especially as various contractors felt it was people, not ITP, who really made the difference.

This study was based on qualitative information. Future studies will pursue quantitative data to determine correlation, and perhaps later find causality, between greater governance led contractor ITP changes and improved tender win-rates and project outcomes. Need still exists for further quantitative studies on the true status of LL procedures, and their links to ITP, within larger contractors, recognising that Shokri-Ghasabeh and Chileshe's (2014) 'large' contractors were still relatively small compared to the contractors included within this purpose selected sample. Even major high-profile contractors do not necessarily have LL procedures within their ITP, despite the benefits identified by past research. As long as contractors fail to seriously consider and apply past 'lessons learned' when pursuing new tenders they are destined to repeat their mistakes, and so they will become 'lessons re-learned'.

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INCORPORATING KNOWLEDGE OF CONSTRUCTION AND FACILITY MANAGEMENT INTO THE DESIGN IN THE BIM ENVIRONMENT

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Many studies have highlighted the importance of early project phases, during which the levels of uncertainty and stakeholder influence are considerably high, but the cost of change is substantially low. Construction projects become increasingly complex and require the early involvement of project participants. Consequently, the knowledge of construction contractors and facility management (FM) teams should be considered in the design phase to improve project management. Building information modelling (BIM) is an object-oriented and parametric-based information technology, which is characterised by digital representation, project lifecycle simulation and collaborative working. However, existing studies have considerably focused on BIM-based information management and limited research has considered BIM-based knowledge management (KM). This study aims to explore collaborative KM during design in the BIM environment. Semi-structured interviews and questionnaire surveys are conducted to collect qualitative and quantitative information from people working in the construction industry in the UK and Ireland. A conceptual framework is developed based on the analysis results to illustrate how knowledge of construction and FM can be incorporated into the design phase in the BIM environment. BIM's potential for KM has been identified in this study. Moreover, the expectations and requirements of BIM-based KM are also identified that include technical, process and cultural aspects. Consequently, this study provides new insights into the transformation from BIM to building knowledge modelling (BKM).

Keywords: BIM, knowledge management, collaboration

INTRODUCTION

Construction is a knowledge-intensive industry. Compared with information that answers 'when', 'where', 'who' and 'what' questions, knowledge answers 'how' and 'why' questions. Knowledge management (KM) is the process of capturing, storing/retrieving, transferring and applying knowledge (Alavi and Leidner 2001) and is driven by the integration of people, processes and technologies, whereas information is mainly technology driven. As projects become increasingly complex, various disciplines must be involved in these projects thus the requirements for KM have increased. To improve KM in the construction industry, different types of information technology (IT) have been applied.

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Building information modelling (BIM) is a new-generation IT in the construction industry which has achieved considerable progress in information management because of its parameter-oriented modelling method and its capability to retain graphic and non-graphic information. Only a few studies have explored BIM at the knowledge level, including Wang and Leite (2016) for BIM-based KM during design, Ho *et al.*, (2013) for BIM-based KM during construction and Motawa and Almarshad (2013) for BIM-based KM during operation and maintenance (O&M). However, no study has yet considered collaborative KM in the BIM environment. Additionally, Dainty *et al.*, (2017) explained that BIM's power of aspiring integrated work, collaboration and innovation is overstated because political reform agendas centred recently on BIM. Therefore, information from practitioners working in the industry should be collected to reflect the potentials and expectations of BIM for KM, particularly in terms of collaborative KM.

Moreover, the potential risks of constructability, operability and maintainability in large and complex projects are difficult to identify in advance. To proactively address these problems, construction contractors and FM teams must be involved in the design stage. Early contractor involvement (ECI) aims to appoint contractors earlier than normal to assist in planning and design (Samuel and Ron 2016). Early facilities management involvement (EFMI) represents a process, in which FM experts are introduced in planning and design to raise the potential O&M issues (Meng 2013). Although a few studies have explored ECI and EFMI, no research has used BIM to aid in the early engagement process. To fill in the knowledge gap, this study selects semi-structured interview and questionnaire survey as the main research methods to explore how the knowledge of construction contractors and FM teams can be incorporated into the design process in the BIM environment. This study answers the following questions. (1) How is the knowledge of construction contractors and FM teams involved in the design stage of existing projects? (2) Can BIM potentially aid KM? (3) What are the expectations and future trends of BIM-based KM for ECI and EFMI? Lastly, a conceptual framework is developed to summarise the expectations on BIM-based KM for ECI and EFMI.

THEORETICAL BACKGROUND

Early Involvement of Construction Contractors and FM Teams in Design

ECI was proposed by the UK Highways Agency to appoint contractors earlier than normal to aid in planning and design (Samuel and Ron 2016). The benefits of ECI have been identified in existing studies. Firstly, ECI can reduce the probability of potential risks. ECI improves the constructability of design because the contractor's knowledge of building materials and construction methods is considered in this process (Song *et al.*, 2009; Motiar and Aminu 2012; Love *et al.*, 2014). Gil *et al.*, (2001) emphasised the important role of specialist contractors in constructability. They have a sensitive sense of labour, material and equipment availability. Specialist contractors also have a good understanding of suppliers' lead time and reliability because they have a close relationship with suppliers. If contractors and specialist contractors are involved in the design stage of a project, then informed decisions can be made (Gil *et al.*, 2001; Song *et al.*, 2009; Samuel and Ron 2016). Secondly, potential risks, such as health and safety risks and time and cost overruns, can be proactively avoided (Gil *et al.*, 2001; Song *et al.*, 2009; Eadie *et al.*, 2012; Lenferink *et al.*, 2012; Motiar and Aminu 2012; Love *et al.*, 2014; Meng 2014; Samuel and Ron 2016). Thirdly, ECI can also improve the relationship among project parties, thereby

resulting in increased interaction, mutual trust and respect (O'Connor and Miller 1994; Motiar and Aminu 2012). Fourthly, ECI can provide opportunities to generate innovative design and construction strategies through collaborative effort (Gil *et al.*, 2001; Mosey 2009; Lenferink *et al.*, 2012; Motiar and Aminu 2012). Eadie *et al.*, (2012) indicated that ECI can assist in waste reduction, quality improvement, environmental impact control and sustainability.

FM teams possess extensive knowledge of and experience on O&M, as well as energy consumption and adaptability to future developments. If FM teams are involved in the design phase of a project (EFMI), then the project can gain many benefits. Firstly, EFMI prompts the proactive consideration of potential problems during the design stage. Meng (2013) reported that EFMI facilitates the identification of potential design flaws and the achievement of accurate design, operability, maintainability and serviceability. Mohammed and Hassanain (2010) and Wang *et al.*, (2013) added that FM teams can recommend the appropriate equipment and systems in terms of durability and reliability because of their in-depth knowledge of building service systems. Secondly, FM teams can reflect the needs of clients/end users. Consequently, they can obtain benefits from the FM teams' early involvement, such as guaranteeing system or material performance (Dunston and Williamson 1999), increased suitability to meet the clients'/owners' business objectives (Jensen 2009; Meng 2013), good value for money (Mohammed and Hassanain 2010; Meng 2013) and sustainability (Jensen 2009). Additionally, several studies have established a feedback loop between design and FM, in which FM teams report the problems encountered during the O&M phase to the design group. Consequently, the design team can consider similar potential problems in future projects (John *et al.*, 2005; Mohammed and Hassanain 2010). Apart from the benefits gained from ECI and EFMI, barriers and challenges have also been identified by existing studies. The six barriers to ECI are responsibility allocation (Jergeas and Van der Put 2001; Samuel and Ron 2016), reluctance to change (Song *et al.*, 2009; Jergeas and Van der Put 2001; Love *et al.*, 2014), lack of understanding of benefits (Song *et al.*, 2009; Eadie *et al.*, 2012), lack of mutual trust and respect (Jergeas and Van der Put 2001), loss of competitiveness (Motiar and Aminu 2012) and lack of technical support (Fischer and Tatum 1997; Gil *et al.*, 2001; Jergeas and Van der Put 2001). Previous studies have also identified three barriers to EFMI, namely, lack of understanding of benefits (Dunston and Williamson 1999; Meng 2013), lack of common knowledge (Jensen 2009; Meng 2013) and lack of technical support (Jensen 2009).

BIM-Based KM

BIM-based KM is an emerging research field. This KM system integrates KM techniques and BIM to facilitate KM activities. Knowledge capture and retention in the BIM environment are mainly based on customised parameters related to building objects in the BIM model (Deshpande *et al.*, 2014). BIM applications enable users to predefine parameters to record knowledge of building objects in the BIM model (Motawa and Almarshad 2013; Deshpande *et al.*, 2014). Deshpande *et al.*, (2014) developed a BIM-based KM system in which various pre-defined parameters, such as lessons learned and subject experts involved, have been created. These parameters are used to capture and retain knowledge.

Although studies have acknowledged knowledge sharing in the BIM environment, no research has shown that BIM can be used as a tool to share knowledge. All existing studies have combined the BIM model with knowledge sharing tools, such as web-

based system and desktop knowledge sharing platform, to achieve knowledge sharing (Grover and Froese 2016; Ho *et al.*, 2013). Ewenstein and Whyte (2009) indicated that visual representations can serve as epistemic objects to facilitate a collective understanding among different epistemic communities. Accordingly, the 3D visualisation of the BIM model can be regarded as the epistemic object for eliminating the boundary among different disciplines to facilitate knowledge sharing.

Existing studies on BIM-based KM have failed to extensively explore knowledge reuse. They do not use BIM to support knowledge retrieval directly but combine technologies that promote knowledge retrieval with BIM to realise the knowledge retrieval function. For example, ontology-based knowledge representation is adopted in a few studies to aid knowledge retrieval in the BIM environment (Park *et al.*, 2013; Ding *et al.*, 2016). Additionally, Motawa and Almarshad (2013) applied case-based reasoning to a BIM-based KM system to support knowledge retrieval and storage. Although a few studies have explored the KM in the BIM environment, several aspects of KM in construction have yet to be considered. Existing studies of BIM-based KM fail to consider knowledge capture, retention and retrieval in collaboration circumstances. Additionally, a few features of BIM, such as clash detection, simulations and early analysis, have not been considered to support KM.

METHODOLOGY

This study applied two research methods; a semi-structured interview and a questionnaire survey. For the interviews, a qualitative semi-structured interview format was selected because it enables researchers to collect data with relative flexibility. A total of 30 interviewees from different companies belonging to the construction industry in the UK and Ireland participated in semi-structured interviews. The selection of appropriate interviewees was made using a purposeful sampling strategy that is extensively used to identify and select individuals who have experience on a phenomenon of interest. The interviewees work in different disciplines of building projects, namely, design, construction, FM and consultancy. They have at least one year of BIM experience. A total of 19 interviewees had over 5 years of BIM experience. The number of interviewees was confirmed using the information saturation criterion, in which no new information is obtained from additional interviews over an interviewee sample size. Eventually, nine contractors, eight architects, seven FM experts, four consultants, one structural engineer and one client were interviewed. The industrial experts were interviewed face-to-face or through Skype video call. The same open-ended questions were asked in all interviews, following the pre-defined guide for ease of subsequent data analysis. To maintain confidentiality, the interviewees were coded as Interviewee 1, 2, 3 ...30 based on the order in which the interviews were conducted. The interview scheme was divided into three sections. In the first section, the interviewees were asked to provide their occupational and company information to determine if they would meet the criteria for this study. In the second section, the interviewees were asked to describe the KM methods used in their project and the potential of BIM for KM. In the last section, the interviewees described their ECI and EFMI experiences and shared their perspectives on BIM for early engagement.

The second method, the questionnaire survey, was developed based on the literature review and was revised according to the suggestions provided by six other BIM experts from the construction industry. The purpose of the questionnaire survey is to obtain people's accurate ideas and opinions on the BIM-based KM system in

construction projects. The survey also examined whether the features of BIM can assist construction organisations overcome the challenges to KM. The survey targeted people who had experience in using BIM across the UK. A total of 70 participants from the construction industry were asked to rank the significance of 35 variables that facilitate KM by using BIM. These variables were identified through the literature review. The results collected from the questionnaire were processed through exploratory factor analysis using SPSS. This study applied the Kaiser-Meyer-Olkin measure, Bartlett's test and anti-image correlation matrix analysis to confirm the adequacy of the samples and deduct the insignificant variables (denoted as V [number] in the remainder of this paper). Total variance explained, scree plot, rotated component matrix and reliability analysis were used to classify the related variables into different components and to determine the number of components that should be retained.

RESULTS AND DISCUSSION

Early Involvement of Contractors and FM Teams in the Design Stage

The results of the interviews indicate that ECI and EFMI are common in projects. A few interviewees from the design team stressed that contractors should be involved in providing creative suggestions before the detailed design stage. Thereafter, the design team will create the details by considering the contractors' advice. Such scenario is preferred because although the design team understands the benefits of ECI, the team is unwilling to redesign its work based on the suggestions of the contractors. The interviewees also explained that current ECI fails to involve specialist contractors. Accordingly, the interviewees proposed that the advice of specialist contractors should be considered during the design stage because the former has considerable knowledge of technical details (Gil *et al.*, 2001). Moreover, a few interviewees mentioned that some specialist contractors even have their own design team. The projects' design team will discuss and confirm the design intention with the specialist contractors. Thereafter, the specialist contractors will directly design the details. The design results are further discussed and confirmed with the projects' design team.

Some interviewees believed that the FM teams should be involved during the entire design process, whereas others believed that considering the knowledge of the FM before proceeding to the detailed design stage is ideal. Interviewees considered that the different opinions were derived from the lack of geometric thinking of the FM members and their inability to visualise design intentions in their minds. Therefore, some interviewees believed that design drawings can improve the efficiency of knowledge exchange during EFMI. This view is supported by Ewenstein and Whyte (2009), who stressed the importance of visual representation for communication between different disciplines. Some studies have also shown that this lack of commonality can result in a conflict of opinions between design and FM teams (Jensen 2009; Meng 2013). By contrast, several interviewees believed that relying excessively on visualisation tools will reduce the efficiency of knowledge exchange between the design and FM teams because the latter will require additional time to understand the drawing before they can provide their suggestions. Additionally, the interviewees emphasised that if the involved FM team lacks knowledge on the business objectives of building end users, then EFMI will be ineffective.

BIM's Potential for KM

In the questionnaire survey, the respondents were asked to rank the significance of 35 variables related to the BIM-based KM. In accordance with the results of the anti-

image correlation matrix analysis, the correlation values of V17 and V34 are below 0.5. Thus, 33 variables were subsequently analysed. A rotated component matrix analysis was performed to classify variables into different components. The variables in each component exhibit common characteristics. In the rotated component matrix, the loading value should be above 0.4. Lastly, the 33 variables were classified into nine components. However, a component that contained only 1 variable was excluded. The reliability of the remaining eight components was tested. In the reliability analysis, the confidence interval value was set to 0.95. The Cronbach's alpha values of Components 1, 2 and 6 are 0.834, 0.815 and 0.698, respectively. The value of the other components is nearly or below 0.6, which means poor reliability. Components 1, 2 and 6 are discussed with the results of the interviews (see Table 1). Appropriate tags are assigned to each component to summarise the KM aspects that they explain. Components 1, 2 and 6 explain the proactive KM, lifecycle KM and KM processes, respectively.

Table 1: Matrix of the Rotated Components

Components	Variables	Factor Loadings
Component 1 (Proactive KM)	V28 Achievement of client requirement	.805
	V27 Avoidance of repeated defects	.708
	V32 Reduction of conflicts in decision-making	.641
	V26 Avoidance of potential defects	.631
	V30 Early informed decision-making	.565
Component 2 (Lifecycle KM)	V23 Knowledge used in each project phase	.683
	V35 Simulation for early knowledge application	.653
	V24 Visual-aided knowledge identification	.600
	V11 KM supported by disciplines from each project phase	.578
	V20 KM from one stage to another	.527
	V19 Information in BIM for knowledge improvement	.516
Component 6 (KM processes)	V 9 Knowledge capture from other projects	.504
	V 6 Knowledge storage (digitalised documents)	.731
	V10 Knowledge sharing among different project phases	.655
	V29 Identification of the relationship between current and past activities for knowledge reuse	.541

The analysis results of the interview also identified three potentials of BIM for KM, namely, knowledge capture and retention, proactive KM and visual-aided KM. For proactive KM, the interviewees explained that BIM exhibits the capabilities of clash detection, simulation and analysis. Thus, designers can proactively solve potential problems based on their experiences. Furthermore, the design team can further optimise their design based on the simulation results. The early analysis of lifecycle cost and energy consumption via BIM application also facilitates early decision-making. The preceding discussions are consistent with the analysis of the questionnaire survey results and those of existing studies, such as Wang *et al.*, (2013). However, the quantitative survey determined that BIM can mitigate conflicts among disciplines during decision-making (V32). This result is consistent with the view of Ho *et al.*, (2013), which stressed that the drawings with supported data stored in BIM can facilitate decision-making. The survey also determined that BIM can promote the use of knowledge to reduce repeated defects (V27). This result was not obtained in the interviews but was indicated by Park *et al.*, (2013). Moreover, the requirements of clients are proactively considered and solved through the involvement of BIM (V28). This result is consistent with Cavka *et al.*, (2017) but was not identified in interviews.

The questionnaire survey and interviews determined that BIM can support KM processes. However, the interviewees only indicated that BIM exhibits the potential for knowledge capture and retention. BIM applications enable users to create the customised parameters that can be used to obtain and retain knowledge (Motawa and Almarshad 2013; Deshpande *et al.*, 2014). The interviewees even suggested that clients/end users should indicate the knowledge that they need. The design team and contractors should also input this required knowledge into the BIM model during the

design and construction processes. Thereafter, this knowledge-rich model will be forwarded to the FM team for O&M. However, existing studies only explore the information requirement rather than knowledge requirement by each project parties (Cavka *et al.*, 2017). Additionally, the results of the questionnaire survey showed that BIM can support knowledge sharing and reuse, which is indicated in Ho *et al.*, (2013).

The questionnaire survey results showed that BIM can facilitate KM throughout the project lifecycle. V24 in the component of the lifecycle KM (Component 2) particularly stressed that the 3D visualisations of BIM can facilitate KM throughout the project lifecycle. Although the interviewees emphasised the importance of the 3D visualisation of BIM, they believed that such visualisation improves the collective understanding among the different disciplines and assists people who lack geometric thinking and cannot visualise things in their mind. Ewenstein and Whyte (2009) emphasised that visual representations can be regarded as epistemic objects to facilitate common understanding among different epistemic communities. The BIM model can be regarded as the so-called epistemic object. Consequently, the efficiency of knowledge sharing is increased. The remaining variables of this component are generated based on the lifecycle evaluation capability and central collaborative platform provided by the BIM applications. Existing studies also confirmed that early simulation and evaluation of BIM can help solve problems from the lifecycle perspective (Wang *et al.*, 2013).

Future Development Trend of BIM-Based KM

BIM-based KM is an emerging research field. Consequently, the expectations from the construction industry to identify the future development and research direction of this field must be clarified. The interviewees proposed that BIM-based KM should have the ability to support knowledge capture and retention because BIM exhibits the potential for such purpose. This idea is confirmed in the questionnaire survey (V6 and V9) and existing studies (Motawa and Almarshad 2013; Deshpande *et al.*, 2014). The expected BIM-based KM is mainly used to support the involvement of knowledge of contractors and FM teams, thereby requiring a high degree of collaboration in early design. Therefore, interviewees indicated that the processes of capturing and retaining knowledge in the BIM environment should consider the knowledge index that is suitable for different disciplines.

The interviewees suggested integrating knowledge sharing tools into BIM-based KM to realise knowledge sharing. For example, they believed that common data environment (CDE) should be included in BIM-based KM. Although the BIM application at level 2 emphasises the integration of 3D model with related information, this application is created in a separate discipline model. The interviewees further explained that CDE can be viewed as a single source of information collected from those separate models. Consequently, CDE can facilitate collaboration work in construction projects by providing a central repository and data sharing platform. Although CDE is currently used at the information level, the interviewees believed that CDE can also be used at the knowledge level. Additionally, the interviewees infer that CDE relatively alleviates the problem of knowledge redundancy in BIM-based KM because data can be synchronised and updated in a timely manner. Moreover, the interviewees also hope that BIM-based KM can embed a comment function on building objects to establish the relationship between knowledge and building objects. The interviewees also suggested that BIM-based KM requires a discussion module to increase interaction among people. The

analysis results of the questionnaire showed that BIM can also be used to share knowledge among the different phases of a project (V10). Wang *et al.*, (2013) realised the knowledge exchange between the O&M and design phases.

The expectations on knowledge reuse of the interviewees are mainly on the knowledge retrieval process. The interviewees proposed three methods for knowledge retrieval, namely, keywords, screening and knowledge category. Furthermore, the desired knowledge retrieval method should be easy to use in a collaborative environment because the proposed BIM-based KM is utilised to support the early knowledge involvement of contractors and FM team. The interviewees also believed that the BIM features of visualisation, simulation, clash detection and early analysis should be applied to the BIM-based proactive KM. Component 1, which was generated in a rotated component matrix, also stressed the importance of these BIM features for KM. Additionally, V24 and V35 in Component 2 emphasised the visualisation and simulation of BIM for KM throughout a project's lifecycle. These BIM features can serve as a factor triggering proactive application of relevant knowledge in the early project stage to prevent potential problems.

The interviewees also believed that applying a BIM-based KM system is necessary in an appropriate project management process, such as asset information requirement (AIR), employer's information requirement (EIR) and soft landing (SL). AIR is used to specify the information required from an organisation in relation to an asset. EIR is developed based on AIR and is the information required that clients will use during the project development and O&M phases. The information specified in EIR can be used to support decision-making at each employer's decision point. Cavka *et al.*, (2017) also stressed the importance of these information requirements in the BIM environment. They developed owner information requirements in the BIM environment for asset management. SL is a strategy that stresses collaboration among the design, construction and O&M phases. This process also includes a post-project evaluation that can provide lessons learned for future projects. Although AIR, EIR and SL are currently applied at the information level, the interviewees proposed that these management strategies can be used as carriers of knowledge to enhance collaborative KM among different disciplines, particularly in the early stage of the project.

Based on the discussion above and the review of previous studies, BIM's potential for KM and the expectations of BIM-based collaborative KM in the early design stage are identified. These expectations are finally classified into three aspects, namely technical, process and cultural aspects. A conceptual framework of BIM-based KM for ECI and EFMI is proposed to summarise BIM's potential for KM and expectations of BIM-based collaboration in early design stage in detail (Figure 1).

CONCLUSION

This study applied semi-structured interviews and a questionnaire survey as the main methods to explore the involvement of contractors and FM teams in the design through BIM-based KM. The existing strategies for the early incorporation of contractors and FM team were firstly explored. Thereafter, BIM's potential of KM was identified. These potentials include knowledge capture and retention, knowledge sharing and visual-aided KM. Moreover, a few features of BIM, such as clash detection, early simulation and analysis, play a role in facilitating a proactive KM. This study also identified expectations for the early involvement of the knowledge of construction contractors and FM teams through the BIM-based KM.

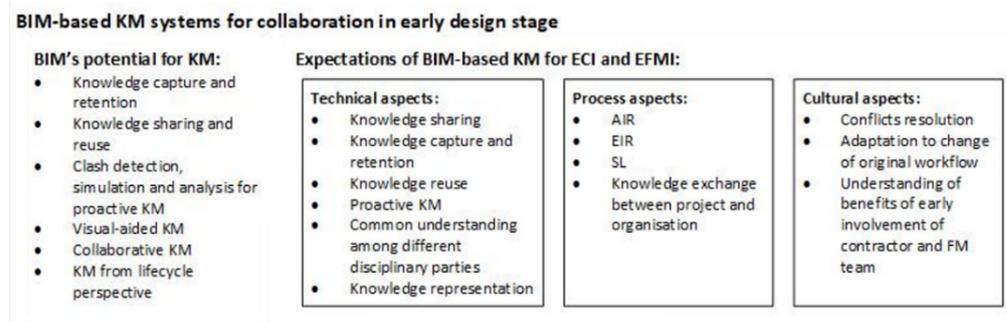


Figure 1: Conceptual framework of the BIM-based KM for ECI and EFMI

These expectations can be classified into three aspects (i.e. technical, process and cultural aspects) based on their characteristics. Lastly, a conceptual framework was proposed in this research. This framework represents a conceptual BIM-based KM system for collaboration in the early design stage, in which BIM's potential for KM and the expectations of BIM-based KM for ECI and EFMI are integrated. This study proposed a research direction for the transformation of BIM to BKM.

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FACTORS NEEDED FOR THE DEVELOPMENT OF A CONSTRUCTABILITY ASSESSMENT MODEL FOR BUILDING RENOVATION AND EXTENSION IN KOREA

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It is important to measure and evaluate, and thus control, constructability in construction at an early stage. This is especially important in renovation projects because it may affect various aspects such as the remaining structures, adjacent buildings, and those remaining in operation. In the construction industry, constructability studies have been carried out pertaining to deriving, quantifying, and evaluating constructability factors. However, most of these studies are focused on new building construction. As a result, there is no tool available for assessing constructability in renovation projects. Therefore, the purpose of this study is to analyse factors affecting renovation constructability to enable quantitative assessment. A literature review and expert interviews were conducted to derive the factors, and factor analysis was performed to assess constructability. Twenty-seven key factors were derived and the factors that should be considered when evaluating constructability of building renovation have been summarised. In the future, renovation constructability assessment models can be developed using these factors. Furthermore, the quantitative evaluation of renovation design is possible if a comprehensive evaluation of the constructability index, project cost, and time is integrated into one package.

Keywords: building renovation, constructability assessment model

INTRODUCTION

Across the world, the number of ageing buildings is increasing rapidly. As the number of these buildings increases, the interest and investment in renovation is also increasing (Ma *et al.*, 2012). As a result, many studies have been conducted to manage old buildings effectively. Renovation is considered a maintenance plan for old buildings; it plays an important role in the maintenance of existing buildings and in saving energy, increasing structural safety and improving the residential environment (Baek and Park, 2012). In addition, renovation projects affect profitability by raising the value of existing buildings, and, as a result, owners of renovation projects are interested in making profits (Cho and Yoon, 2016). In Korea,

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owners who are also union members form groups to drive the renovation of old apartments and these projects are promoted based on their collective opinions.

Apartment house renovation has a variety of alternatives (ALTs) at the design stage, and therefore the optimal design selection process is inevitably conducted jointly (Yoon, Jung and Yu, 2017). When choosing a renovation design, the clients (owners) consider the range of improvement given the limited space and resources (Rosenfeld and Shohet, 1999). This notwithstanding, construction costs and constructability are important factors for the contractor (the construction company). In other words, the client evaluates the design from the viewpoint of profitability, while the contractor evaluates the design in terms of the construction cost and constructability. A conflict of interest is a major risk factor in renovation projects.

In renovation projects, design evaluation is carried out at the design stage. However, the evaluation of constructability during this design evaluation process is not sufficiently performed (Yun, 2015). The renovation design is taken forward based on profitability alone, without accounting for construction efficiency. This can eventually lead to an increase in construction time and project costs. Constructability evaluation should be performed at the schematic design stage to ensure that construction knowledge is integrated into the design (Albattah, Goodrum and Taylor, 2015; Dai, Goodrum and Maloney, 2009) and to ensure that an appropriate agreement between the client and the contractor. Constructability analysis is conducted to reduce the construction period, construction cost, and, at the same time, improve quality. Therefore, there is a substantial amount of literature on various facets of constructability analysis and evaluation.

However, most of the constructability research has been limited to newly constructed buildings. Furthermore, constructability analysis focuses less on quantitative analysis than on the qualitative approach (Wong, 2007). Quantitative assessment allows objective evaluation based on attribute values (Lam, Wong and Chan, 2006). In Singapore, a buildable design appraisal system (BDAS) has been used to quantify the constructability (buildability) score for measuring the performance of construction projects since 2001. This system is employed as the measurement methodology for various types of buildings (residential, commercial, industrial school, institutional, and others), and is therefore important because it can be universally applied. However, there is no provision for renovation.

In view of the rapid increase in the number of old buildings and the important role of maintenance in the industry, an index of constructability for renovation is needed. Wong (2007) created an evaluation model for the constructability of various types of new buildings in Hong Kong, which is similar to the BDAS. As in the case of BDAS, however, there is no provision for renovation. In other words, there is a lack of provision for major types of work that are important in renovation, such as foundation reinforcement work. BDAS (2017) and Wong (2007) are limited because, although they are designed to be applied to various types of buildings, renovation is excluded from consideration. In other words, the evaluation factors do not comprehensively reflect the characteristics of all building types.

In addition, at the design stage, constructability evaluation factors are closely related to risk factors; however, development takes place without reflecting on the risk factors. Therefore, a new evaluation index is needed (Table 1). Some studies have been conducted on some aspects of renovation constructability analysis, but they are limited to the qualitative evaluation of the constructability checklist. Therefore, the

objective of this research is to derive key factors to develop a quantitative evaluation system for renovation projects. Furthermore, this research addresses underground expansion construction, which is the most important part of a renovation project. This is because it is most difficult and costly to expand underground space while maintaining the existing structure. It also affects the foundation reinforcement and upper expansion works. In addition, it addresses the key factors including the remaining types of work.

Table 1: Problem statement and research purpose

Division	Contents
Limitations of Constructability Assessment Model(CAM)	The measurement target is for almost all types of buildings
	No evaluation index for demolition or reinforcement, which is a renovation characteristic
	Not considering risk factor in design evaluation
Response to the limitations of previous CAM	Identifying factors and process development for quantitative constructability evaluation of renovation project Deriving risk factor in building renovation

METHODOLOGY

This research was conducted in two stages. In the first stage, a literature review was carried out to draw out the problem statement and constructability factors. Constructability factors were derived by analysing the prior literature related to constructability evaluation and expert surveys. In the second stage, the constructability factors were evaluated by experts in the renovation field. From the expert interviews, 27 factors were selected for the renovation constructability assessment model (RCAM) (Table 2).

Table 2: Summary of the RCAM factor selection procedures

Phase	Objective	Analysis	Summary of analysis		
			Subject	Method	Output
I	To prepare RCAM factor pool	Qualitative	Prior research and cases	Literature Survey and expert survey	Candidate factor list (40 factors)
II	To find applicable factors	Qualitative	Selected factors list (40 factors)	Expert interviews	Applicable for RCAM factor list (27 factors)

LITERATURE REVIEW

Building Renovation and Extension

Renovation can be defined as enhancing the value of buildings that are degraded in physical, economic, and environmental value compared to the value at the time of construction (Yoon and Yu, 2017). Such renovations, including horizontal and vertical expansion, are limited to the extent permitted by law (Figure 1).

Constructability Analysis

Prior to deriving constructability factors for renovation, it is necessary to analyse the constructability factors of previous studies. Many constructability studies summarise the critical factors, but these factors are focused on new buildings. Therefore, factors related to renovation should be selected out of these and then applied. This research summarises the literature review of constructability factors related to building (Table 3).

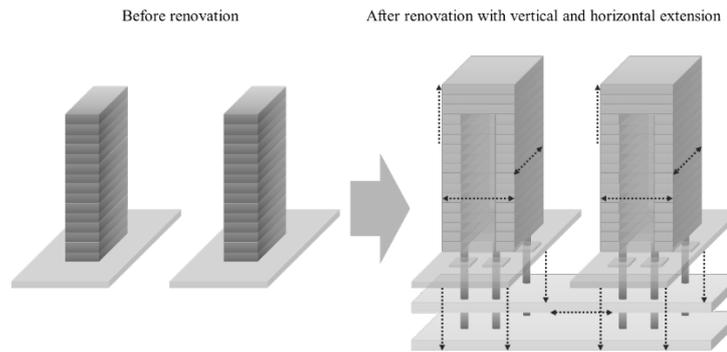


Figure 1: The concept of building renovation and extension

Table 3: Constructability literature review

No	Reference	Scope of Application	Constructability Attribute (Number)	Constructability Attribute (Contents)	Measurement Method	Country
1	BCA (2017)	All building types	Not specified	Structural system, projected area, basement area, wall system, labour saving index, designs/features such as standard columns and beams, prefabricated mechanical electrical and plumbing (MEP), high strength concrete, etc.	Quantitative analysis (calculating buildability score)	Singapore
2	Lam and Wong (2011)	All building types	9 buildability factors	Economic use of contractor's resources, design requirements to be easily visualised and coordinated by site staff, development and adoption of alternative construction details, standardisation and repetition, prefabricated and onsite works, simplification, Minimising the impact of weather conditions, safe construction sequence	Quantitative analysis The analytic hierarchy process (AHP), survey, interview)	Hong Kong
3	Wong (2007)	All building types	6 elements, 47 attributes building system	5 structural frames, 4 roofs, 5 slabs, 5 envelopes, internal walls, 5 finishing systems, 7 building service aspects, 7 building features, 5 site specific factors	Quantitative analysis (calculating buildability score)	Hong Kong
4	Yang <i>et al.</i> , (2003)	Not specified	Buildable component from clients, designers, contractor's requirement	Structural systems, wall systems, refuse chute, bath room, balcony	Quantitative analysis (House of quality and fuzzy theory)	Not specified
5	Zolfagharian and Irizarry (2017)	Commercial buildings	10 elements, 50 attributes building system	11 structural frame types, 7 slab types, 10 roof types, 11 external wall types, 9 internal wall types, 4 staircase types	Quantitative analysis (AHP, survey, interview)	United States

It is necessary to add or delete factors considering the renovation characteristics (such as existing structure condition and environmental factors). Furthermore, as a quantitative model for design evaluation, the BDAS in Singapore can be actively referred to as a precedent study. The BDAS was applied to improve constructability in Singapore (Lam *et al.*, 2006). The following is the concept of the BDAS evaluation model.

[Buildable design score of superstructure or basement = Buildable design score of structural system + Buildable design score of wall system + Buildable design score of design for manufacturing and assembly technologies]

Each score is expressed as the product of the labour saving index and floor area ratio, and the product of the labour productivity index and wall area ratio. The system consists of a hierarchy model that is made up of structural systems, roof systems, wall

systems, other constructability factors, bonus points and so on, similar to the BDAS. In this research, it is necessary to create an evaluation system by deriving factors that reflect the existing structured model and the required renovation characteristics. For example, this research presents the factors of underground space expansion, which is the most important and critical type of work. Underground space expansion has the largest impact in terms of cost and time, because it greatly affects the superstructure

Factors Affecting Constructability

Types of Underground Space Expansion

The expansion of the underground space of an apartment can be divided into horizontal expansion, vertical expansion, and the construction of a house separate from the main building (annex) (Figure 2). The constructability varies greatly depending on each type. This is because the selection of the construction method, the type of foundation reinforcement, and the construction process are determined according to the underground expansion type.

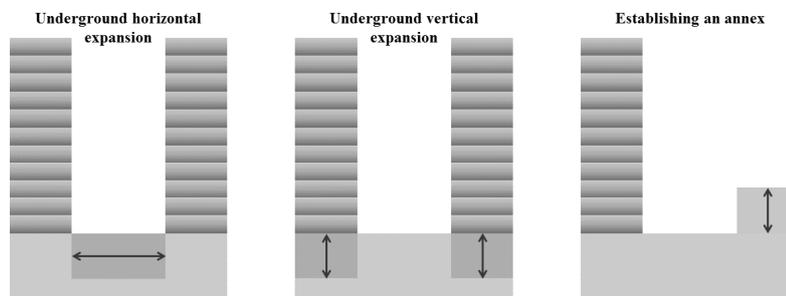


Figure 2: Types of underground space expansion

Constructability Factors When Expanding Underground Space

Expert interviews were conducted with seven renovation experts. The main objective of the expert interview was to derive the factors affecting the constructability in underground expansion. In fact, as there are numerous factors affecting constructability in renovation projects, we tried to derive the critical factors for the constructability assessment model.

Table 4: Overview of expert interview

Division	Description
Objective	To identify constructability factors when expanding underground space in renovation
Target	Five project managers of construction companies experienced in renovation projects (3 construction managers, 1 foundation reinforcement work, 1 demolition work) Two professionals associated with renovation projects (professors of construction management)
Method	Questionnaires through meetings, and question and answers addressed online and via the telephone

The process of extracting constructability factors of underground space expansion work is derived from the decision-making process that determines the type of underground space expansion and construction method. It also includes predictable risk factors in the process. The decision process of underground expansion is as follows (Figure 3).

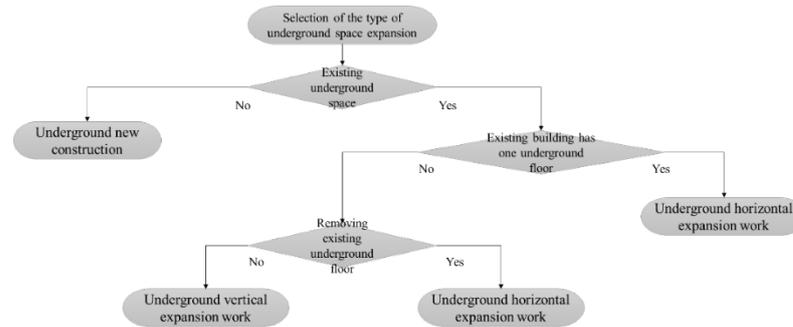


Figure 3: Decision flow in underground expansion

Based on the above figure, a total of five key factors were derived: (1) underground floors, (2) location and spacing of adjacent buildings, (3) scale of existing building, (4) demolition range and reinforcement method, and (5) selection of the construction method considering the constructability when reinforcing the foundation by extension.

Key factors affecting constructability in renovation projects

On the basis of the building renovation and extension study, the renovation constructability study, and the expert interviews, 27 constructability key factors were derived: 15 structural factors, 2 wall factors, 5 architectural factors, and 5 other factors selected as key constructability factors of the renovation work (Table 5).

Table 5: Key factors affecting constructability in renovation projects

Level 1	Level 2	Level 3	Reference		
Structural systems	Existing building structural systems	Consistency of drawings with existing buildings	Lam and Wong (2011)		
		Structural safety index of existing buildings			
		Site accessibility of manpower, equipment, and materials in accordance with existing buildings			
		Existing building slope			
		Structural reinforcement scope			
		Selection of materials and equipment for demolition and repair work		Yun (2015); Lam and Wong (2011)	
		Selection of the construction method considering the constructability when reinforcing the foundation by extension		Yun (2015)	
		Underground space expansion		Underground space expansion	The number of underground floors
					Location and spacing of adjacent buildings
					Scale of existing buildings
Demolition range and reinforcement method	Yun (2015)				
Wall system	External	Selection of the construction method considering the constructability when reinforcing the foundation by extension	Wong (2007)		
		Etc.			
	Internal	Prefabricated MEP			
		Standardisation and repetition		Lam and Wong (2011)	
		High-strength concrete application		BCA (2017)	
Architectural system	Internal	Cladding system application	Zolfagharian and Irizarry (2017)		
		Dry method application			
		Workspace optimisation in limited space	BCA (2017)		
		Technical provisions and clarification of specifications for renovation projects	Yun (2015)		
		Moving ground parking space underground			
Etc.	Internal	Internal and external specialisation plans			
		Increase the number of bays (e.g. 2bay → 3bay)			
		Requirements of the client			
		Constraint (noise, vibration, and environmental pollution such as dust)			
Etc.	Internal	Accuracy of site survey for existing buildings			
		Underground facility status			
		Complaints from the neighbourhood			

Methodology to Develop Renovation Constructability Assessment Model (RCAM)

The goal of the analysis of constructability factors is to develop a constructability evaluation model. Through this, we can find optimised design alternatives by evaluating each of the design alternatives. The following analysis methodology can be applied on the basis of the constructability factors (Figure 4). After the factor finding, factor weighting is performed to derive the constructability index (CI). Using CI and expert evaluation, the score of the design (ALT 1, 2, 3...N) can be derived as shown in Figure 5. From the sum of each constructability score, design ALTs are compared.

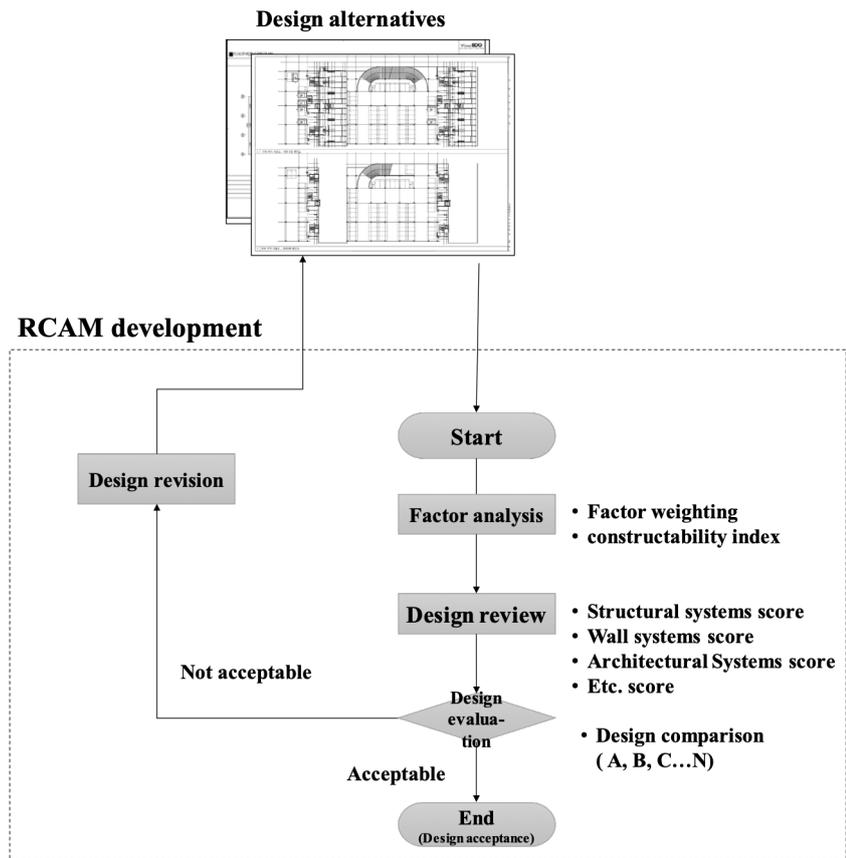


Figure 4: Methodology to develop constructability assessment model of renovation

$$\begin{aligned}
 &\text{Renovation Constructability Score} \\
 &= \sum \text{Buildable Design Score of Structural System} \\
 &+ \sum \text{Buildable Design Score of Wall System} \\
 &+ \sum \text{Buildable Design Score of Architectural system} \\
 &+ \text{Extra score}(N)
 \end{aligned}$$

Figure 5: Formula of renovation constructability score

CONCLUSIONS

This research has been conducted to find the constructability factors of building renovation and extension to develop a constructability assessment model for renovation design evaluation. To derive the factors, expert interviews and extant

literature were reviewed. For example, in the case of underground space extension construction, factors were derived from the decision flow of the selection of underground space types and risk factors. Including the rest of the renovation works, a total of 27 key factors were derived from the renovation expert interviews and analyses of previous constructability studies. The findings of this research are meaningful because of the preliminary study of the development of a quantitative constructability evaluation model for renovation design alternatives. Prior research on the constructability evaluation of renovation projects is limited to checklists or qualitative evaluation, but it is expected that the evaluation system based on these factors can be established more quantitatively. The extracted factors can be used to develop construction assessment models for renovation projects. In addition, as the problem of ageing buildings is increasing, and effective renovation is being discussed across the world, it can be used in the context of this research industry as well. In future research, AHP or fuzzy methods can be used for deriving the constructability index and quantitative evaluation score. The developed model will help in decision-making when selecting the renovation design. Furthermore, a quantitative evaluation of renovation design is possible if a comprehensive evaluation of constructability, project cost, and time is integrated into one package.

ACKNOWLEDGEMENT

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ACTIVATION TRIGGER FOR ORGANISATIONAL BIM LEARNING: VIEWS FROM MALAYSIAN CONSTRUCTION STAKEHOLDERS

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Building Information Modelling (BIM) is one of the current initiatives by the construction industry to escalate the performance and productivity in managing construction projects. Despite various initiatives that have been taken to encourage construction organisation to adopt BIM in Malaysia, the response remains unfavourable. As part of a wider study to understand the concept of Absorptive Capacity (AC), this study aims to explore the critical activation triggers for construction organisations in Malaysia towards BIM learning. Data were gathered and analysed quantitatively and qualitatively through a questionnaire survey and semi-structured interviews research method involving a wide range of construction organisations. The findings revealed that the top five activation triggers were; initiatives by construction constitutional bodies; BIM standard manual and guidelines; appointment of well experienced BIM manager; established BIM monitoring unit and opportunity for collaboration and susceptible to new environments using BIM. The study gives an initial insight on what it takes to drive Malaysian construction organisations towards BIM implementation. Future research is recommended to further explore the other elements of AC in developing a framework for BIM learning among local organisations.

Keywords: absorptive capacity, organisation, Malaysia

INTRODUCTION

Poor project delivery is one of the main issues in the construction industry in Malaysia. This issue associated with problems of fragmentation, including the isolation of professionals, lack of coordination between design and construction and as it is carried out in a sequential manner, it leads to time delays, poor communication, conflicts and misunderstanding between design consultants and contractors (Nawi, Lee, Kamar and Hamid, 2012). Building Information Modelling (BIM) can be seen as a solver in tackling these problems and thus bringing the much needed improvements in the construction industry. BIM technology can be utilized to enhance construction project performance in all stages of construction namely planning, design, construction as well as maintenance and operations of buildings (Hamid and Embi, 2016).

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Despite many advantages of BIM, the usage of BIM in Malaysia is still at infancy stage. Like other developing countries, the adoption of BIM is still in the discussion on the boundary of Government mandate, software usage, policies and standards, education, possible drivers and barriers of implementing the technology (Ismail, Chiozzi and Drogemuller, 2017).

BIM in Malaysia started in 2010, where the National Cancer Institute became the first government project to implement BIM (Latiffi, Mohd, Kasim and Fathi, 2013). In year 2012, the Public Works Department (PWD) formed the Project unit under the complex project division, also known as PROKOM, which consists of architects, civil and structural engineers (CandS), mechanical and electrical engineers (MandE) as well as quantity surveyors (QS). The first BIM guideline for projects intending to use BIM was published by PWD in order to encourage the usage of BIM amongst construction practitioners.

However, although the relevant constitutional bodies have introduced measures to increase the usage of BIM in Malaysia, these efforts have not been very successful due to lack of involvement from construction stakeholders. This is mainly due to lack of awareness, which could be overcome through training and seminars on BIM (Latiffi, Brahim and Fathi, 2016) (Harris, Ani, Haron and Husain, 2014).

Construction stakeholder's organisation have had difficulties for various reasons in acquiring and using BIM technology for more effective project delivery. Based on BIM report 2016 by Construction Industry Development Board (CIDB) (CIDB, 2017), the readiness levels of BIM among the construction players in Malaysian is low due to lack of clear policies and financial incentives to support the implementation of BIM.

On the other hand, some organisations may simply be unaware of the potential of BIM to improve the process in their construction projects. To enhance BIM implementation, it is crucial for the top management as decision makers in an organisation to first realise the potential of BIM (Latiffi *et al.*, 2016; Harris *et al.*, 2014). Nevertheless, a strategic model is required to assist construction players in implementing BIM in construction projects as it will lead to improved cooperation among BIM practitioner and for researchers to educate and expose BIM (Latiffi *et al.*, 2016; Harris *et al.*, 2014). Incentives can also be introduced to increase demand on application of BIM in their project.

To enable a better understanding of BIM implementation in construction projects, Absorptive Capacity (AC) concept can be used as a strategic model in assisting the construction stakeholders to recognize knowledge on BIM and its implementation. According to Cohen and Levinthal (1990), the new knowledge application and implementation is to be reviewed in terms of the concept of knowledge source, driven factor and the organisation performance. The AC concept is a systematic approach of organisation behaviour study on individual, group, firm and national levels of a new knowledge adoption to enhance their process and productivity (Cohen and Levinthal, 1990). In the case of BIM implementation, AC serves to provide an additional approach to see the overall implementation beginning with recognizing the knowledge of BIM, what motivates the organisation to implement BIM, its activation triggers and how the organisation assimilate this new knowledge. Hence, producing a better result will further encourage the construction stakeholders to utilize BIM at their own capacity as required by their top management or other relevant parties in the construction industry. One of the elements that give a significant impact on AC of

BIM implementation is the Activation Trigger. This paper will discuss the factor that activated BIM implementation among Malaysian Construction Stakeholders.

The activation trigger is defined as an event that encourage or compel a firm to respond to specific internal or external stimuli. In a product innovation research by Kocoglu, Akgün and Keskin (2015), activation trigger is a dynamic element of AC that is presented as influencing the responses a firm gives to external stimuli, such that enabling the firms to achieve intensified learning skills and efforts. In the construction industry, BIM can be seen as a push factor in escalating the performance and productivity of construction projects. As for the implementation of BIM, CIDB plays a significant role to educate and increase the awareness on BIM in order to encourage all the construction stakeholders to implement BIM in their construction project.

Building Information Modelling In Malaysia

According to Latiffi *et al.*, (2013), the idea of implementing BIM in Malaysia was introduced by the Director of Public Work Department (PWD) in 2007. In August 27 of the same year, PWD committee was formalized by the government to decide on BIM platform based on the availability of computer systems and software. BIM is briefly defined as a process supported by a technology of computer software generated model used in both to populate information and simulate the construction stages including planning, design construction and operation of facility management (Takim, Harris and Nawawi, 2013). BIM is known as the new technological approach software which provides an integrated accomplishment and able to improve the client satisfaction on time, cost, safety and functionality of construction projects (Takim *et al.*, 2013).

According to Takim *et al.*, (2013), one of the Malaysian government agenda in the 12 National Key Economic Area (NKEAs) under the Economic Transformation Program involves upgrading and escalating business growth in the architectural, engineering and construction industry. It aims to comprise selected sectors of economic opportunity for private sector, which will drive Malaysia towards high-income status and global competitiveness.

The government of Malaysia plays the principal role to ensure successful BIM implementation in the industry through the constitutional body, which is CIDB and PWD (Latiffi, Brahim, Mohd and Fathi, 2014). Thus, the benefits include having an integrated software application and standardisation for achieving operative workflow for progress and application of a project (Harun, Samad and Haron, 2016). The massive potential that BIM has on solving problems of construction projects, have prompted the government to put great efforts in encouraging the stakeholders to implement BIM throughout the project lifecycle (Latiffi *et al.*, 2014).

Examples of BIM projects in Malaysia are National Cancer Institute of Malaysia located in Putrajaya, Educity Sport Complex in Nusajaya and Ancasa Hotel in Pekan, Pahang (Mohd and Ahmad Latiffi, 2013). All of these projects are pilot projects initiated by the PWD (Harun *et al.*, 2016).

The PRIMA Corporation Malaysia has initiated BIM through their development of affordable residential house to deliver quality houses (Harun *et al.*, 2016). The Multimedia Super Corridor (MSC) have also invited undergraduate students and organisations for training on BIM, covering BIM guidelines and utilization of BIM tools (Latiffi *et al.*, 2014). Similarly, according to Latiffi *et al.*, (2014), Construction

Research Institute of Malaysia is also providing education and training on BIM in order to create awareness and readiness to implement BIM among construction stakeholders.

The focus of CIDB currently in improving the construction industry is through the implementation of BIM under its productivity P4 initiative “Construction Industry Transformation Programme (CITP 2016-2020)” which is to roll out technology advantage across the project life cycle. Under this initiative, CIDB facilitates BIM adoption in the construction industry via regulations and to establish a reference centre to support the development and adoption of BIM and modern methods.

Although all the initiatives played by constitutional bodies in encouraging the construction industry player using BIM, the usage is still low as majority of the stakeholders still prefer traditional approach to execute construction project. Implementing BIM without knowing the benefits and how to deliver project-using BIM may result in project delay, major changes during construction and other issues. To relate to this situation, Mohd Harris Ismail Director of building SMART Malaysia in May 2018 wrote an article entitled understand BIM-what kind of result, emphasising that BIM should be used to deliver project not the other way around. The study on AC enables the organisation to gauge their overall capacity and the organisation in implementing BIM.

Absorptive Capacity of BIM Implementation

AC was first defined by Cohen and Levinthal (1990) as a firm's ability to recognize the value of new information, assimilate it and apply it to commercial ends. Osman, Mazlina, Khuzzan and Razaksapian (2015), stated that a strong AC in an organisation will improve the productivity of an organisation by synchronizing peoples’ capabilities, processes involved and technology used.

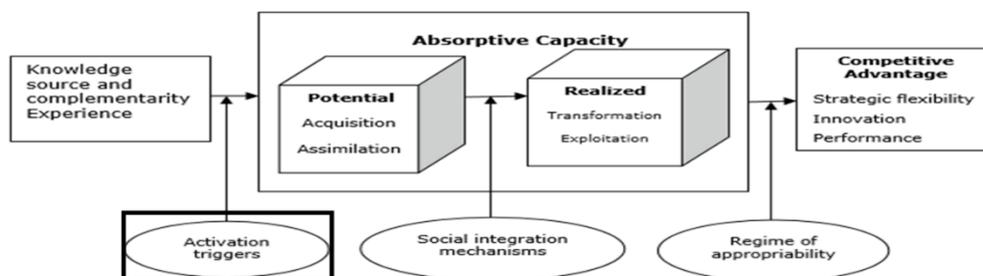


Figure 1: A model of an AC (Zahra and George, 2002)

Based on model of AC develop by Zahra and George (2002), the firm’s potential AC influence by external knowledge sources which is experiences. They also added that, external knowledge and experience from past projects is not sufficient to create an AC development in an organisation. The model signifies that activation triggers have the biggest impact to an organisation in development of AC.

AC is divided into two component subsets, which are potential AC (PACAP) and realized AC (RACAP) PACAP, involves acquisition and assimilation of the knowledge. Between both PACAP and RACAP, social integration mechanism is developed based on the communication skill of the top management on how they deliver the knowledge to the staffs in application of the new knowledge. Reducing the obstacles for information sharing is one of the aim in a successful AC development. Transformation and exploitation lies under component subset of RACAP (Gluch, Gustafsson and Thuvander, 2009). Gluch *et al.*, (2009), further simplify that

transformation defines as organisation's ability to develop and clarify the routine of new environment. In sense of BIM implementation, the organisation needs to synchronize routine by incorporating recent knowledge and to apply it throughout the operation and practices. Likewise exploitation, the theory behind BIM implementation reflects the organisation's ability to exploit the knowledge and assign it as common practices (Mustafa Kamal and Flanagan, 2012). AC provides the theoretical basis for comprehensive understanding of the usage of new knowledge to be implemented in the company (Park, Suh and Yang, 2007) A research concluded by Belso-Martínez, Expósito-Langa and Tomás-Miquel (2016) a company with a low AC tend to be left on the side-lines and face greater difficulties in accessing valuable technical knowledge. According to Saša and Andy (2018), diversity of knowledge is critical for potential AC, knowledge overlap is critical for realizing AC.

There is a strong basis to develop the AC of a construction organisation in the process of adopting a BIM as a new knowledge in the construction project execution. The external knowledge in AC is referred to BIM implementation among construction stakeholders. For example, how the construction stakeholders managed to handle the BIM knowledge and apply it to the construction project with compromising the project. To relate to Zahra and George (2002) model, regime of appropriability defines as the organisation ability on protect and value their new product of BIM where all the advantages comply in regime of appropriability being maintained. Lastly, according to Gluch *et al.*, (2009), an organisation with well-developed AC will create business advantages through innovation and technological advanced. For example, for a company to sustain in this construction industry, it is crucial to enhance the performance of working environment for positive effects to the company. Once the company has positive effects, it will improve productivity as well as integrity of the company (Kamal, 2013).

Activation Trigger of AC in BIM Implementation

Activation triggers of AC are approached through studies on the role of internal and external innovation intermediary in technology transfer and diffusion (Todorova and Durisin, 2007). Two main roles played by different stakeholders using BIM are described in the triggering phase of AC. Firstly, it is a modern tool that is proven to benefit construction stakeholders' organisation as usage of BIM in construction project improves coordination of all discipline. Secondly, are the roles of BIM consultants or BIM manager as coordinator to capture and to solve design issues before getting to the construction stage. The other mechanisms that are directly related to knowledge and activated differently, the triggering sequences are (1) selection (2) adoption (3) contextualization and (4) preservation of knowledge (Servajean-Hilst and Picaud, 2014). These mechanisms affect the AC on BIM implementation in Malaysia.

The selection of a BIM tool to be used in the construction project execution is based on construction project lifecycles. The activation trigger relates with the process of coordination of all discipline in one project which my result in the project delivery effectiveness and efficiency. Furthermore, BIM is adopted due to its capability that suits to the construction stages appropriability. Encouraging factor in adopting those BIM tools is based on the project needs. Thus, the guideline develop by constitutional bodies is to assist the assimilation of new knowledge in enhancing productivity. Selection of relevant BIM tools to be used at every stage of construction is crucial. For example, in design stage the BIM design tools must be able to cater respective

fields and to enable coordination of all the design. This improves the Bill of Quantities (BQ) accurateness for the tender process. Preservation of knowledge is required to achieve the productivity and efficiency in project implementation and to enhance it further. BIM knowledge in project execution is preserved to maintain the momentum of the construction industry. Internal knowledge is also preserved by innovation to enhance the overall process in the long-run.

RESEARCH METHOD

The research is conducted by linking the concept of AC from previous studies by various industry in measuring their movement toward a new knowledge. The AC concept is used to study the movement towards BIM implementation in construction projects in Malaysia. The element of activation triggers is a dynamic element in AC presented as influencing the response a firm gives to external stimuli, such that enabling the firms to achieve intensified learning skills and efforts (Kocoglu *et al.*, 2015). Zahra and George (2002) model is used as a basis to explore BIM where it starts with the external knowledge source and experience on BIM implementation. This is followed by awareness on the potential of BIM by acquisition and assimilation element. The organisation will then realize BIM implementation by transformation. Finally, the output of BIM implementation is the business advantage by a better performance in project execution. The most important element is the activation trigger where it is a dynamic element prior to BIM implementation. Activation triggers of BIM implementation among construction stakeholders is an important element in the AC as this is an indicator on what trigger the stakeholders to use BIM at the first place. BIM implementation is a continuous and inter-related process among construction stakeholders. Therefore, the feedback from various stakeholders in different stages of construction is required.

Data were gathered and analysed quantitatively and qualitatively through a questionnaire survey and semi-structured interview research method involving the range of construction organisations to identify activation triggers for BIM implementation among the construction players. The survey questions were designed based on literatures on BIM in the Malaysian Context by gathering all trigger factors on what makes the construction players use BIM. A total of 89 respondents responded to the survey from all construction stakeholders' organisations namely architect, engineering consultants, contractor and quantity surveyors (Table 1). The analysis is based on relative important index (RII) and mean ranking of a Likert scale of RII. The Activation trigger is first quantified by the relative importance index (RII) method prior to mean ranking.

Data is further comprehended using semi-structured interview question and the analysis using content analysis to correlate with questionnaire result by broader patterns of meaning in interviews answers. Semi-Structured interview allowed the discussion on the BIM progress in Malaysian context. The first theme identified from interview analyses relate to their opinion as representative of the organisation what motivates their organisation to use BIM was based on appropriability of the tools and the benefit on BIM in construction project execution. Based on the content analysis, the similarity on the statement given by these three respondents is mapping to the result of survey on RII and Mean ranking. The enquiries are to comprehend the questionnaire data on activation triggers in adopting BIM in Construction project. The findings are revealed through analysis of interview sessions and the survey from construction stakeholders on what motivates them to used BIM.

Table 1: Population size and respondents

Construction Stakeholders	Description	Population size	Sample size required	response	%
Contractor	Registered with CIDB	1744	315	13	4.13
Architect	Registered with Ministry of Finance Malaysia	152	109	33	30.28
Quantity Surveyor	Registered with Board of Quantity Surveyors Malaysia	132	98	29	29.59
Consultant	Registered with Ministry of Finance Malaysia	312	171	14	8.19
Total				89	72.18

RESULTS AND DISCUSSION

Table 2: Comparison RII and mean ranking of Activation Trigger of BIM Implementation

No	Activation Trigger	Mean	Ranking	RII
1	Construction Industry Development Board (CIDB) initiative approach by providing BIM Portal, Seminar and Workshop	4.16	1	0.831461
2	Public Work Department initiative approach for preparing BIM Standard Manual and Guidelines for construction stakeholders	4.13	2	0.826966
3	Establishment of BIM Unit Projects by Complex Project Management Branch (PROKOM)	4.08	3	0.81573
4	Well experience of project manager handling construction project	4.08	3	0.81573
5	Opportunity from other parties to collaborate implement BIM in construction project	4.07	4	0.813483
6	Susceptible to new environment of construction phase	4.02	5	0.804494

Table 3: Mapping of Interview and Questionnaire Result

Interviewee	Stage of Construction	Activation Trigger (Interview)	ranks	Top 5 Activation trigger (Questionnaire)
Respondent 1 (Client firm)	All Stage	The Awareness on the movement toward BIM by Constitutional bodies such as CIDB and PWD.	1	Construction Industry Development Board (CIDB) initiative approach by providing BIM Portal, Seminar and Workshop
			2	Public Work Department (PWD) initiative approach for preparing BIM Standard Manual and Guidelines for construction stakeholders
			3	Establishment of BIM Unit Projects by Complex Project Management Branch (PROKOM)
Respondent 2 (Engineering Firm)	Design Stage	The benefit of solving the issues in design stage by coordinate all discipline in the project before goes to awarding the tender to the contractor	3	Well experience of project manager/BIM consultant handling construction project
			4	Opportunity from other parties to collaborate implement BIM in construction project
Respondent 3 (Engineering Firm)	Construction stage	The Industry Foundation Classes (IFC) format of drawing can be used to visualize the building in 3D. it benefit to all the stakeholders in term of visualization. Enhance the construction method that contributes to better planning.	4	Opportunity from other parties to collaborate implement BIM in construction project.
			5	Susceptible to new environment of construction phase

Based on the relative important index (RII) and mean ranking analysis, the top ranks Activation Trigger of AC (ATAC) of BIM implementation in construction project was the initiative of Construction Industry Development Board (CIDB) by providing BIM Portal, seminar and workshop. That factor is supported by several authors. According to Takim *et al.*, (2013), the technical committee and workshop formed by CIDB is the initial effective initiative to discover the technical limitation in implementing BIM in construction industry. The other author, which is Bin Zakaria *et al.*, (2013), state that the government through CIDB could promote the benefits of BIM thus directly can spark the curiosity about BIM among construction stakeholders as individual and as an organisation. A research concluded by Park *et al.*, (2007) effective knowledge transfer requires an individual to understand acquired knowledge in the new context and synthesize it into their task environment.

The other ATAC of BIM implementation in construction project lies in second ranks was a Public Work Department initiative approach to prepare BIM Standard Manual and Guidelines for construction stakeholders. The statement is quite similar with (Bin Zakaria *et al.*, 2013) which government through PWD should provide grant scheme for BIM training. According to Latiffi *et al.*, (2013), the encouragement from government to initiate the BIM implementation can be increase by providing training and appropriate guideline for BIM as one of the condition imposed in project documentation tender. The ranks followed by the establishment of BIM unit by PWD lies in third rank and same par as the roles of BIM manager and BIM consultants in handling project-using BIM. The fourth and fifth activation triggers ranked by respondents are the opportunity in collaboration among parties involve in construction project and susceptible to new environment of BIM implementation in construction project, respectively.

The ATAC of BIM implementation activated by the construction project is a sign that their level of awareness and understanding on BIM is high and parallel to the government's direction towards the executions of the project using BIM in enhancing the project delivery in terms of productivity, efficiencies and effectiveness toward triple constraint of the construction project. The BIM movement driven by CIDB and PWD as the constitutional bodies in Malaysia that governs and provides further direction to the construction industry in increasing its effectiveness in the project execution.

CONCLUSIONS

The AC concept starts with external knowledge source and experience on BIM implementation. Prior to implementation of BIM, the activation trigger is the most important element for an organisation to realize the potential of BIM and implement it in their organisation.

This paper presented the top five (5) activation triggers in AC study that drives Malaysian Construction stakeholders to adopt BIM in their construction projects. It can be concluded that the constitutional bodies in Malaysia namely CIDB and PWD have a major role in providing the awareness and support that can further activate the adoption of BIM amongst construction organisations. The role of BIM managers or BIM consultants are also among the top of activators of BIM implementation in Malaysia. The opportunity to collaborate in the coordinating process and susceptibility of the new environment during construction project execution among various disciplines in a construction project is also another activator of BIM implementation in Malaysia.

Knowledge and awareness on the potential of BIM, is the major activation trigger of BIM implementation among construction project stakeholders, which is driven by CIDB and PWD. Constitutional bodies in Malaysia act as external intermediaries that facilitate the knowledge transfer across people, organisations and industries via linking BIM knowledge bases and helping the recipient and the source to transform the transferred knowledge. This will be followed by the execution of the project by experience project managers and BIM consultants that will further initiate collaboration across all discipline in the construction project.

With the fact that the takers of BIM are still limited, the role of the constitutional bodies namely CIDB and PWD are ranked as the top activation trigger of BIM

implementation in Malaysia. In future, the activation trigger will change as the BIM takers increases among construction industry players.

The AC approach can be applied to study BIM knowledge of individual, group, firm and at national levels. The government and all other construction stakeholders can use the AC concept to explore the BIM potential at their own capacity of discipline in construction project. This will further contribute to BIM awareness systematically and increasing the maturity level of BIM implementation in Malaysia.

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