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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

It has been twenty years since the ARCOM Conference took place in Cambridge, at King's College in 1997. We return in 2017 with the theme, *Brutally Innovative Construction*, inspired in part by the venue Fitzwilliam College. Fitzwilliam began in 1869 as a non-collegiate institution, providing Cambridge education to undergraduates unable to afford membership of a college. Fitzwilliam College received its Royal Charter in 1966, 3 years after moving into its new premises on its present Huntingdon Road site. The College has been decorated with several architectural awards, including the two buildings used for the ARCOM 2017 Conference – Fitzwilliam Hall and Central Building (designed by British Brutalist Architect, Sir Denys Lasdun, and built 1960-1963) and the auditorium (built in 2004).

This year's conference attracted 345 submissions in January 2017. Following three rounds of double-blind peer-review, a total of 113 papers were eventually accepted for presentation at the conference. In a field that is now saturated with so many international conferences, this success rate demonstrates the rigour applied to the ARCOM peer-review process. Of course, this cannot be achieved without the support of 110 reviewers drawn from across the world, including 21 ARCOM Committee members and 89 members of the extended Scientific Committee. Thank you to all involved in the peer-review process.

This is the second year in which the ARCOM Conference is themed. There were also 10 thematic tracks proposed for the conference, covering a range of issues from service innovation to novel research methods for studying innovation in construction. There were also a number of tracks relating to the social aspects of innovation, including corporate social responsibility and social procurement in construction. These thematic tracks now form an important part of shaping the papers received and accepted and, we hope, of steering the conversations at the conference. As expected in a conference on innovation, we received a number of papers on the development and use of technology. Digitisation of the construction industry continues to be a significant theme, with several authors examining how information modelling is transforming the people, professions and practices in construction. Another significant area in this year's conference is the focus on environmental sustainability, with authors addressing questions around low energy and low carbon construction.

It is also encouraging to see authors becoming more explicit about and experimental with the theories informing their studies of innovation in construction. Social network theory, actor-network-theory, institutional logics and institutional work, and even critical discourse analysis inspired by a smattering of Marxist thinking are some of the lenses used by authors to study the innovations that are radically transforming and disrupting the construction industry. Construction management researchers can be seen to mature from a relatively atheoretical field to one that is actively trying to put theory to work. It is therefore appropriate that the first keynote speaker is by Professor Chris Ivory from the Lord Ashcroft International Business School in Anglia Ruskin University, Cambridge; Chris will be provoking us to think about the role of theory in innovation in construction.

There is also a mixture of different epistemological positions found in the papers accepted for this year's conference. A number of authors are also researcher-practitioners, and it is good to see such engaged forms of scholarship as action research featured in some of the papers. Innovation is also a collaborative endeavour, often involving actors across the value chain from supply networks to clients and end-users. It was not so long ago that collaboration was seen in the construction industry as an innovation itself, and while there is still much room for improvement, it is also interesting to see so many papers refer to collaboration as a source of innovation. To this end, we have scheduled four early-career

researchers (incidentally, all women) to be featured in the Langford Spotlight. This spotlight scheduled for the morning of Wednesday 6 September seeks to showcase research on collaboration through different theoretical lenses.

In such an applied field as construction management, collaboration between academic researchers and industry practitioners seems appropriate. We are delighted therefore to have a second keynote led by the programme team, including Nicolas Caille, David Coulet and Simon Evans, who are delivering brutal innovation within the New Safe Confinement Project at Chernobyl. This is a 36,000-tonne structure that is due to complete by the end of 2017 to cover the accident site in Chernobyl. For more information about this project, please see <http://www.ebrd.com/what-we-do/sectors/nuclear-safety/chernobyl-new-safe-confinement.html>. This second keynote will also be followed by an Industry Panel Discussion on Disruptive Innovation in construction.

ARCOM continues to attract an international audience, and we have delegates joining us this year from inter alia Europe (with colleagues from the Netherlands and across Scandinavia), the United States of America, South Africa, Sri Lanka, India, China, Malaysia, Australia and New Zealand. It is good to welcome colleagues from both developed and emerging economies alike. In times of rising nationalism, there is a need to ensure that knowledge benefits many and not just a few elites. To this end, we will also organise a Knowledge Café to discuss how construction management and built environment researchers can contribute to the production of knowledge around the pursuit of the Sustainable Development Goals. This Knowledge Café will be convened on Tuesday afternoon, 5 September, by Alex Opoku from UCL and Christian Thuesen from the Technical University in Denmark.

Following the successful ‘Meet the Editors’ session in ARCOM 2016, we will run this session again at the ARCOM 2017 Conference. Editors from the ASCE Journal of Management in Engineering, Building Research and Information, Construction Management and Economics, and the International Journal of Building Pathology and Adaptation will discuss what constitutes novelty in the field of construction management research. In a world dominated by performance metrics, it is hoped that the editors will discuss how various publication metrics are helping (or hindering) progress made in finding the novel in the field.

Whether loved or loathed, the use of publication metrics is likely to intensify. Nevertheless, this should not distract researchers from doing high-quality studies. ARCOM has always been intended as a forum for supporting and developing researchers. To this end, we introduced two types of papers for the ARCOM 2017 Conference: the working paper and the published paper. Although working papers and published papers go through the same rigorous peer-review process, working papers are not indexed in the ARCOM and Scopus databases. This allows authors of working papers to extend their paper into a journal publication without diluting their publication metrics.

Last, but not the least, I also wish to show my sincere appreciation to a number of key individuals for their support and help over the past year, including the ARCOM Committee, Cath O’Connell, Alan Pease, all the folk who helped us at Cambridge Conference (including Anita Macdonald, Emma Hilditch and Laura Webb), and of course, our ever-patient and increasingly overworked Conference Secretary, Chris Neilson.

Enjoy the ARCOM 2017 Conference.  
Paul W Chan  
Chair, ARCOM 2017  
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 89 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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# **BUILDING INFORMATION MODELLING**

# A SYSTEMIC BIM INNOVATION MODEL IN THE CONSTRUCTION SUPPLY CHAIN

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BIM innovation research has mainly focused on diffusion models of acceptance at the individual and organisational levels. However, BIM has the potential to bring together multiple organisations working collaboratively in a coordinated fashion. Realising this potential requires a study of BIM innovation at the inter-organisational level, which is considered to be systemic BIM innovation. Systemic BIM innovation and its effect in the construction supply chain have not been sufficiently investigated. The aim of this paper is to present a critical review of literature on the diffusion of BIM innovation in the construction industry. A conceptual model of systemic BIM innovation is developed and presented. The proposed model incorporates factors such as individual BIM acceptance, organisation's drivers of BIM usage, organisation's linkages, supply chain management challenges, and the role of context. It is found that variables facilitating systemic BIM innovation are interrelated at different analytical levels, and are shaped by the context. Directions for future research and empirical validation are presented.

Keywords: BIM, construction supply chain, diffusion model, inter-organisation, systemic innovation

## INTRODUCTION

Research in information and communication technologies (ICTs) in construction, such as BIM, has investigated ICT adoption from perspectives such as enablers for technology uptake (Sargent *et al.*, 2012), alignment of technology with current work processes (Hartmann *et al.*, 2012), implementation constraints (Peansupap and Walker 2006), user resistance (Sargent *et al.*, 2012), and user technology acceptance (Howard *et al.*, 2017). As such, BIM adoption is usually approached at the individual level (Davies and Harty 2013), and the firm level (Peansupap and Walker 2006). It is argued that BIM unfolds its potential in complex inter-organisational settings, however, inter-organisational BIM studies are scant (Papadonikolaki *et al.*, 2017). The challenge is to make BIM work at an inter-organisational level in a temporary construction project-coalition in the context of various governance modes (Keast and Hampson 2007), procurement methods (Rose and Manley 2014), and top-down and middle-out BIM diffusion dynamics (Succar and Kassem 2015).

The innovation diffusion literature offers multiple names to the networks of agents in a social system interacting with technology, institutions and infrastructure to generate, diffuse, and utilise a technology. This concept has been labelled as systemic innovation (Bröring 2008), or system innovation (Geels 2002). Systemic innovations in the supply

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chain require multiple partners participating, adhering, modifying and adapting innovations in order to make them work (Chesbrough and Teece 1996).

In construction innovation research, Slaughter (1998) described system innovation as a set of complementary innovations working together to provide new attributes or functions of a system or facility. To achieve the greatest potential, the set of innovations requires implementation from the earliest stages, multiple firms working collaboratively, combined with organisational authority to ensure integration (Slaughter 1998). Taylor *et al.*, (2004) defined systemic innovation as innovations that reinforce an existing product but necessitate a change in the process that requires multiple firms to change their practice.

A systemic BIM innovation in this research is defined as the set of BIM-related innovations, including technology, process and organisational innovations, which requires multiple firms to change their practice simultaneously in order to reduce the asymmetry between the theoretical BIM potential and empirical results in projects. Systemic BIM innovation impacts the inter-organisational sphere in the construction supply chain. It requires high-level BIM applications, which have more barriers to adoption and less immediate benefits (Davies and Harty 2013). It is argued that challenges of the construction supply chain management are also challenges for the diffusion of a systemic BIM innovation. The resistance to innovation adoption is observed at organisational as well as individual levels (Singh 2014). Thus, systemic BIM innovation requires further attention to the effect of individual acceptance, organisation's drivers for technology uptake, inter-organisational linkages, and the role of the context.

The objectives of this review paper are to: (1) identify factors influencing the diffusion of systemic BIM innovation across the construction supply chain in a temporary project-coalition, and (2) develop and present a diffusion model of systemic BIM innovation. To achieve these objectives, a literature review was conducted and a systemic BIM innovation model was developed and presented. The model is discussed and directions for empirical validation are presented.

## **DIFFUSION OF INNOVATION IN CONSTRUCTION**

The innovation diffusion process has been investigated in the construction industry by a number of authors. Harty (2008) claimed that the complex context of innovation in construction, characterised by inter-organisational collaboration and project-based approach, can be studied through the sociology of technology approach. The concept of socio-technical systems was used to understand the social and organisational contexts in which innovation success can occur. These include actors and objects as mutual constituents when technology is used and negotiated in practice (Schweber and Harty 2010). Nevertheless, in a broader definition, a socio-technical system includes the cluster of technologies, regulation, user practices, infrastructure, cultural meaning and supply networks (Geels 2002). Sackey *et al.*, (2014) used the socio-technical approach in a BIM-enabled intra-organisational construction context and revealed how BIM can be aligned with concomitant work processes to maintain systems alignment.

Some other perspectives from the sociology of technology approach have also been investigated. Larsen (2005) presented cohesion, structural equivalence, and thresholds as dominant concepts in the diffusion process. Such concepts involve how individuals take up adoption based on peer's level of innovation. Larsen and Ballal (2005) identified six stages in the innovation diffusion process: awareness, interest, opinion, forming, decision-making, use and promote/impede. The research concluded that the innovation-decision

process cannot be seen without a specific context and actors initiate the innovation at any point in relation to cohesion, structural equivalence, and thresholds.

Larsen (2011) argued that awareness and influence are key concepts in the early stages of the innovation process. Linderoth (2010) suggested the actor network approach as a means to understand how to transfer knowledge and benefits from BIM adoption from one project with a constellation of firms to a consecutive project network with another constellation of firms. The perspectives of sociology of technology in construction have helped to understand technology diffusion across individuals who accept or reject a technology, organisations which negotiate in practice the use of technology, and organisations which are influenced by a more powerful firm. However, it is still unknown the effects of industrial contexts which can constraint or promote the use in the long-term. Linderoth (2010) highlighted that clients and regulation bodies are the actors believed to be the triggering point of BIM usage at an inter-organisational level and ultimately to an ecosystem level.

## **PREVIOUS MODELS ON SYSTEMIC INNOVATION**

The underlying problem of inter-organisational analysis is the constantly changing constellation of firms working on different projects (Adriaanse *et al.*, 2010; Linderoth 2010). Winch (1998) represented the construction industry using a complex systems model composed of a superstructure (clients, regulators, and professional institutions), systems integrators (contractors, architects and engineers), and infrastructure (subcontractors and suppliers). The model highlights the system integrator at the design and construction phases as the innovation champion required to integrate innovation into a coherent whole. Taylor and Levitt (2004) found influential factors facilitating the diffusion of systemic innovation among trades: organisational variety, boundary strength, interdependence of tasks, and span. However, the unit of analysis is a construction project with downstream stakeholders, namely, contractors and trade contractors.

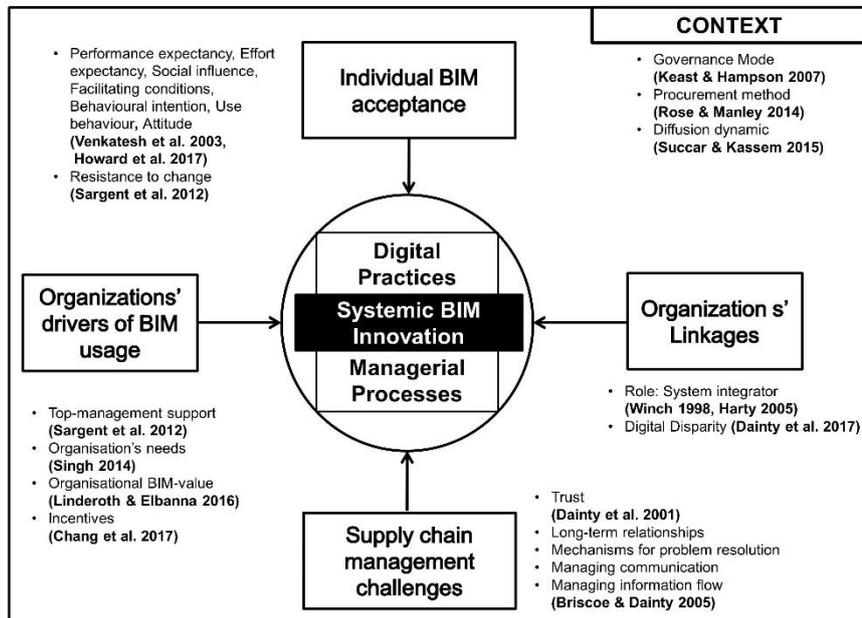
Adriaanse *et al.*, (2010) presented a model to explain the inter-organisational use of ICTs. The model showed that personal motivation, external drivers, knowledge and skills, and acting opportunities trigger the intention to use ICT, thus, the inter-organisational use of ICTs. However, these constructs are ingrained in the individual and organisational dimension of technology uptake. Moreover, BIM is defined as coordination and communication tool, leaving unexplored the process and inter-organisation changes required. Singh (2014) described three types of systemic innovation-related needs to analyse diffusion of innovations: need to innovate, need for the innovation and need for the diffusion of the innovation. Nevertheless, these needs are explained from an intra-organisational perspective in various context settings such as project complexity, client's requirement, and firm's leadership. There is a lack of understanding of how the needs of a given organisation interrelate with the needs of other firms. Mahamadu *et al.*, (2014) catalogued technological, organisational and environmental determinants to understand BIM acceptance in the construction supply chain. The focus is on user acceptance that plays a major role in BIM implementation in the supply chain context.

## **SYSTEMIC BIM INNOVATION MODEL**

The resistance to innovation adoption is observed at organisational as well as individual levels (Singh 2014). Several theoretical insights were found in the literature which help to construct a diffusion model at the inter-organisational level. The literature suggests that a systemic BIM innovation model should include: (1) BIM acceptance at the individual level; (2) organisational drivers of BIM usage; (3) inter-organisational linkages

between firms; (4) supply chain management challenges; and (5) the role of the context. The elements of the literature review were combined into a Systemic BIM Innovation Model, as shown in Figure 1.

Figure 1: First Version of the Systemic BIM innovation model



### Individual BIM acceptance

Most researchers investigating user's technology acceptance have utilised the Unified Theory of Technology Acceptance (UTAUT) to explain the acceptance and use of various ICT's in the construction industry (Davies and Harty 2013; Howard *et al.*, 2017) The model developed by Venkatesh *et al.*, (2003) predicts factors influencing the behavioural intention and the intention to use of information systems. Behavioural intention is affected by performance expectancy, effort expectancy and social influence, whereas intention to use is driven by behavioural intention and facilitating conditions. The model has been modified to explain ICT appropriation in the construction industry. Sargent *et al.*, (2012) included resistance to change to understand the individual intention to use an ICT, whereas Howard *et al.*, (2017) found attitude as a construct that correlates to the behavioural intention to use BIM. Improper ICT adoption and misalignment between construction project's problems and BIM implementation may lead to user resistance at the top-management and user levels, thus, negatively affecting the diffusion process.

### Organisation's drivers of BIM usage

A top-down approach of BIM usage within a large organisation implies that top managers are convinced that their organisation-related problems might be solved by proper use of BIM. As such, managers use it as a strategic platform to overcome problems during the design, construction and operation of building projects. Sargent *et al.*, (2012) argued that top-management support plays a crucial role in determining the failure or success of technology implementation.

Singh (2014) presented ICT innovation-related needs to understand why organisations make adoption decisions: (i) some organisations seek innovations to stay ahead of the competition (need to innovate), (ii) organisations need to improve their efficiency and manage complex projects (need for the innovation), (iii) some organisations need to drive and facilitate change as a social responsibility (need for the diffusion of the innovation).

These needs are intrinsically related to organisational ICT-value. In the inter-organisational perspective, a basic condition for value creation is the existence of firms willing to form cooperative clusters and co-create value in a thoughtful way. However, lack of incentives constrains organisation's willingness. Furthermore, firms are more focused on their own processes and ICT return of investment (Linderoth and Elbanna 2016). Economic incentives are also found in the literature as drivers of organisation's BIM uptake and inter-firm collaboration, particularly in high collaborative environments such as Integrated Project Delivery (Chang *et al.*, 2017).

### **Organisation's linkages**

Pryke (2005) contended that all organisations are social networks, thus, projects should be analysed in terms of networks of relationships, and classified according project coalition roles. A similar view is shared by Linderoth (2010) who stated that a new network of actors with new experiences will shape roles and relationships in the network. BIM will delegate new roles and competencies such as an increased need for collaboration, for example, subcontractors could soon assume a more decisive role in the design process (Papadonikolaki *et al.*, 2016). Harty (2008) claimed that there is a strong systems integrator needed to steer and manage innovation processes. This gravitating force can be defined as 'relatively bounded' which aligns various participants and reconcile potential conflicts. This relatively bounded force can be seen as a prominent role in the innovation process and has inter-organisational effects in a number of spheres of influence.

Technological disparities are also key elements to understand organisation's linkages. The term digital divide (Van Dijk 2006) refers to the gaps in access and usage of ICTs. Appropriate technology uptake requires material access (hardware and software), mental access (digital experience and interest), skills access (digital skills) and usage access (use opportunities). Large companies are in the position to use BIM due to previous experience, investment opportunities, and power. However, small and medium enterprises (SMEs) might have the usage access (e.g. a contract) but lack of the skills, material and mental access. This digital disparity makes BIM uptake in these companies an important barrier to deploy the innovation across the supply chain (Dainty *et al.*, 2017). As a consequence, some stakeholders are not in the ability to adopt new tools and processes when required.

### **Supply chain management challenges**

To unfold a systemic innovation it is crucial to unveil systemic problems that hinder the development of a specific technology development (Wieczorek and Hekkert 2012). Such problems are rooted in the network of supply chains. Bröring (2008) argued that the more systemic the innovation, the more centralised supply chain coordination should be. Nevertheless, systemic innovation is not possible in a fragmented industry (Dubois and Gadde 2002; Taylor and Levitt 2004).

A number of authors have identified problems in the management of supply chains. Thorpe *et al.*, (2003) suggested that having preferred subcontractors is actually a disadvantage. By contrast, Dainty *et al.*, (2001) claimed that main contractors tend to work with similar subcontractors and suppliers across projects. This suggests that it is possible to integrate the construction supply chain in subsequent projects when learning loops and improvements are made. However, there are factors that hinder subcontractors' integration and performance such as poor feedback and late payments made by the contractor. In this context, better achievements are hindered by decreased trust in upstream tiers and adversarial relationships in downstream tiers (Dainty *et al.*, 2001). To

address the main barriers to full deployment in supply chain management, Briscoe and Dainty (2005) identified key attributes deemed to be the most important for the successful integration of the supply chain. Such drivers are managing communication and information flows, mechanisms for problem resolution, and establishing long-term relationships.

### **Context**

Existing research recognises the critical role played by the context in the diffusion of systemic innovations (Larsen and Ballal 2005; Harty 2008; Linderoth 2010; Sackey *et al.*, 2014). The context in which the technology is deployed has direct influence in its rate of adoption. Rose and Manley (2014) catalogued contextual determinants which influence the decision to adopt innovative products. This research argues that systemic BIM innovation within a project-based coalition is shaped by client's decision on the procurement method, the governance mode and the diffusion dynamics.

Governance modes appear to be an important contribution to the field of context of innovation networks as they configure the behaviour of project teams and the BIM diffusion process at the inter-organisational level. Keast and Hampson (2007) identified hierarchy, market and networks as different governance modes that directly affect the process and of the diffusion of innovations. In the hierarchical model, an authority integrates and regulates relationships between actors. By contrast, in the market mode, organisations are regulated by demand and supply by means of contracts. The network governance is underpinned by relational aspects such as reciprocity, trust and mutual benefit.

These governance modes lead to specific procurement methods and diffusion dynamics. The hierarchy mode is closely related to the top-down approach (Winch 1998; Succar and Kassem 2015) in which all stakeholders within the circle of influence of the authority are regulated. The market mode is related to a more natural diffusion of innovation in which a large organisation or industry association exert pressure to small organisations further down the supply chain, and upwards to regulatory bodies and governments, namely, the middle-out approach (Succar and Kassem 2015). Finally, the network mode of governance resembles supply chain partnerships in which inter-organisational teams integrates beyond organisational boundaries in a long-term perspective (Papadonikolaki *et al.*, 2017). Active clients have been identified as positive influential factors for the diffusion (Rose and Manley 2014) as they are able to decide the scope of innovations since the early stages of a project.

## **DISCUSSION OF THE MODEL**

The variables in the model appear to be dynamic, interrelated, and shaped by the context. When individual and organisational acceptance is analysed, a paradox is uncovered. According to (Jacobsson *et al.*, 2017), the central elements in construction are time and action, thus, immediate results in time and cost. Although some literature suggests a high return of BIM investments (Azhar 2011), it is also observed that top-management may not be fully convinced to invest in BIM due to lack of performance metrics and tangible results in the short-term. Thus, organisation's facilitating conditions decline and users at the operational level do not perceive strategic interest in adopting BIM. Individual acceptance at operational level triggers organisational decisions at the top level and vice versa.

At the organisational level, there seems to be a misalignment between a firm's strategic objectives and BIM use as means to achieve such objectives. When escalated to the inter-

organisational level, mismatches between each firms' objectives impede the diffusion of systemic BIM innovation. Inter-organisational BIM will work if win-win relationships between firms are set. For example, the rebar supplier might use BIM to improve the pre-fabrication process, and the constructor can use the same model to improve quality assurance. As such, both organisations benefit from BIM. It is also argued that systemic BIM innovation might exploit a high-level of implementation to realise the theoretical potential advantage of BIM and the highest level of collaboration (e.g. design simulation or prefabrication). Thus, client's demands, project's size and their complexity are variables for organisation's drivers of BIM usage, as noted by Singh (2014).

Organisation's linkages also impact systemic BIM innovation. A concurrent topic found in the literature is the necessity to steer innovations through innovation champions (Winch 1998), relative boundedness (Harty 2008), or power (Schweber and Harty 2010). The systemic integrator, as a role in the systemic BIM innovation, steers the innovation process, aligns objectives and overcomes individuals' and organisations' resistance. However, the impact of one big company choosing BIM on other firms it is still unknown (Papadonikolaki *et al.*, 2017) in temporary project-coalitions. In this context, digital disparities seem to be a significant barrier within inter-organisational relationships, especially when small and medium enterprises are forced to engage in BIM processes. Long-term relationships are fundamental to achieve a systemic BIM innovation. With short-term focus, firms in the project-coalition lack of incentives to diffuse knowledge and innovation, thus, hindering collaboration (Jacobsson *et al.*, 2017). This is particularly a challenge when it is observed the nature of industry as temporary project-networks.

The context shapes the innovation diffusion process. An interplay is found between the client, the procurement method, the diffusion dynamic and the power. The client stands out as one of the most powerful institutional actors (Jacobsson *et al.*, 2017). It is the client who select early in the project the procurement method and in turn, the level of supply chain integration (Briscoe *et al.*, 2004). In a top-down approach, the client would decide BIM use with a compatible procurement method and an experienced team. On the other hand, if the client does not promote BIM, other powerful actor, such as the contractor, might demand its use, exerting pressure to the downstream supply chain (Jacobsson *et al.*, 2017) in a middle-out approach (Succar and Kassem 2015). The client's procurement approach might hinder BIM use and engagement of key stakeholders. If long-term relationships in the client-supply side are required, changes to the traditional approach are deemed as necessary (Briscoe *et al.*, 2004).

## CONCLUSIONS

BIM at the inter-organisational level is labelled systemic BIM innovation. This requires a set of BIM innovations (e.g. technology, process and organisational innovations) to be deployed simultaneously by firms in a temporary project-coalition. Drawn from the literature, the systemic BIM innovation model is identified to have five dimensions for inter-organisational BIM uptake. These dimensions are (1) BIM acceptance at the individual level; (2) organisational drivers of BIM usage; (3) inter-organisational linkages between firms; (4) supply chain management challenges; and (5) the role of the context. The model includes factors in different interrelated analytical levels, namely, the individual, the organisation, and the supply chain. It is the context which shapes all levels of analysis, as noted by (Jacobsson *et al.*, 2017), who contends that context shapes individual interpretative frames of a technology, and implicitly organisational drivers for BIM usage. However, the question remains how actors give meaning and make sense of BIM applications. The interplay between the client, the procurement method, the

dynamics of technology diffusion, and power shapes the way BIM innovations are perceived by firms. Moreover, the challenge remains of investigating what are the contextual determinants for systemic BIM innovation. Finally, the proposed model would serve as a framework for future research with detailed case studies to obtain larger datasets and confirm all variables in the model and their relationships, in both the public and the private sectors in the UK and overseas.

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# KEY CONSTRAINTS TO OPTIMAL AND WIDESPREAD IMPLEMENTATION OF BIM IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

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Building information modelling (BIM) implementation in South Africa, though spanning over a decade, has been neither widespread nor optimal, prompting a need to identify key constraints to achieving this. Data was collected through semi-structured interviewing of purposively selected consultants who have implemented BIM within their organisations and on projects. Key industry level constraints to optimal and widespread implementation of BIM in South Africa include lack of standards and uniform protocols as well as lack of government capacity, buy-in and support. These in turn contribute to varying patterns of implementation methodologies among collaborators along with non-interoperability of technology and business processes. The findings establish a clear demand for country-specific standards and institutional backing, though current implementers adopt or adapt standards and protocols from other countries. Taking the proliferation of BIM standards into account, rather than recreating such standards for the South African construction industry, it is more efficient to adopt or adapt existing standards from countries already leading in BIM. Therefore, as countries lagging in BIM continue to adopt or adapt existing BIM standards, diverse standards and methodologies across the world may evolve towards a dominant pattern of BIM implementation practice among existing variants, and with global collaboration global BIM standards may emerge.

Keywords: BIM, constraints, standards, South Africa

Implementing BIM as a way of improving the outcomes of construction projects has continued to gain prominence across the world, more so in the United States (US), United Kingdom (UK) and the Scandinavian countries (Shou *et al.*, 2015; Smith 2014; Wong *et al.*, 2010). Nevertheless, BIM has been in use in some form or another in many other countries than is commonly reported in literature. The distinction is made in the extent to which BIM is implemented within organisations, on projects, how many of such projects are executed, and how mature BIM-enabled project practices within such a country's construction industry context actually are (BSI 2013; Succar 2010). Other delineators among countries are the presence or otherwise of a deliberate mandate driving adoption and implementation, and to what extent that drive is supported by government, professional and educational institutions, and private sector organisations.

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In particular, government (and related entities) involvement in driving BIM adoption and implementation is reasoned first on the position that they are often the biggest investor of resources in the construction industry and exercise considerable 'market' power as clients. They therefore hold a major stake in the success of the industry and every effort to innovate, such as with BIM, benefits from their support. Second is the heavy dependence of BIM-enabled project success on the uniformity of shared information and processes (Gu and London 2010; Porwal and Hewage 2013), for which government policies and legislation are essential drivers. These go a long way in driving support from construction professional institutions and even private clients' buy-in and demand for BIM on projects. Perhaps the most prominent example of this is the UK construction industry's approach to BIM adoption and implementation, which is the most structured among the leading countries when it comes to BIM implementation.

However, in these same countries leading in BIM, there is a proliferation of BIM implementation standards and methodologies as argued by Smith (2014) and evident in the analysis of Shou *et al.*, (2015). While the importance of standardising BIM practice is not in doubt, in setting standards guiding such practice, duplication of effort may not be beneficial. This therefore raises the question on whether it is needful for all countries to have separate BIM standards and guidelines. Nevertheless, in South Africa where BIM authoring software have been in use for at least a decade, some progress is being made even though its implementation has neither been widespread nor mature (Booyens *et al.*, 2013; Froise and Shakantu 2014). While there are several factors that might account for these, in this study the investigation is of industry level impediments to widespread and optimal implementation of BIM in the South African construction industry context.

## **RELATED LITERATURE**

### **BIM Implementation Challenges**

Numerous authors have studied BIM implementation challenges in different contexts. These challenges are many and are procedural, socio-cultural and technical in nature. Key challenges that have been identified as impediments to implementing BIM include inter alia varied readiness to implementing BIM among project stakeholders (Singh *et al.*, 2011), the need for adapting intra- and inter-organisational workflows, lack of clarity of stakeholder roles and responsibilities (Elmualim and Gilder 2014; Rekola *et al.*, 2010), and lack of proficiency that often requires huge investments in training (Becerik-Gerber and Kensek 2010; Elmualim and Gilder 2014). At the industry level, depending on the context, the challenges include the lack of standards, lack of government support and drive, lack of incentives (Abubakar *et al.*, 2014; Aibinu and Venkatesh 2014; Smith 2014), the need for cultural change in the industry (Ambrose 2012; Rowlinson *et al.*, 2010) and lack of demand by clients (Aibinu and Venkatesh 2014). These are challenges that are not specific to any organisation or project team, beyond their immediate control, and have become concerns at the industry level. These challenges nevertheless have far-reaching effects on the success of BIM implementation within organisations and on BIM-enabled projects.

### **The Importance of BIM Implementation Standards and Guidelines**

BIM standards and guidelines are important for facilitating seamless coordination and collaboration through digital methods (Shibeika 2014). As a set of agreed upon rules, they are essential for achieving interoperability and standardisation of information across different areas (Wang *et al.*, 2013). By implication, the lack of widely accepted standards limits effective collaboration as alluded to by Beach, Rana, Rezgui and Parashar (2015).

However, it is not uncommon for individual organisations to develop their own guidelines and protocols to address procedural and contractual challenges, especially in countries where there are no commonly accepted BIM standards.

There have been several BIM adoption and implementation initiatives to facilitate the success of BIM implementation throughout the building lifecycle (Atkinson *et al.*, 2014; Shou *et al.*, 2015). The ultimate aim is to institutionalise a preferred pattern of collaborative practices for the delivery and operation of construction projects with the aid of BIM. Wong *et al.*, (2010), Smith (2014) and Shou *et al.*, (2015) provide valuable insight into patterns of BIM practice in various countries. Their analyses show two patterns: those who have taken a structured approach to implementing BIM countrywide through central standards and guidelines, and those who have been implementing without clear standards and guidelines.

Shou *et al.*, (2015), in a similar approach to Wong *et al.*, (2010), outlined a non-exhaustive list of about 40 BIM-related standards and guidelines from 10 different countries that define information creation, usage, sharing, storage and reuse standards and procedures. They are products of initiatives by government bodies, educational institutions and private sector entities, sometimes solely, and at other times in collaboration. Clearly some of these efforts are duplications. However, a proliferation of guidelines that dictate implementation methodologies may not necessarily mean progress for the construction industry globally.

BIM standards documents from different contexts often have closely-related purposes, although the UK approach to implementing BIM has been deliberate and structured, and is therefore often cited as a model for other countries. There is a central, government-backed initiative to institutionalise a preferred pattern of BIM practice. The Australian and New Zealand Revit Standards (ANZRS) are said to have been downloaded, and perhaps used, in 72 different countries (ANZRS 2017). Furthermore, comparing existing BIM standards from the UK, US, Singapore and Australia, it is evident that they are all geared towards achieving largely similar purposes, namely: to ensure the production of coordinated information such that it can be used and reused throughout the project and life of the asset (BCA 2013; BSI 2013; NATSPEC 2012; NBIMS 2015).

*Table 1: Comparing standards from different contexts*

| Standard   | Purpose   | Country        | Year |
|--|---|----------------|------|
| NATSPEC National BIM Guide, (NATSPEC 2012)                     | Intended as a planning tool for consultants to clarify the services they propose to provide and to assist all stakeholders in defining their BIM requirements consistently  | Australia      | 2012 |
| PAS 1192-2:2013, (BSI 2013)                                    | To ensure the production of coordinated information such that it can be used and reused throughout the project and life of asset  | United Kingdom | 2013 |
| Singapore BIM Guide Version 2, (BCA 2013)                      | To demystify BIM and provide clarity on BIM implementation requirements at different stages of project delivery   | Singapore      | 2013 |
| National BIM Standard - United States® Version 3, (NBIMS 2015) | To provide a means for organising and classifying electronic data and also to streamline communications among project stakeholders and structure of collaborative practices | United States  | 2015 |

South Africa has striven to achieve a balanced socio-economic development through heavy capital investments in infrastructure with limited resources. In spite of the expectations of the construction industry, it contends with several impediments, the likes of which could potentially be alleviated through implementing BIM. These include generally poor levels of project performance (Emuze and Smallwood 2012), inadequate documentation, poor knowledge transfer and poor multidisciplinary project team interface (Emuze and Smallwood 2014). For instance, in the UK, the deliberate drive to implement BIM, among other things, is claimed to have delivered efficiency savings of up to 3 billion pounds over the years 2011 to 2015 (Cabinet Office 2016). Further targets have been set for the next 5 years for a 33 per cent reduction in costs, 50 per cent in emissions, and 50 per cent in delivery times (Cabinet Office 2016).

The limited use of BIM and low maturity of implementations in South Africa are the prompters for this study. The South African construction industry context is peculiar in its reliance on traditional methods of procurement and delivery. Notable is the absence of any widespread patterns of collaborative practices that might provide a fertile environment for BIM adoption. Therefore, unlike countries leading in BIM and on which much of existing literature focuses, the changes required for implementing BIM within organisations and on project teams are likely to be much more disruptive, as they have to change not only workflows, but also the prevailing industry culture to be optimally used. The aim was thus to investigate the impediments to implementing BIM to full maturity in the South African context.

## **METHODS**

This study is positivist in philosophical leaning, qualitative and deductive in approach. Being mainly exploratory, it was carried out using a pre-prepared interview guide that facilitated conversations with 11 purposively selected construction professional service providers (key informants) (Marshall 1996). The selection consisted of architects, engineers and project managers representing 8 organisations who have implemented BIM within their organisations and on multidisciplinary projects. Probing questions were asked about their experiences with BIM implementation including their perceptions on industry-level impediments to widespread and optimal implementation of BIM in South Africa. Optimal BIM implementation is taken to be a level of implementation that coincides with the requirements for BIM level 2 by the organisations in implementing BIM within their organisations and on construction projects as defined in the PAS1192:2 document (BSI 2013). Using Succar's (2010) BIM maturity matrix model however, the organisations represented have achieved the 'defined' and, sparingly, the 'managed' levels of maturity. This is adjudged to be between BIM maturity level 1 and 2. They have been able to define implementation protocols, technological requirements and inter-organisational workflows around BIM. Further, while implementing BIM, the organisations have been able to integrate BIM technologies into their organisational strategies.

The key informants (as shown in Table 2) were consulting professionals who are in BIM leadership positions within their respective organisations. Their organisations were mainly multidisciplinary and involved in multinational operations, although their responses for this study were specific to the South African context. Audio recordings were taken during the interview sessions to ensure that all information was captured and thereafter transcribed verbatim. Handwritten notes and preliminary reflections from the interviews were summarised into memos, one for each interview. The organisations were largely operational internationally, and provide a wide range of construction-related

services. Data collected were analysed by analytical memoing, transcribing, coding and interpretation, and preparation of matrix data tables (Miles *et al.*, 2014).

*Table 2: Participants Characteristics*

| Participant                                 | Organisation Practice Type |
|---|----------------------------|
| C2_ Architect _BIM Coordinator              | Multidisciplinary          |
| C3: Structur. Engr._ Director_ Head VDC/BIM | Multidisciplinary          |
| C4_Architect_VDC /BIM Facilitator           | Multidisciplinary          |
| C7_BIM manager                              | Multidisciplinary          |
| C6_BIM Manager Architect                    | Multidisciplinary          |
| C8_Architect                                | Architectural              |
| C9_Architect_Director                       | Architectural              |
| C1_BIM manager                              | Multidisciplinary          |
| C10_Structural_ Civil Engineer_Director     | Multidisciplinary          |
| C5_Architect                                | Architectural              |
| C11_Architect_BIM Coordinator               | Architectural              |

*The participants (as outlined in Table 2) were selected from organisations with mainly multinational experience and they provide a variety of services.*

## DATA ANALYSIS AND DISCUSSIONS

In summary, the findings establish the following:

- Lack of drive and support for BIM by government bodies including the Construction Industry Development Board (CIDB); a body that registers business entities in the industry and regulates industry practice through codes and standards;
- Lack of drive and support for BIM by South African construction industry professional registration councils that cover the architectural, quantity surveying, project management and engineering professions;
- A perception that there is lack of understanding of BIM among construction industry professionals; and
- Lack of uniform standards and guidelines for implementing BIM in a preferred uniform pattern.

The findings are presented below in themes.

### **General industry constraints to implementing BIM in South Africa**

Despite all informants reporting BIM benefits in the form of improvements in productivity, integration, error/rework reduction, visualisation and competitive advantage, the findings also show serious challenges. Virtually all of the participants alluded to the lack of South African BIM standards to cater for the peculiarities of the South African construction industry context, which are deemed to set it apart from other contexts (as in Table 3 below). Furthermore, BIM adoption is mainly driven by private consulting organisations who act as clients' agents and, occasionally, private clients and client

organisations that are sometimes knowledgeable about BIM. Nevertheless, the findings also highlight the professionals' scepticism regarding the ability of public clients and construction industry councils for the built environment professions to drive BIM adoption and implementation countrywide, judging by their perceived lack of understanding and proficiency in BIM. One of the peculiar challenges of the South African construction industry has been a severe shortage of skilled professionals in the government's Department of Public Works, which prevents it from operating as an 'informed' or 'expert' client. Second, and also linked to skills shortages, is that government projects are executed and supervised by private consultants particularly at the delivery stage. Therefore, the capacity to drive and support innovation by government is doubtful. These are similar to the findings of Abubakar *et al.*, (2014) in a Nigerian study and the summation of Smith (2014) regarding countries like Brazil and India.

*Table 3: General industry concerns for BIM implementation in South Africa*

| Concerns  | Key informants          |
|---|-------------------------|
| Lack of drive for BIM adoption and implementation from government and related institutions. Consequently, there are no local BIM standards and guidelines and private organisations are compelled to borrow from countries leading in BIM | C1, C2, C3, C4, C11, C7 |
| Lack of buy-in and demand for BIM on public works   | C2, C3, C4, C7, C11     |
| Doubts and scepticism about the competence and capability of professional and regulatory councils and other government bodies to receive and assess such information as might be produced using BIM                                       | C2, C3, C11, C7         |
| Without increased awareness and client demand, construction-related organisations will not change   | C3                      |
| Implementation maturity in the country is low   | C4                      |
| Lack of supportive legislation and guidance from councils and government institutions   | C4                      |
| There is no mandate for BIM use on public sector projects   | C4                      |
| Many organisations are still not using BIM authoring software   | C4                      |
| There is no incentive from government for construction organisations to change  | C8, C11                 |
| Proprietary materials/component manufacturers have no incentives to begin developing BIM content  | C1                      |
| Procurement methods have to be rethought  | C7                      |
| Changes experienced outside the African continent would make it more difficult for non-adopting local firms to be competitive internationally   | C1                      |

### **Lack of Professional Councils' and Government Support for BIM**

In South Africa, the responsibility for developing the construction professions, maintaining professional standards in the built environment professions and coordinating the different professional councils rests with the Council for the Built Environment (CBE) and its subsidiary professional councils, while that for promoting uniformity and efficiency in construction procurement and infrastructure delivery lies with the construction industry development board (CIDB). The Department of Public Works (DPW) holds the mandate for the provision and management of the government's fixed assets, with the CIDB and CBE both reporting to the Minister in charge of the DPW. Together, these provide guidance for, and also regulate industry practice. However, in

contrast to similar organisations like the Royal Institute of British Architects (RIBA) and the Construction Industry Council, among others, in conjunction with educational institutions in other countries, there are concerns about their level of awareness and knowledge about BIM (Atkinson *et al.*, 2014). Therefore, private organisations/entities are at the forefront of BIM advocacy and development without support from government. For example, key informants C2 and C11 questioned the skills and capabilities of government bodies to drive BIM. According to Informant C2, “There is a definite concern in the industry that councils (professional councils) do not have the capability to really assess the information that they are getting”.

### **Need for South African BIM standards**

The need for country-specific standards for BIM practice was also established in the findings, as Informant C3 associated the lack of “guidance and drivers from any government authority in the (Africa) region”, while affirming that they have observed “much better uptake where there is a driver (for BIM)”. Similarly, the availability of BIM guidelines was linked to improved adoption by Al-Shammari (2014). Presumably, the lack of guidelines and driver is attributable to the lack of understanding of its potential and implications by the relevant organisations. This lack is a source of frustration for BIM implementers in South Africa as illustrated below:

It is hard for us in South Africa, I think Africa actually, around BIM implementation. It is driven by the private sector because we don't have the backing of government - C11

... with new roles, we need some sort of BIM standards in South Africa to work towards, not for private companies pioneering and working towards other companies' standards that are not our standards - C8

While it is not uncommon for the private sector to lead in driving BIM, the evidence therefore illuminates the peculiarity of the South African case in the inability of government agencies to adequately drive BIM adoption and implementation, as well as lead in the development of guidelines. Nevertheless, existing standards from countries leading in BIM are being adapted for use in South Africa but have remained discrete efforts. According to informant C1; “In terms of guidelines, there is a lot of documentation these days which offer some kind of advice that is generally driven by government. The UK in particular has fantastic documentation that you can refer to when it comes to BIM”.

While there is a demand for country-specific standards and guidelines for implementing BIM in South Africa, adoption and adaptation of standards from countries leading in BIM have been with reasonable levels of successes. Nevertheless, since these are discrete efforts, the direct implications are experiences of varying patterns of implementation among project stakeholders and, consequently, non-interoperability as supported by Beach *et al.*, (2015).

### **Experiences of Varying Patterns of Implementation and Non-Interoperability**

Clearly, these two challenges are strongly linked to the lack of uniform guidance for BIM practice. The findings suggest that BIM implementers experience great difficulty in managing multidisciplinary team collaboration with BIM, often leading to rework on BIM models created by BIM coordinators. According to Informant C1, “the make or break of BIM and its ideology is ability to exchange information”. This is further buttressed by informant C11, whose organisation has been quite successful with implementing BIM (achieving close to BIM level 2 maturity (BSI, 2013)) as illustrated below:

In the last five years or so, the biggest challenge that we have been experiencing has been around team collaboration.

Poor collaboration whenever it occurred was attributed to lack of proficiency of collaborating project team members and the lack of uniform guidelines on which BIM-enabled projects may be executed. In response to the lack of uniform guidelines for implementing BIM, whenever two collaborating organisations come with different implementation methodologies or plans, a meeting is held to examine the pros and cons of each approach. Thereafter, an agreement is made on how to implement BIM on a project-by-project basis (Informant C3). On the other hand, whenever the integrity of a collaborating team member's model falls short of requirements, the BIM coordinator assumes the responsibility for reworking such substandard models.

The foregoing substantiates the need for uniform standards for implementing BIM in South Africa. Arguing from a different level however, it is questionable that all countries should require the development of BIM standards. Taking the current proliferation of BIM standards and guidelines into account (Shou *et al.*, 2015; Smith 2014), an alternative argument exists for the adoption and adaptation of what works in countries leading in BIM, rather than for re-creation of existing standards. According to Wortmann *et al.*, (2016), existing BIM standards and guidelines across different country contexts are quite similar but should be nuanced to cater for context-specific differences.

Therefore, BIM standards and guidelines will continue to be fundamentally similar, hence a globally acceptable standard and guideline would need to broadly dictate an agreed pattern of BIM practice that may be adapted as required. For instance, the BIM protocols drafted by a private South African initiative, the BIM Institute, were almost entirely adapted from the UK BIM standards and guidelines, thereby creating duplications. An option may therefore be for construction industry stakeholders in South Africa to jointly agree on which existing standards to adopt and thereafter provide guidelines for their adaptation to suit context-specific requirements. However, it is still incumbent on the relevant government and professional institutions to drive and shape the adoption and adaptation processes to suit the South African context and to ensure acceptance.

It can be posited therefore that as BIM implementers across the world, particularly from countries lagging in BIM implementation continue to adopt and adapt existing standards from those leading in BIM, a dominant pattern of implementation and supporting standards and guidelines may emerge. The UK approach towards implementation standards and guidelines, being very structured, is the closest to achieving such dominance as it is often adopted by project teams in countries lagging in BIM.

## CONCLUSIONS

Even though the use of BIM has continued to increase, not many construction industries have taken a structured approach to its adoption and implementation. In the South African context, there is a clear demand for uniform implementation standards and guidelines. Without these, there have been experiences of varying patterns of implementing BIM among project stakeholders, often leading to technological and business non-interoperability. Without doubt, BIM implementation requires top-down strategic drive to facilitate widespread and high maturity implementation. Although the South African construction industry is not ready for a BIM implementation mandate at the moment, the industry would benefit greatly from incentives and motivations for adoption and implementation by public sector organisations and clients. However, given the proliferation of BIM standards and guidelines, an argument for adoption and adaptation of existing standards is made. That way, as implementers continue to adopt and adapt

what works, rather than recreate new guidelines or standards in this regard, global implementation standards may emerge therefrom.

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# HOW BIM IS ASSESSED USING ARUP'S BIM MATURITY MEASURE?

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Since 2007, seventeen Building Information Modelling Assessment Methods (BIM-AMs) have been developed globally. Most previous studies on BIM maturity, however, tended to focus on promoting and introducing new assessments - but they rarely documented how these assessments are applied in the Architecture, Engineering and Construction (AEC) industry. It is this gap that this paper seeks to address. To do so, the Arup's BIM Maturity Measure, one of the current BIM-AMs, is applied to 1291 live projects. Through this application, the paper aims to identify how the AEC industry could use BIM performance measurement systems to create knowledge and feedback loops. Two main concluding remarks are highlighted. Firstly, it is observed that 'mature' projects are influenced by multiple internal and external forces that impact on BIM's implementation including the application of efficient BIM Execution Plan and BIM Design Data Reviews. Secondly, through data mining, it is possible to identify best BIM practices which is important to learn lessons and use as examples. These findings contribute to the BIM maturity agenda and provide fresh perspectives and insights in BIM-AMs.

Keywords: BIM, BIM Maturity Measure, BIM assessment method, Arup

## INTRODUCTION

Performance measurement has been the subject of various studies in the last couple of decades. The evolving nature of businesses, growing competition, specific improvement initiatives, the power of information technology and the changing business roles have all led to a significant interest in performance measurement in different research disciplines (Neely, 1999), e.g. education, business management and environmental buildings. The potential of performance measures has been widely acknowledged, as Behn (2003), notes:

As part of their overall management strategy, public managers can use performance measures to evaluate, control, budget, motivate, promote, celebrate, learn and improve.

In the Building Information Modelling (BIM) research agenda, the emergence of Assessment Methods (AMs) has started in 2007 with the release of the National BIM Standard Capability Maturity Model (NBIMS-CMM) (NIBS, 2007). Since then seventeen assessments have emerged globally to assess BIM on the level of projects, organisations, teams or individuals (Azzouz, Copping and Shepherd, 2016).

Despite the high level of academic and construction industry interest in BIM maturity (BRE, 2015; Månsson and Lindahl, 2016; Kassem, Succar and Dawood, 2013), there has been limited studies on the application of BIM-AMs to live projects in companies. Past assessments, such as the BIM Proficiency Matrix (Indiana University Architect's Office,

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2009), the Building Research Establishment (BRE) BIM Level 2 Certification (BRE, 2015) and the Organisational BIM Assessment Profile (CICRP, 2013) have contributed to the research agenda of BIM-AMs. Yet, there are no available publications on the use of these assessments in the Architecture, Engineering and Construction (AEC) industry. Other assessments were applied only to two studies as with the Owner's BIMCAT (Giel, 2013) and the Goal Driven Method for evaluation of BIM project (Lee and Won, 2014). Applying BIM-AMs to case studies will help not only to test and validate these assessments, but also to demonstrate how BIM is implemented across different projects, companies and geographies that have different social and cultural contexts.

Researchers on BIM-AMs have acknowledged the need and benefits of BIM-AMs. They explained how AMs assist AEC companies to measure their own successes and or failures (Succar, Sher and Williams, 2012), identify areas for improvement, compare their BIM progression with other AEC companies (CICRP, 2013) and help 'to realise the promise of BIM' (Kam, 2013). But with the lack of case study projects, it has been a challenge to provide a robust and thorough evidence of these benefits. Therefore, the application of BIM-AMs in the AEC industry is important to unlock the full potential of assessments; their opportunities and challenges.

This gap in literature is addressed here by applying one of available BIM-AMs, the BIM Maturity Measure (BIM-MM), to a sample of 1291 projects in Arup - a global firm of designers, planners, engineers, consultants and technical specialists. Through this application, the paper aims to highlight how the use of BIM-MM could contribute towards creating feedback loops and identifying best BIM practices in the built environment. The paper expands what is currently known about BIM maturity and builds on the small number of limited previous studies that apply BIM-AMs in the AEC industry.

## **LITERATURE REVIEW: BIM MEASUREMENT**

When released in 2007, the aim of the NBIMS-CMM, the first developed BIM-AM, was 'to help users gauge their current maturity level, as well as plan for future maturity attainment goals through commonly accepted, standardised approach' (NIBS, 2007). Today, there are seventeen AMs with different aims, perspectives and evaluation focus (these assessments have different levels of similarities and differences). They have individually and collectively reflected a wide range of criteria such as the methods of data exchange, the level of development of model elements and the processes involved when implementing BIM.

To shift the research field of BIM maturity from theory to practice and to help AEC professionals managing BIM projects, organisations and policies, there is a need to apply AMs to live projects. This is a challenge that has been addressed by very few researchers. Amongst these researchers are Kam *et al.*, (2013) of Stanford University who apply the VDC Scorecard to 130 projects 'to validate and inform the evaluation measures while demonstrating the scalability and repeatability of the scorecard framework and the value of a global knowledge base of BIM and VDC maturity to benchmark project performance.' The collected data were then analysed according to measured criteria, project phase and countries.

Another study that documents the application of an AM in practice is carried out by Berlo and Sebastian (2012) of TNO Built Environment and Geosciences in the Netherlands. In their study, the 'BIM Quick Scan' was applied in 130 companies. The tool was developed in 2009 in a form of an online questionnaire with almost 50 questions grouped into four

main sections. After applying this tool in the AEC industry, collected data were analysed to compare BIM maturity levels across the four sections of the BIM Quick Scan. These sections are: Organisation and Management, Mentality and Culture, information Structure and Information Flow, and Tools and Applications. Together, these sections help to evaluate BIM on the level of 'organisations', not on the level of projects as in the BIM-MM and the VDC Scorecard.

This paper contributes to these studies. It focuses on the application the BIM Maturity Measure (BIM-MM) to 1291 projects. The BIM-MM is one of the seven available AMs that evaluate BIM in 'projects'. It is practical, fast to complete, user-friendly and available freely online for other professionals to use - some assessments as the one provided by the BRE requires fees (BRE, 2015). Furthermore, the BIM-MM offers a comprehensive and balanced platform to measure BIM and reflects its interdisciplinary approach - some of the current BIM-AMs reflect one side of BIM as in NBIMS-CMM. BIM-MM constitutes of different measurement criteria that address the internal and external forces influencing the implementation of BIM (Figure 1). Internal forces reflect Arup's key BIM criteria such as Virtual Design Reviews and Common Data Environment, whilst external forces refer to client's drivers when implementing BIM i.e. Employer Information Requirements, Projects Procurement Route and BIM Contract.

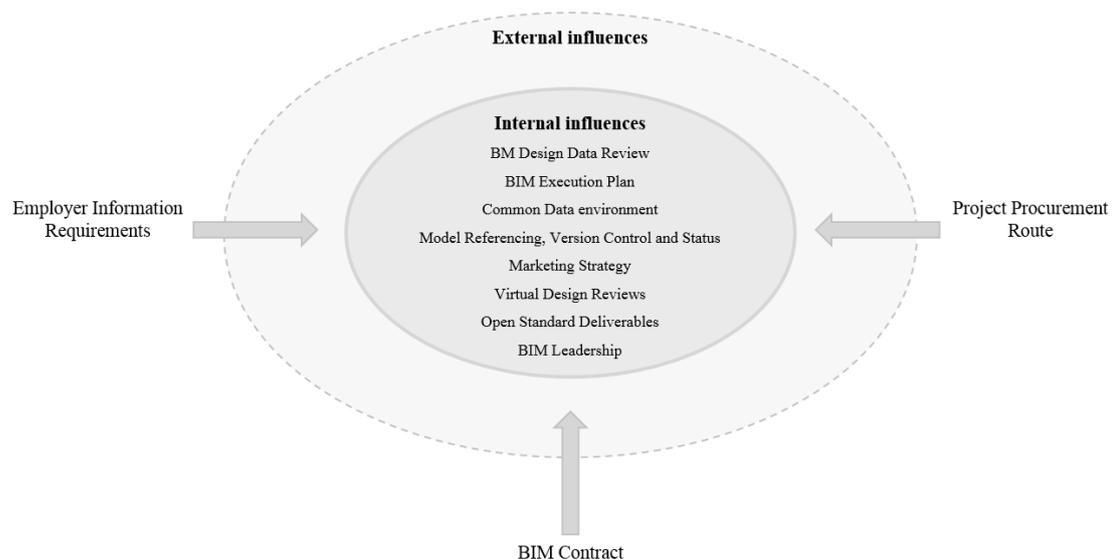


Figure 2: Internal and external forces of BIM in BIM-MM

## RESEARCH METHODS

This research relies on quantitative approach. It applies the BIM-MM to 1291 projects in Arup's five regions: Americas, Australasia, East Asia, Europe and UKMEA. These projects are widely varied with different types, size and phase. The BIM-MM was developed in Arup to assess the evolving nature of BIM and to create a common view of BIM best practice (Azzouz and Hill, 2017). It constitutes of over 20 critical criteria which covers two main parts:

1. Project: this first part of the BIM-MM assesses project wide processes and practices. It looks at the project from an overarching perspective rather than focusing on assessing BIM in a specific discipline involved in the project. Completion of this section results in the creation of Information Management Score (IM Score), left side of Figure 2.

- Disciplines: this part assesses specific disciplines involved in the project such as architecture, mechanical and electrical disciplines, (right side of Figure 2). The assessment sheets of these disciplines are mostly similar, but each has a section for discipline specific criteria.

Together, the average scores of 'Project' and the assessed 'disciplines' gives a Primary Score of the project as a coherent whole.

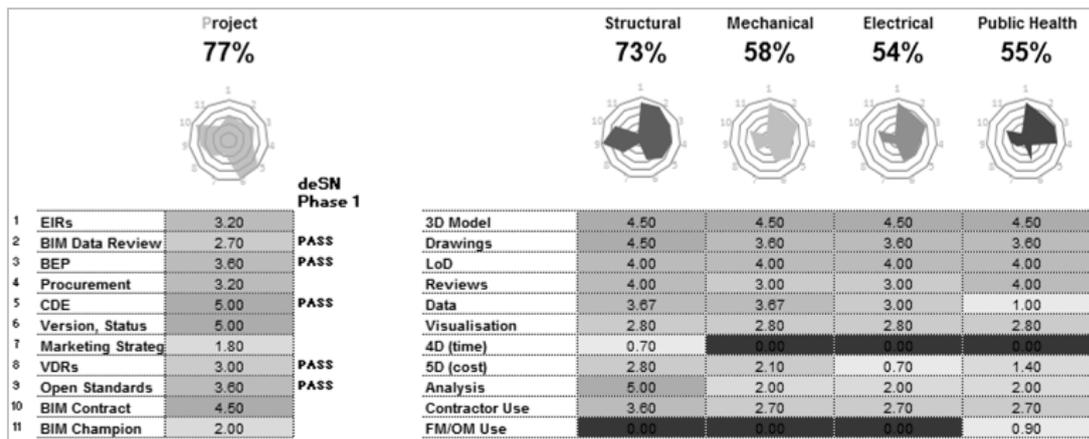


Figure 2: A snapshot of the BIM-MM (two parts: project and disciplines)

### Global BIM Maturity Initiative: Data Collection

As part of their BIM strategy, Arup has directed significant efforts towards BIM measurement. This has led to the development of the Global BIM Maturity Initiative to create a comprehensive overview of how BIM is implemented across projects, disciplines, groups and regions. Only between March and September 2016, the BIM-MM was applied to 1291 projects. Choosing projects to assess relies on a specific criteria and all projects that meet the criteria should be measured. Moreover, selecting which projects to measure is also influenced by projects' phase and status. Projects that are on hold, before concept, after site, or do not include any design services (such as consultancy and desktop research studies) are excluded.

To collect the data, the BIM Maturity Team (the authors) contacts project managers, BIM Champions and Group Leaders of all offices across Arup's regions - Arup has offices in more than 40 countries. Communication process is illustrated in Figure 3 that shows the two parallels of communication (A and B).

Managers of each project would then assess if the project should be measured or not. If yes, then they would submit the BIM-MM of the project, and if not, they identify the reason for exclusion. Once completed and submitted, the BIM-MM of each project will be sent automatically to one platform for analysis by the BIM Maturity team. Following the analysis, findings and reports are sent to all BIM Champions and Groups Leaders to use locally and get more insights on how BIM is applied in their group compared to other groups.

### RESULTS: APPLYING THE BIM-MM IN PRACTICE

The collected data can be analysed and communicated differently according to the angle the analysis is considering. However, due to the scale of the dataset, only two points are addressed in this paper (1) the correlation between specific criteria and the overall score of projects, and (2) top ten BIM practices across the measured projects.

### The Forces That Shape the Successful BIM Projects

There are different forces and influences that impact on the successful implementation of BIM in projects. These are both internal implemented by AEC businesses and external driven by the client. To explore these influences, the research investigates the correlation between different BIM criteria and the average overall score of projects. In particular, it focuses on the impact of the BIM Execution Plan (BEP) and the BIM Design Data Review (BDDR) on the overall scores.

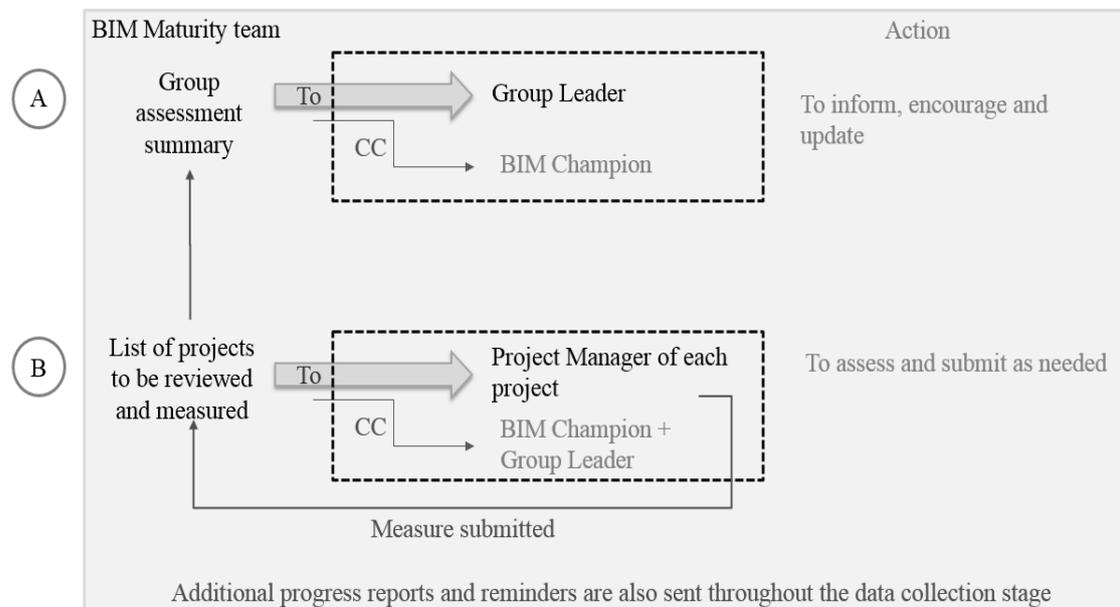


Figure 3: Communication process when collecting data

BEP refers to the formalisation of digital design goals and the specification of standards, roles, procedures and information exchange. BEP, as all the rest of criteria in BIM-MM, has six maturity levels which participants have to select one of them to define the current status of their projects. These levels evolve from level 0 where the criterion is not applied, to level 5 where the criterion is most optimised. BEP's maturity levels are:

- Level 0: No BEP.
- Level 1: Documented 'Traditional' Drawing / CAD Management Plan.
- Level 2: BEP created and used by Arup core disciplines.
- Level 3: BEP used by whole Arup design team.
- Level 4: Project-wide BEP driven by client information requirements and team collaboration needs.
- Level 5: Project-wide BEP based on defined information requirements cascaded through supply chain.

Observations of the findings show a juncture exists between efficient BEP and high overall scores of projects. As illustrated in Figure 4, average score of overall projects increases gradually when BEP maturity levels evolve. For instance, average overall IM Score with BEP Level 5 (68%) is over six times the average score of projects with no BEP (10%). Similar findings have been noted when looking at the correlation between BDDR and overall scores of projects.

## Best BIM Practices

Through the application of the BIM-MM, best BIM practices can be identified. Across the 1291 assessed projects in this research, the Information Management (IM) Score of all top ten projects is above 80% (the highest is 93.4%). The IM Score focuses on the first part of the BIM-MM - 'Project' rather than concentrating on a specific discipline. IM Score reflects eleven criteria including (Table 1): 'Employer Information Requirements (EIRs)', 'BIM Design Data Review' (BDDR), 'BIM Execution Plan (BEP)', 'Project Procurement Route' (PPR), 'Common Data Environment' (CDE), 'Document/Model Referencing, Version Control and Status' (Doc Ref), 'Marketing Strategy' (knowledge sharing), 'Virtual Design Reviews' (VDR), 'Open Standard Deliverables' (OSD), 'BIM Contract' and 'BIM Champion'.

Each of the ten projects is a unique case study as projects are different in regards to scale, client, phase and type. However, despite these differences, the ten projects have relatively similar maturity levels for most of the evaluated criteria.



Figure 4: The correlation between BEP and the average overall score of projects

Table 1 shows the weights allocated to each measure in the ten projects. Common maturity levels are the highest in three criteria:

- Document, Model Referencing, Version and Status (Doc Ref), refers to good practice on projects and paramount when sharing models where the recipient needs to know what has changed and what it can be relied upon. Amongst the top ten projects, nine projects have Level 5. This means that these projects have 'project wide file naming, version control and status compliant with recognised BIM standard'. It is also important to note that this criterion has the highest average score when compared to the rest of the criteria across the ten projects (all ten projects are allocated to either Level 4 or 5 in this criteria).
- CDE, acts as a 'single source of truth' and facilitates the robust and controlled sharing and coordination of models, drawings, analyses, documents and data. Seven out of the ten projects have Level 5 CDE, which means that 'client, designers and contractors are using a CDE to create and share work'.
- PPR, which refers to the consideration of BIM during procurement discussions with client, contractors and supply chain. In the top ten projects, seven have Level

5 PPR, which means that procurement strategy is developed to use BIM to create value through project optimisation.

- The top ten projects have high maturity levels. In each project, most evaluated BIM measures are allocated to Level 3 or higher (two exceptions are observed). All projects have BIM Champions who are guiding the teams to improve their BIM implementation and all projects have BIM contracts that define responsibilities across different engaged parties. So, the successful implementation of BIM in these projects is shaped by multiple integrated influences that reflect the internal forces of BIM within the organisation, and the external engagement of the client (all projects have BIM contracts and defined EIRs and PPRs). However, only two projects have low maturity levels in certain criteria (highlighted in blue in Table 1). These are in Projects 7, with BIM Contract Level 2 and Project 9 where there is no OSD in the project.

Table 1: Top ten projects and the weights of each measure

| Project | EIRs | BDDR | BEP | PPR | CDE | Doc Ref | VDR | OSD | BIM Contract | BIM Champ | IM Score |
|---------|------|------|-----|-----|-----|---------|-----|-----|--------------|-----------|----------|
| 1       | 4    | 4.5  | 4.5 | 4.0 | 4.0 | 5.0     | 5.0 | 3.6 | 4.5          | 5.0       | 92.4%    |
| 2       | 4    | 4.5  | 3.6 | 3.2 | 4.0 | 5.0     | 4.0 | 4.5 | 4.5          | 4.0       | 89.2%    |
| 3       | 3.2  | 2.7  | 3.6 | 4.0 | 5.0 | 5.0     | 5.0 | 4.5 | 3.6          | 5.0       | 87.3%    |
| 4       | 3.2  | 2.7  | 3.6 | 4.0 | 5.0 | 5.0     | 5.0 | 4.5 | 3.6          | 5.0       | 87.3%    |
| 5       | 4    | 4.5  | 4.5 | 4.0 | 5.0 | 4.0     | 4.0 | 3.6 | 4.5          | 4.0       | 85.9%    |
| 6       | 4    | 4.5  | 4.5 | 4.0 | 5.0 | 5.0     | 5.0 | 4.5 | 3.6          | 2.0       | 85.9%    |
| 7       | 4    | 4.5  | 4.5 | 4.0 | 4.0 | 5.0     | 4.0 | 3.6 | 1.8          | 4.0       | 85.3%    |
| 8       | 2.4  | 2.7  | 3.6 | 3.2 | 5.0 | 5.0     | 5.0 | 3.6 | 4.5          | 4.0       | 84.5%    |
| 9       | 4    | 4.5  | 4.5 | 3.2 | 5.0 | 5.0     | 5.0 | 0.0 | 3.6          | 5.0       | 82.4%    |
| 10      | 4    | 2.7  | 4.5 | 4.0 | 5.0 | 5.0     | 3.0 | 4.5 | 4.5          | 3.0       | 82.0%    |

## DISCUSSION

'How to tell if the implementation of BIM is successful?' has been the subject of several research studies (Won and Lee, 2016; Arayici., 2011). In the last decade, seventeen AMs have emerged in academia and the AEC industry. Each of these assessments has different criteria to measure BIM (though some of them overlap with some common criteria); the BRE assessment, for instance, focuses on UK's Level 2 requirements and how BIM utilisation comply with the Government's strategy (including PAS 1192-2:2013) (BRE, 2015), the NBIMS-CMM focuses only on one facet of BIM, namely, information management (NIBS, 2007), whilst other methods, as the Virtual Design and Construction Scorecard (Kam *et al.*, 2013), presents a more comprehensive approach when measuring BIM.

In the BIM-MM, multiple BIM perspectives are combined to reflect the internal and external influences influencing the BIM culture. However, it is crucial to investigate which the most critical criteria are contributing to the high overall score of projects. To address this point, this paper has focused on the correlation between BEP and BDDR and the overall score of projects. In addition, the correlation between the engagement of the BIM Champion and the overall score of projects was also investigated by the authors previously (Azzouz *et al.*, 2016). What has been observed in this paper is that multiple

integrated elements lead to the successful implementation of BIM. Some of these elements, however, are more critical than the others.

It is difficult to compare the findings in this paper with previous studies as there is a shortage of publications on the application of BIM-AMs in the AEC industry. The study of Berlo and Sebastian (2012), mentioned in the literature review, evaluates BIM across 'organisations' not 'projects'. However, they conclude in their study that average BIM score is the highest in 'Information Structure and Information Flow' (one of the four main areas covered in the BIM Quick Scan). In our study, the highest average score amongst criteria is found in 'Document, Model Referencing, Version and Status' when looking at the top ten projects.

Due to the scale of the collected data, it is possible to compare BIM maturity levels between different countries (this has already been done by the authors and will be published in future work). Comparisons would help the business to better understand how BIM policies, technologies and processes are being utilised –similarly or differently– across different cultures and geographies. By doing so, areas of strengths and weaknesses can be identified in each region, and knowledge can be transferred between regions, groups, teams and disciplines. The findings would provide feedback for continual improvement when implementing BIM. Comparing maturity across geographies can be found in the work of Kam (2013) when applying the VDC Scorecard to 130 projects (one of the very few studies that focus on applying BIM-AMs in the AEC industry). In Kam's study, a comparison is made between different countries and finds 'Technology' to have the highest scores amongst the four main sections of the VDC Scorecard (Planning, Adoption, Technology and Performance).

## **CONCLUSION**

One of the most obvious aims of AMs is to 'measure' BIM across projects, organisations, teams and individuals. However, it is important to note that BIM-AMs entail more than evaluation. AMs play a significant role in focusing people and resources on specific elements of BIM, they engender greater levels of communications across different levels of the business and help project managers and project teams to clarify what 'BIM' is and what 'good' looks like. With the uncertainty surrounding BIM definition, and the lack of guidance on how to implement it, it is seen that the BIM-MM can help to create a common understanding of BIM and its critical elements.

Since its release, the BIM-MM has attracted significant interest internally within Arup and externally. Internally, the BIM-MM has not only been helpful to the higher management level, but also at the operational level. It has been used by several projects managers as a method to communicate BIM strategies with different members of their teams including technicians. Furthermore, group leaders and BIM Champions have been using the overall outcomes to track their current BIM strategies and inform future directions. Externally, several researchers and professionals have expressed their interest in the BIM-MM and its findings. Some AEC companies are already using the tool in their businesses.

Arup is using the BIM-MM as a platform to drive innovation in their business. The wide implementation of the BIM-MM is in its second year. Further analysis has been carried out to compare BIM maturity levels across regions, groups, disciplines and teams. Data has been classified by project stage, client type, income, geography and project team. This analysis is of vital importance to illustrate the wider picture of BIM implementation

globally. It is also critical to learn lessons and transfer knowledge and skills between different teams and regions.

With the emergence of BIM-AMs, research across a range of areas will evolve; diverse measures will be added, further implementation of AMs in practice will be undertaken, more efforts will be directed towards transforming the outcomes into informative source of feedback and new optimised AMs will be created. This will require building bridges between professionals, academics and policy-makers.

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# INTEGRATING BIM AND GIS IN RAILWAY PROJECTS: A CRITICAL REVIEW

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The railway plays a significant role in human life by providing safe, reliable, cost-effective services, which are environmental and drive economic growth. Significant decisions are taken at early stage of rail projects which need effective tools to avoid rework and save time, cost and increase work efficiency. Indeed, the continuous upgrading of this sector is needed to respond to technological advances, environmental change and increased customer demands. Integrating Building Information Modelling (BIM) and Geographic Information systems (GIS) is promising since the scope of BIM usually does not extend beyond the footprint of the “building”; it does not provide geospatial data. Therefore, integrating BIM with GIS provides a complete picture of the project. However, this integration is challenging especially in rail projects as they are amongst the most complicated projects and numerous parties are involved in making important decisions. This paper reviews the literature regarding integrating BIM with GIS systematically, with the aim of analysing the need for this integration and its benefits. The paper highlights a lack of a clear guideline for collaboration in the railway project lifecycle and indicates the need for research to focus on this issue as well as the possibility of applying integrated BIM with GIS as a potential solution to improve collaboration for better decision among project participants.

Keywords: railway, collaboration, BIM, GIS, integration

## INTRODUCTION

Railway transport is considered a mature industry in the developed world. It is showing a remarkable comeback after a period of decline. The obvious rediscovering of railways is boosted through its ability to move enormous amounts of freight or passengers efficiently from one place to another with minimum energy and emissions. However, railways in many countries are still struggling to be more efficient and commercially viable; rather they still depend on, government subsidy and legacy companies (Bank, 2015). To achieve such efficiency, there is a need for a continuous upgrade in different operational activity in response to technological advances, environmental changes and increasing customer demands. Railway infrastructure has greatly contributed to society in terms of safety, reliability, sufficient capacity and availability over its lifecycle (Patra, 2009).

BIM and GIS as recent technologies can realise the huge benefits of infrastructure through its lifecycle. BIM has the ability to improve efficiency and effectiveness through providing a different process of collaboration and a new working approach to transform current Architecture, Engineering, Construction industry structure and practice (Bradley

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*et al.*, 2016). BIM has been used to facilitate the integration, interoperability, collaboration and automation of processes in the construction industry (Isikdag and Zlatanova, 2009).

Although BIM has significant features, it has been restricted to building information (indoor environment). Therefore, to integrate interior and exterior information to provide a complete picture of the built environment, attempts have been made to integrate it with GIS. The core theme of the UK government strategy is working collaboratively using integrating BIM with GIS in projects such HS2 and Crossrail, which are considered amongst Europe's largest infrastructure projects. Would assist in ensuring that the right information is available at the right time in the right format for the right person (May, Taylor and Irwin, 2017). Combining BIM with GIS would provide a complete picture for the project because of the complementary nature of the information that each technology can provide (Fosu *et al.*, 2015).

## **RAILWAY**

Rail is considered as a safe, efficient, environmental transport mode. However, recently, there has been a decline in the publics' perception of railway (Berrado, Cherkaoui and Khaddour, 2011). According to a report by Network Rail, collaboration is one of the most effective factors to deliver better railway in terms of safety, reliability, capacity, cost-effectiveness, quality and productivity (Network Rail, 2014). Collaboration, however, needs effective tools. BIM enables participants to collaborate in a shared software platform to share information, enabling better decision making throughout the project lifecycle (AGC, 2006). However, it lacks the ability to analyse spatial data. GIS tools have the ability to deal with spatial and geographic information (Karan *et al.*, 2015). Therefore, integrating BIM with GIS can provide a complete toolset to support collaboration between participants for better collaborative decision making throughout the lifecycle of the railway project. Despite this potential merit, data on the application of BIM and GIS integration in infrastructure is rather lacking when compared with buildings. This is expected to change as countries such as the UK are now mandating that heir public sector projects use BIM, with other countries expected to follow suit (Karan *et al.*, 2015).

### **Building Information Modelling (BIM)**

Building Information Modelling is facilitates the decision making (Utiome, 2010). It can be defined as a process of creating, sharing, exchanging and managing information in an effective way through the whole lifecycle of the building (Isikdag *et al.*, 2007). The fundamental concept of BIM is the use of a single repository of data which all team members share. This single model or database or group of databases can be linked together, thereby, easing accessing and sharing information (Autodesk, 2011).

Thompson and Miner (2007) clarified the basic theory of Building Information Modelling as the execution of the project in a virtual environment where it is possible to store all project-related data in a single (central) online system. Furthermore, the time (schedule) and cost dimensions can be added to the model which in turn allows an immediate analysis of the benefits of various cost-time options. Thompson and Miner (2007) developed BIM models for all phases of the project which enables more stakeholders to be involved practically in the early project stages. These stakeholders can use their knowledge (business- and engineering) in the facility design, scheduling and organising which would lead to improved coordination in all project stages (Fischer and Kunz,

2004). Thus, the BIM model will act as a repository of data to serve the project throughout its lifecycle.

BIM will become a source of reliable information. It becomes possible to bridge the gap between the world scale and detailed data through linking BIM and GIS platform, which offers a high level of information from GIS to detailed information in BIM. Furthermore, BIM in the long term will provide high efficiency from knowledge capture, stimulating communication, and continuous analysis of work, which will result in increased productivity.

### **Geographic Information System (GIS)**

During the last few decades and with the rapid development of technology, the demand for more efficient construction has increased. Doing more with less is the target that all relevant parties are keen to achieve. New approaches are needed to cope with these current requirements. Geospatial technologies are one of the interesting approaches to meet the current needs. GIS is used as a platform to manage and present spatially referenced information, (Amirebrahimi *et al.*, 2015).

GIS is defined as “a system for capturing, storing, checking, integrating, manipulating, analysing, and displaying data which are spatially referenced to the Earth”, (Fazal, 2008, p7). Consequently, GIS depends on geographic coordinate systems and projections of the world map, whilst BIM coordinates depend on modelling objects not relative to a specific place on the earth ( Fosu *et al.*, 2015). Ebright-mckeehan *et al.*, (2009) used GIS to assess rail corridors in terms of their proximity to the intermodal services and their importance to the traffic. Wiltshire Council uses solutions from mobile GIS to deliver public services cost-effectively. In Ireland, a mobile ArcGIS app is used to identify leaks, manage repair teams, handle data and maintain the water network more efficiently, helping Ireland's national utility to provide 1.8 million households with clean drinking water.

GIS has many applications in civil engineering fields, to which it offers spatial solutions. For example, transportation, water resources, facilities management, urban planning, construction and E-business. Moreover, GIS can be used as an effective visualisation tool for construction site topographical conditions (Palve, 2013).

Over the years, continuous attempts have been made to integrate BIM and GIS for different purposes which it can provide a project with an inclusive picture and highly detailed in terms of information from building information models and related geographical data (Fosu *et al.*, 2015).

### **BIM and GIS Integration**

Integrating BIM with GIS is not a novel idea (Fosu *et al.*, 2015). Several methods have been used to achieve complete integration of BIM/GIS. For example, various authors have proposed different methods and developed new tools by using available standards. As a result, extensions were created that may offer a needed functionality to be added to one or other platforms such as the extension of Geo BIM (Laat and Berlo, 2011), or the extension of urban information modelling for facility management (Mignard and Nicolle, 2014). In order to integrate BIM into GIS, Amirebrahimi *et al.*, (2015) suggest the use of a data model. Hjelseth and Thiis, (2008) propose an IFC-based (Industry Foundation Classes) tool.

El-Mekawy, Östman and Hijazi (2012) proposed an approach called Unified Building Model (UBM) which allows users to combine the features and abilities for both BIM and

GIS into one central mode. UBM allows bi-directional data to be transferred between IFC for BIM and CityGML for GIS. This minimises the loss of data through the conversion for the exchange. Integration BIM and GIS has been applied to address many issues as illustrated in next section, but not specifically to collaborative decision making. Integration for this study aims to provide updated information for more accurate collaborative decision making.

## APPLICATIONS OF BIM/GIS INTEGRATION

Integrating BIM with GIS offers huge advantages; Kolbe, König and Nagel (2011) argued that using BIM and GIS allows planning questions to be addressed. Targeted application areas of integrated BIM and GIS clearly include urban planning and landscaping, architectural design, tourism and leisure, 3D cadastre, simulation of environments, mobile telecommunications, disaster management, homeland security, vehicle and pedestrian navigation, training simulators, and mobile robotics (Kolbe, König and Nagel, 2011). Table (1) illustrates the applications of BIM/GIS integration throughout the project lifecycle.

*Table 1: Application of integration BIM/GIS*

| Project stage                     | Application   |
|-----------------------------------|---|
| Planning and Design               | Select the site and manage fire response (Isikdag, Underwood and Aouad, 2008).  |
|                                   | Easiest collaboration between planning (Niu, Pan and Zhao, 2015).   |
|                                   | Effective traffic planning (Wang, Hou, <i>et al.</i> , 2014).   |
|                                   | Plan and make a decision of low- disturbance bridge construction bridge (Sebastian, Böhms and Helm, 2013).                      |
|                                   | Identify optimal number and location of tower cranes (Irizarry and Karan, 2012).  |
|                                   | 4D topology and use novel IFC in planning a path for 3D indoor spaces respectively (Lin <i>et al.</i> , 2013).                  |
| Construction                      | Indoor geovisual analytics (Wu and Zhang, 2016).  |
|                                   | Speed up the work (Shiu and Sar, 2014).   |
|                                   | Managing construction supply chain, green design, construction and sustainable consequences (Irizarry, Karan and Jalaei, 2013). |
| Operation and Facility management | Metro construction project (Wang, Li, <i>et al.</i> , 2014).  |
|                                   | Facility management, facility analysing, visualising and assess damage in buildings such as flood (Karan and Irizarry, 2014).   |
|                                   | Emphasise the materials delivered by enabling tracking the status of the supply chain (Irizarry, Karan and Jalaei, 2013).       |
|                                   | Flood damage assessment (Amirebrahimi <i>et al.</i> , 2015).  |
|                                   | Evaluate the performance of construction (Elbeltagi and Dawood, 2011).  |
|                                   | Managing the processes of maintenance and repair of facility management (Karan and Irizarry, 2014).                             |
|                                   | Detect and map the information for pipe networks (Liu and Issa, 2012).  |
|                                   | Manage the maintenance using a UML (unified modelling language) in Taiwan railway (Shr and Liu, 2016).                          |

There are several researchers addressing similar areas by using integrated BIM and GIS such as facility management, utility visualisation, analysis, assessed damage and natural disasters. (Liu and Issa, 2012)

On the other hand, the most important area that stands to benefit from the integration of BIM/GIS to provide a collaboration environment. Through collaboration, large problems can be tackled and huge benefits can be gained. Collaboration includes facilitating sharing knowledge, risks, skills and reducing cost (Prahalad and Hamel, 1990a).

### **Integrating BIM and GIS for Collaboration**

The importance of collaboration has increased with advances in Information and Communication Technologies. Collaboration improves decision making, exchange of knowledge and skills, access to information and sharing of risks and responsibilities (Prahalad and Hamel, 1990b). As Gerges *et al.*, (2016) concluded, based on interviews, collaboration leads to reducing risks. Collaboration is considered as a solution to many issues such as social challenges, environmental issues, and economic recessions. Moreover, Moon *et al.*, (2004) noted that effective collaboration requires integrating models for the whole life of railway construction from planning to the maintenance.

There is various research into using different techniques and methods to achieve collaboration for several purposes. BIM and GIS are among the two most important technologies that might be used for providing a collaborative environment for rail projects. Although integration of BIM with GIS has the potential to produce a powerful tool for collaboration in railway projects, there are just few studies around this topic.

Several studies have been conducted in order to determine the success in collaboration whether using BIM and GIS separately. Shim *et al.*, (2008) suggested using a RIIM (Railway Infrastructure Information Model) model to provide integration and interoperability during the whole lifecycle of the railway infrastructure from planning until maintenance.

BIM can offer a high level of efficiency in communication and collaboration (Bryde, Broquetas and Volm, 2013). Sebastian (2011) emphasises that using BIM optimally could lead to achieving a multi-disciplinary collaboration.

Similarly, GIS has also used alone in railway projects. Guler, Akad and Ergun (2004) found that through GIS, better decisions could be made by using it to identify the event or asset to another event or asset and determining if the relationship between them may be considered as a crucial factor in deciding the design, construction and maintenance. For the same purpose, in selecting an optimum railway line, Wei (1996) developed a new RGIS technology (Railway Geographic Information System) to select a new railway line. He found that there is the insufficient difference in results between using a computer and using a traditional method, even though the computer was more efficient.

Nyerges and Jankowski (1997) suggested a theoretical framework for human decision making collaboratively based on GIS. One of the practical aspects of integrating BIM and GIS explored by Kim *et al.*, in 2015 was to provide a program for a safe path for pupils travelling to school called Safe Routes to School (SRTS). The purpose of this program was to reduce consumption of energy and CO<sub>2</sub> emissions, resulting in improving the safety and health of children. This program consists of integrating BIM with GIS in providing a visualisation for the weather and monitoring this information via participants.

There are many ongoing studies of collaboration in the railway sector using techniques such as BIM and GIS. However, there is a lack of integration of BIM and GIS for

collaboration in this sector. Combining them may provide a significant role in every lifecycle stage of railway projects especially for better decision making and more efficiency. Therefore, to bridge this gap an attention is needed to be taken in order to consider this issue.

## DISCUSSION

From the literature review, it is appearing that railway projects are very crucial and need collaboration for safety, reliability capacity, cost-effectiveness, quality and productivity. For example, improving collaboration can result in saving time, cost, improving quality, reducing carbon emissions, increasing efficiency, productivity and availability of information throughout the project lifecycle. Collaboration can be supported through integrating BIM with GIS, on which several studies have been conducted focusing on different aspects of this issue. Integration of BIM and GIS can provide a platform for collaboration for better decision making.

Wognum and Faber (2002) argued that there is a lack of understanding of collaboration among organisations. Consequently, there are few techniques to facilitate and manage collaboration. This may be because collaboration needs several factors to succeed. To illustrate that, Eriksson and Pesämaa (2007) pointed out that moving towards collaboration in construction projects, relationships and delivery methods require a comprehensive change in structures, processes and attitudes. Moon *et al.*, (2004) stated that to provide an active collaboration environment, a single integrated model would be required for the design, construction and maintenance process.

## CONCLUSIONS

This paper reviewed literature and provided evidence around integrating BIM and GIS in the railway industry, and explored the potential benefits applying BIM and GIS integration in the railway sector. The railway sector needs to keep up to date with technological developments to realise the potential benefits of BIM and GIS. There is a possibility to bridge the gap between the world scale and detailed data through linking BIM and GIS platforms. The literature has revealed that collaboration may play a crucial role in railway projects and may solve existing problems; thus, providing huge opportunities and better decision making. However, it was found that despite the importance of collaboration and even with using BIM and GIS separately in railway projects, there is a lack of research focusing on using them in an integrated manner. Therefore, serious attention should be considered to tackle this issue, through developing a framework for integrating them to improve collaboration for better decision making which it will be the next step for this study.

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# GRASPING BRUTAL AND INCREMENTAL BIM INNOVATION THROUGH INSTITUTIONAL LOGICS

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Building Information Modelling (BIM) as an innovation contributes to construction digitalisation. BIM affects various actors of the built environment, e.g. government structures, enterprises, and industry groups. Notably, BIM is not newly-found, yet it radically alters the way construction firms operate. BIM evolved from an industry-sponsored effort to share consistent information among low tiers of the supply chain, towards collaboration across all tiers. As public bodies start to mandate BIM, firms have to radically – or brutally – innovate their businesses. This paper explores BIM innovation via the lens of institutional logics in contexts with low and high BIM diffusion. It compares the United Kingdom – where BIM was mandated in 2016 – and some Nordic countries and the Netherlands – where it is not yet mandated. The study draws upon grey and scientific literature to explain how innovation unfolds macroscopically and concludes that contextual sensitivities are lacking in BIM debate.

Keywords: BIM, innovation diffusion, institutional logic

## INTRODUCTION

Innovation entails a new product, service or process (Abernathy and Clark, 1985). Traditionally innovation has been typified into incremental – evolutionary, involving gradual changes – and radical – or brutal – by engaging in completely new approaches (Burns and Stalker, 1961, Abernathy and Clark, 1985). Whereas innovation is mostly observed in projects, it impacts the wider context beyond project-based limitations. Thus, whereas innovations are observed and rely on good projects, context affects them and pushes or suspends change. The construction industry is project-based and considered a laggard in technology take-off and adopting technological innovations (Davies and Harty, 2013). Thus, there is probably a need to look beyond projects, into their context, in order to support innovation adoption and construction management.

This paper explores the interactions of construction management with innovation, drawing upon a recent hot topic in the industry: adoption and diffusion of Building Information Modelling (BIM). Undoubtedly, innovation diffusion relates to a macro-level, whereas adoption relates to a micro-level. Entities adopt innovations at a micro scale, e.g. firms, and ultimately innovation diffuses at a macro-level (Rogers *et al.*, 2005), i.e. the industry. This paper connects these two levels for understanding BIM, especially at macro-level. Various actors of the built environment, e.g. individuals, project teams, firms, supply chains, state, and market affect innovation adoption and

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diffusion. Using the concept of *institutional logics*, suggested by Friedland and Alford (1991) as a theoretical lens, the study aims to understand the nuances of innovation. The paper compares countries with high BIM diffusion (some Nordic countries and the Netherlands) with the United Kingdom (UK), which has low BIM diffusion. This theoretical study aims to explore the context that affects BIM diffusion, and is structured as follows. First, the theory and gap on innovation, BIM, and institutional logics are offered. Second, the methodology and methods deployed are presented. In the ensuing sections, the data analysis, discussion against literature, and implications are given. The study concludes with a summary of findings and further research.

## **THEORETICAL BACKGROUND AND RESEARCH GAP**

### **BIM as Construction Innovation**

#### *Diffusion of innovations*

The diffusion of innovations model by Rogers (2003) described the process by which innovations spread via communication channels across a social system over time. According to Rogers (2003) some innovations spread relatively rapidly while others spread slowly depending on (a) novelty, (b) compatibility with existing values, beliefs, and experiences, (c) ease to comprehend and adapt, (d) tangibility, and (e) testability. As most real-life systems are not linear, but instead highly complex, likewise during innovation diffusion, multi-scale phenomena add to the complexity. Local networks' interactions trigger the emergence of global structures and behaviours (Rogers *et al.*, 2005). As even the firms that deliver similar services or products are highly heterogeneous, many heterogeneous *micro-scale* behaviours and actions of adoption from those firms contribute to *macro-scale* phenomena, and diffusion (Ibid.). Construction is largely project-based (Morris, 2004) and its projects are unique by displaying high demand and supply variability. Thus, the projects upon which construction industry is organised are also highly heterogeneous and complex. According to Rogers *et al.*, (2005) “*acknowledging the centrality of heterogeneity is also consistent with Actor-Network Theory, which, along with diffusion of innovations theory, points to the alignment of social and technical systems in heterogeneous networks*”. Acknowledging macro-scale phenomena, context and heterogeneous institutions is necessary for understanding innovation in construction (Larsen, 2005).

#### *Building Information Modelling history and precursors*

Projects are nexuses of processing information (Winch, 2002). Neo-institutional views on construction project management generate insights on “*how actors construct the reality around them through interaction, thereby performing scripts and routines to generate organisation*” (Winch, 2015). Thus, information flows are key ingredients of management, within and beyond projects. BIM could then be viewed as ‘systemic innovation’ in the sense that it influences multiple levels of construction (Taylor and Levitt, 2007). BIM is not only a domain of digital artefacts, but has roots in the long process of developing standards for building information, the most long-lived being Industry Foundation Classes (IFC) (Eastman, 1999, Laakso and Kiviniemi, 2012).

BIM is not entirely new for construction as it has evolved from efforts for structuring and consistently representing information and knowledge about building artefacts, which was a predominant line of thought in the 1970s (Eastman, 1999). In the United States of America (USA) initiatives in the mid-1980s for ‘*building product model*’ definitions were developed for exchanging building information amongst computer applications (Ibid.), replacing error-prone human interventions. The advancements in building product modelling followed the long-standing debate on the computerisation and digitalisation of

construction (Eastman, 1999). Against widespread belief, BIM is not newly-found, but evolved from efforts by industry consortia to structure building information (East and Smith, 2016), previously known as *building product models*.

BIM affects various actors across construction lifecycle, while policies, processes, and technology interact to generate a digital building (Succar *et al.*, 2012). BIM is a set of loosely-coupled existing and new Information Technology (IT) systems to generate, control, and manage building information. BIM could still be branded as construction innovation, as whereas its content is already known to lower-tiers actors of the supply chain, implementing it in projects from all actors is entirely new and challenging. Its novelty also lies at policies prescribing BIM in contract addendums and workflows for project delivery. Thus, BIM is not anymore privy to a ‘cohesive’ set of actors, but has passed the ‘threshold’ of diffusion in construction (Larsen, 2005). Undoubtedly, BIM not only affects the representation of building product information, but also multi-disciplinary teams (Dossick and Neff, 2010, Bryde *et al.*, 2013). Whereas BIM is a technological innovation, it not only influences coordination of IT artefacts, but also complex socio-technical processes to align information and actors (Liu *et al.*, 2016, Papadonikolaki, 2016) across projects, supply chains, and markets.

### **The Importance of Institutional Logics for Understanding BIM Diffusion**

The end of the 20<sup>th</sup> and the beginning of the 21<sup>st</sup> century found management scholars problematising on the scope of project management. As projects are embedded into their organisational and institutional contexts (Blomquist and Packendorff, 1998), traditional project management might not be sufficient. Thus, the relational context and the institutional environment of projects should be also managed (Blomquist and Packendorff, 1998). Whereas project management discipline emerged from a Taylorist approach of organising, it now incorporates Social Science. Similarly, construction management developed multi-disciplinary sensitivities and embraced Social Science, and particularly psychology, sociology, philosophy, and organisation theory. Projects shape and are shaped by their environment, that is called embeddedness (Giddens, 1984). Yet, as from the dual structure-agency nature, more emphasis was given on the former than the latter, *institutional logics* were introduced to stress the importance of the relations between agency (behaviour, values, intentions) and context (individuals, organisations, institutions) (Friedland and Alford, 1991). Family, community, religion, state, market, professions, and firms are layers of institutional logics in the West from micro- to macro-scale to understand individuals, organisations, and markets.

In the context of innovation, institutional logics are a useful lens to understand BIM diffusion among firms. Whereas there are many detailed and visionary studies of how innovation unfolds at intra-organisational (Peansupap and Walker, 2006) and project-based settings (micro-scale), there is lack of evidence on how innovation unfolds at a macro-scale. Indeed, there is a lack of contextual awareness in innovation studies (Larsen, 2005). Whyte and Berente (2008) used institutional theory to discuss the influence of BIM on professionalism. Linderoth (2016) used the logics to explore the relation between new technologies and change. Few works studied new technologies across all institutional levels. Those offer a comprehensive view of how innovations unfold, avoiding pitfalls of rhetoric strategies and impression management that unfold by only looking at intra-firm levels (Leiringer and Cardellino, 2008). Comparing BIM diffusion between the UK and Finland (Khosrowshahi and Arayici, 2012), or among UK, Sweden, and France (Davies *et al.*, 2015) some nuances exist. Whereas the North-western European construction and institutional context is treated as one entity

(aggregator of institutional logics), it is in fact made up of various national business systems, where state, industry, political, and epistemic networks interact.

This paper studies content- and context-related dimensions of BIM innovation. First, the study does not generalise on the diffusion of any construction innovation, but only focuses on technological, IT-driven innovation that falls under the umbrella of BIM. As BIM is not yet another innovation *hype* (Dainty *et al.*, 2015), but has emerged from a complex history of standardisation and ‘pull’ efforts in the realm of construction IT from lower tiers of the supply chain (Eastman, 1999), acknowledging these efforts might support the understanding of BIM innovation diffusion. Second, there are currently many voices supporting the transferability of best-practices from BIM innovation across countries (Wong *et al.*, 2010, Khosrowshahi and Arayici, 2012, Davies *et al.*, 2015). However, it is important to understand the extent to which such BIM best-practices are compatible and transferable across contexts. Only then, any mimetic mechanisms for diffusing BIM innovation in countries and across projects could be justifiable and sustainable. Thus, there is room for additional understanding of innovation diffusion through the contextual lens of institutional logics.

## METHODOLOGY AND METHODS

The study follows an exploratory systematic review (Greenhalgh *et al.*, 2004) to seek the relation between context and BIM innovation, through an institutional logics lens. By reviewing various contexts in North-western Europe, the study examines the possibility to transfer conditions for BIM innovation diffusion across countries. The main research question is formulated as follows: “*How does the diffusion of BIM innovation unfold across countries and what are the implications for policy and management?*”. In construction, we distinguish three typologies of national business systems (Winch, 2002) across developed countries (excluding developing countries):

- *Anglo-Saxon* systems, such as those of the UK and the USA, which rely on liberal market values, stock market, and have low state regulation,
- *corporatist* systems, such as Germany and the Netherlands, which primarily rely on banks, and are driven by coordination efforts between state and market. The market is considered a ‘social partner’ of the state. In the Netherlands, this corporatist culture is referred to as ‘*poldermodel*’ culture (Winch, 2002),
- *state-led* systems, such as France and Japan, which display higher coordination between state and market than the corporatist type system.

Denmark, Sweden, and Finland probably also are of *corporatist* culture. Danish firms are keen to negotiate and reach consensus, as industry is regulated as to innovation and loosely regulated as to market rules (Gottlieb and Jensen, 2016). Sweden has both centralised state control and dispute resolution culture (Bröchner *et al.*, 2002), like the Netherlands. Finland has relational stability of actors, fluid boundaries, and network-level change agents, which implies a *corporatist* culture (Taylor and Levitt, 2007). Unwritten rules governed by culture, ethics, and idiosyncrasies shape the context. As technology is also a cultural phenomenon, adopting technological innovations is influenced by culture and idiosyncrasies. The paper is a systematic review of scientific and grey literature, expert advice, and publicly-issued reports on BIM, following the method of Greenhalgh *et al.*, (2004). The data is from Anglo-Saxon and corporatist countries: the UK, Netherlands, and some Nordic countries. The data was thematically analysed around weight of policy and logics involved. Table 1 shows the data sources:

Table 1: Data sources on BIM innovation in countries (numbers indicate sources studied).

| Data sources                       | National contexts across North-western European countries |             |             |         |
|------------------------------------|---|-------------|-------------|---------|
|                                    | United Kingdom  | Netherlands | Scandinavia | Finland |
| Scientific literature              | >41   | >27         | >15         | >11     |
| Publicly-issued mandate            | 1   | N/A         | 3           | 2       |
| Government reports                 | 9   | 1           | 2           | 1       |
| Industry report                    | 8   | 3           | 5           | 4       |
| Online sources                     | 2   | 3           | –           | –       |
| Anecdotal data by industry experts | >20   | >30         | 2           | 5       |

## DATA AND FINDINGS

### Levels for Analysing BIM Innovation

As BIM increasingly attracts interest from various industry players, it inevitably becomes the focus of high quality research. 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 that, research on BIM unfolds in three wide categories:

- *Adoption* of isolated firms –based on individual perceptions of employees;
- *Implementation* in projects – from case study analyses of projects and
- *Diffusion* at a macro-level – by targeting specific professions or countries.

BIM adoption studies provide rich insights into intra-firm barriers and enablers. Son *et al.*, (2015) analysed BIM adoption in architects in China using TAM, and individual perceptions and mistrust were key barriers. Both relational and technical aspects shape the transformation of contractors in the USA for BIM adoption (Ahn *et al.*, 2015). As adoption unfolds at micro- and diffusion to macro-scale, implementation relates to an intermediate or meso-level, which greatly affects the former. Likewise, technical and organisational BIM implementation studies offer a firm grasp of BIM advantages and shortcomings. Some identified benefits lie in design management (Elmualim and Gilder, 2014), project management, communication, coordination (Dossick and Neff, 2010) and performance (Bryde *et al.*, 2013). Yet, BIM adoption and implementation studies often do not detail context, as this is rarely included into their research scope.

### BIM Innovation Diffusion across North-Western Europe

BIM diffusion studies facilitate better understanding of how BIM innovation unfolds across contexts, and whether this is evolutionary or revolutionary (Burns and Stalker, 1961). In projects with various BIM-using firms, implementation varies, as firms carry various BIM capabilities, due to heterogeneity in service and size (Succar *et al.*, 2012, Succar and Kassem, 2015). Succar and Kassem (2015) categorised BIM diffusion dynamics into *top-down*, *middle-out*, and *bottom-up*, depending on pressure, i.e. downwards, horizontal, or upwards, by government, large or small firms, respectively. In Europe, to control various nuances and instrumentalities of BIM, and prescribe BIM implementation to reap its acclaimed benefits, various national initiatives from the government and professional industry associations suggest quasi-contractual means of BIM-related agreements among actors, e.g. pre-contract BIM Execution Plan' (CPIc, 2013) under the efforts of the UK BIM Level 2 mandate, and 'BIM Protocol' Norm issued – but not mandated – by the Dutch Government Building Agency (GBA) (Rijksgebouwendienst, 2012). Both mandates are inspired from the – recently mandated – 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.

However, the UK and Nordic countries’ mandates have different scope. The Finnish and Norwegian mandates place emphasis on interoperability and using IFC-compliant software. In essence, they mandate ‘OpenBIM’ initiative for neutral BIM standards. In Sweden, only the transport authority mandates BIM. BIM is not mandated for buildings (Hooper, 2015), same as in the Netherlands. Other European countries plan BIM mandates, e.g. France will issue regulations to mandate BIM for public buildings in 2017 (Davies *et al.*, 2015) and Germany will issue BIM mandates by 2020. A cross-country study of six BIM initiatives stated that for “*effective implementation of BIM in a country, both the public and private sector should work collaboratively to set up a suitable environment*” (Wong *et al.*, 2010). But not all countries inspire close collaboration of public and private. Whereas “*policy makers can also adopt or adapt compatible BIM content types from other countries and thus reduce duplication of efforts*” (Kassem *et al.*, 2015), context is very crucial. Thus, by examining all pertinent social layers, conditions for partial transferability of BIM diffusion mechanisms could be identified. Table 2 shows social layers active in BIM diffusion across countries.

Table 2: Cross-country comparison of social layers active (shown in bullets) in BIM diffusion.

| Institutional logics<br>Social layers | National contexts across North-western European countries |             |             |         |
|---------------------------------------|---|-------------|-------------|---------|
|                                       | UK  | Netherlands | Scandinavia | Finland |
| Contracting & consulting firm(s)      | •   | •           | •           | •       |
| Public clients                        | •   | •           | •           | •       |
| Private clients                       | –   | •           | •           | •       |
| Suppliers                             | –   | •           | •           | •       |
| Software vendors                      | –   | •           | –           | •       |
| Long-term partners                    | –   | •           | •           | •       |
| Professional bodies                   | •   | –           | –           | –       |
| Personal & a-spatial networks         | •   | •           | •           | •       |
| State regulation                      | •   | –           | •           | •       |

## DISCUSSION AND IMPLICATIONS

### Understanding BIM Diffusion through Institutional Logics

Mapping and understanding institutional logics of BIM innovation across countries, helps to the understand BIM diffusion. Innovation always applies to both micro- and macro-levels. BIM innovation is adopted incrementally in firms and radically in projects that influence and are influenced by their context (macro-level) varyingly, according to institutional logics. Likewise, personal networks and lateral institutions enable the solidification of knowledge, learning, and innovation (micro-level). Widén *et al.*, (2013) explored the importance of engaging key agents, e.g. innovation brokers, role models and risk-takers, early in innovation diffusion. In BIM diffusion, various layers from Table 2 could play such role, e.g. suppliers, software vendors and professional bodies. Mapping them could help engage them. Similarly, different compositions of institutional logics have different equilibria. Policy-makers and other actors interested in pushing BIM in national markets could leverage from these logics, since BIM emerged from a pull strategy (Eastman, 1999) decades ago. Any European-wide BIM guidelines need contextual sensitivities to avert generalised decisions. Acknowledging diverse logics and contexts is crucial for successfully managing innovation as projects are not alone sufficient for inducing and managing innovation.

### Typologies of BIM Innovation Diffusion

Whereas this study analysed institutional logics of BIM innovation per country, the analysis is clustered around business systems. The Anglo-Saxon and corporatist systems are respectively of radical and incremental BIM diffusion. Notably, Sweden and the Netherlands, with high state regulation, follow bottom-up strategy and have not mandated

BIM, whereas the UK with low regulation mandated BIM (Table 2). First, whereas the UK displays less state involvement and *laissez-faire* mentality, had numerous politicised decisions for pushing BIM, similarly to BIM mandate in 2007 in the USA. Yet, the USA seem to have lost momentum in BIM innovation, as not a lot of traction has been gained since (McGraw-Hill, 2014a). In the decade that followed their mandate, most USA construction firms still do not use BIM (McGraw-Hill, 2014b). However, mandating BIM in public projects has different implications for the USA and UK, as these countries have varyingly intertwined institutions and policies, i.e. social infrastructure. In the UK, the government is the biggest construction client. Given that public and social procurement (e.g. hospitals and schools) in the UK is high, correspondingly more construction firms are affected from the mandates. Also, placing the UK PAS 1192-2 under public revision, to involve more institutional logics in BIM diffusion, might indicate a new ‘cultural shift’, featuring bottom-up strategies.

Second, whereas BIM is not globally mandated in the Netherlands and most Nordic countries (Table 2), firms are keen to use it (Davies *et al.*, 2015). The Netherlands published their public but not mandatory BIM guide in 2012 but have high BIM diffusion, same as Norway that only recently (2016) mandated it. These countries are not in BIM industry reports, such as of McGraw-Hill (2014b). Personal, informal, and long-term inter-firm relations (Bröchner *et al.*, 2002, Gottlieb and Jensen, 2016), support BIM diffusion from a middle-out perspective. Surprisingly, professional bodies there are not yet very active in policy-making, whereas the UK Royal Institute of British Architects (RIBA) is. *Corporatist* countries have mandated interoperability, which are supported by bottom-up initiatives by construction alliances and software vendors (Hooper, 2015, Papadonikolaki, 2016). The actors receive pressure to be IFC-compliant, as opposed to the top-down BIM diffusion in *Anglo-Saxon* countries. Any generalisation and transferability of BIM policies are valid when firms compete within a truly global plateau, e.g. international architectural competitions, where BIM was required as early as 2008. When discussing BIM as a global market phenomenon, contextual awareness is needed. Generalisations based on solely economic growth are misguided when social context (logics) and infrastructure are not also acknowledged.

### **Supporting BIM Innovation Policy**

BIM innovation is seen as incremental or radical – brutal – in the UK, from a macro-level view. As innovations are strategically deployed in projects, they depend on micro-, meso-, and macro-level institutional layers, e.g. individuals, firms, clients, suppliers, networks, and state. Innovation management requires synergy among these layers. Aligning the logics helps smooth acceptance of technology (Linderoth, 2016). Rethinking the composition of institutional logics could be used to mobilise key actors, e.g. professional associations, software vendors, suppliers, corporate groups, to induce incremental innovation, mainly in countries with ‘top-down’ BIM diffusion. Dainty *et al.*, (2015) challenged the effectiveness of mandates and policies for BIM diffusion because such policies are usually discontinued for lack of political influence, as in the reform agendas from 1934, 1944 to Latham and Egan reports. However, it seems that the UK political influence grows strong. Fernie *et al.*, (2006: 98) noted the ‘*need for contextual thinking and sensitivity within organisational studies and in the discourse mobilised by the contemporary reform movement*’. Undoubtedly, both the context and content of innovation are needed to understand its diffusion. After all, Kale and Ardit (2006) had previously acknowledged that while innovation is diffused across the industry, the particulars of innovation also evolve over time. This fact also aligns with BIM, considering how it evolved over the decades from a pull strategy under a different name,

i.e. *building product models*. Thus, adjustments in BIM innovation diffusion and hybrid top-down and bottom-up mechanisms emerge, e.g. in the UK's recent decision to place the BIM mandate under public revision (early 2017).

## CONCLUSIONS

The paper explored two realities of BIM innovation diffusion. First, BIM diffusion policy tends to neglect the historical antecedents of BIM, which emerged through a pull strategy. Whereas policy and research bodies see BIM as a *brutal* innovation, its underlying principles were introduced in construction years ago. BIM is seen as brutal in the UK, due to the mandates, and incremental in some Nordic countries and the Netherlands, where it is differently mandated. Second, context and culture influence BIM, as incongruent social layers are activated for its diffusion (Table 2). Mapping and comparing these logics across countries revealed two mechanisms of top-down and bottom-up BIM diffusion. The cross-country comparison of logics, suggests that efforts to diffuse BIM across countries in 'one-size-fits-all' fashion are probably misguided, and could hinder productivity, satisfaction, and performance. Developing both BIM-specific and contextual awareness facilitates BIM innovation management. Future study will address the sampling limitations via snowballing technique.

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# RECEPTIVENESS FOR CHANGE: THE CASE OF A PUBLIC CLIENT

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The construction industry needs to change to meet the needs for a more sustainable built environment. For industry change to happen, public clients have been suggested to play a key role as change agents because of their power to state requirements when procuring, and due to their role as long-term property owner. This makes receptiveness for change within public client organizations a vital issue for industry change. The aim of this paper is to explore receptiveness for change at a public client organisation by applying the framework of receptive contexts developed by Pettigrew *et al.*, (1994). Based on an empirical case study of a public client's implementation of Building Information Modelling (BIM) during the period between 2013 and 2017, findings indicate that there is a lack of a receptive context, which hamper the public client's ability to take on the role as change agent and drive industry change. The conclusion is that the idea of public client's as change agents also comes with challenges and that there is a need for more studies on how to develop receptiveness in large public organizations.

Keywords: change, client, receptive context, BIM

## INTRODUCTION

The construction industry, which is a major contributor to environmental pollution and climate change, is in need of change to meet the needs for a more sustainable built environment. For industry change to happen, public clients have been suggested to act as key change agents (Porwal and Hewage, 2013). In particular, the implementation of new technology such as Building Information Modelling (BIM) is argued to play a vital role for this industry change process to take place (Azhar, 2011; Lee and Yu, 2015; Takim *et al* 2011). The arguments put forward are that public client organisations are in the power position to request BIM when procuring projects and thereby drive change among industry actors. Public client organisations are also, in their role as long-term property owners, argued to be the actors in the industry that will have the largest potential gain from BIM adoption in order to enable efficient facility management (Linderoth 2010, Smith 2014).

The combination of these two factors, of being in a power position to demand change when procuring, and of having long-term focus in change processes, put public clients in the change agent role (Wong *et al.*, 2010; Wong *et al.*, 2011). Recently, public clients in for example Sweden (SOU 2012:39), Hong Kong (HKCIC, 2014) and the US (GSA, 2007) have also initiated BIM implementation projects with the specific purpose to drive industry change. However, recent research from Sweden show that the implementation of

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BIM for industry change also pose intra- and inter-organizational challenges, which influence the public client's ability to drive industry change and there are recent research problematizing the public client's role as change agent (Bosch-Sijtsema *et al.*, 2017, Vass and Karrbom Gustavsson, 2017). There is, for example, a dis-match between the perceptions of project managers and BIM implementation managers within a public client organization with regard to what a public client's role and mission actually is in relation to the construction industry (Vass and Karrbom Gustavsson, 2017).

There is a small but growing critical stream of research on BIM as an uncontested rational 'problem solver'. This research shows that BIM has not yet reached its promised benefits in terms of increased productivity, efficiency or sustainability (Karrbom Gustavsson *et al.*, 2012; Miettinen and Paavola, 2014). Fox (2014) and Dainty *et al.*, (2015), for example, argue that there is hype around BIM promising change and creation of new opportunities while disregarding many of the social and human conditions that constrains and complicate a rational realization of the vision. Miettinen and Paavola (2014, p. 85) describe the current situation as "BIM Utopia". Hence, the public client's role as construction industry change agent needs to be studied and understood better, in particular in relation to the idea of public client's as change agents by implementing BIM for industry change.

Based on a longitudinal case study of a public client organisation's implementation of BIM and the application of Pettigrew *et al.*'s (1994) framework of receptive context the purpose here is to explore receptiveness for change within a public client organization. The findings have contributions for both industry and academia, developing knowledge about client organisation's role in leading inter-organisational change processes in general and supporting the current implementation of BIM in particular.

## UNDERSTANDING CHANGE

Change always takes place within an organizational context and this context directly influences the change process. Pettigrew *et al.*, (1994) introduces the concepts of "receptive" or "non-receptive" contexts to explain differing results from strategic change initiatives. The following eight factors or symptoms, which have impact on the receptiveness of a particular context, are outlined (Pettigrew *et al.*, 1994):

- Quality and coherence of policy - Policies tailored towards the context with a clear link between goals, feasibility and implementation requirements.
- Availability of key people leading change - The availability of the key people, preferably a small group, with individuals from diverse constituencies with complementary assets and skills.
- Environmental pressure - The right level of environmental pressure in relation to the specific context.
- Supportive organisational culture - Establishing an organisational culture, supported by management that motivates and rewards change. This includes a focus on flexibility, risk-taking, openness and team building.
- Effective inter-professional relations - Ensure that individuals linked to the context are involved and not going into opposition of the policy.
- Co-operative inter-organisational networks - Create a network between the actors supposedly influenced by the policy and establish incentives and shared goals and ideologies in this network.
- Simplicity and clarity of goals and priorities - Ability to specify priorities in the change agenda in order to establish short term pressure.

- Fit between the change agenda and locale - How well the change agenda includes awareness of preconditions at the sight for change.

These factors should not be viewed as a checklist for successful change processes but rather as a set of factors that together provides receptiveness for change. The receptivity of a change context is to major extent influenced by both past events and local preconditions and enhancing receptiveness is not easily done only by minor changes. The receptivity or non-receptivity of a specific context is not stable over time, rather it changes and develops with environmental and policy changes (Pettigrew *et al.*, 1994). Thereby the actions (or non-actions) taken during a change initiative has a direct impact on the receptiveness of the context in which it takes place. This framework was developed when doing research on the healthcare industry (Pettigrew *et al.*, 1994) but many of the characteristics of healthcare can also be found in the construction industry. The fragmented process and ‘loosely coupled system’ of actors (Dubois and Gadde, 2002) in the construction industry bares many similarities to healthcare, for example that both are described as change resistant contexts, partly as a result of fragmentation.

## **METHOD**

This is a qualitative and exploratory case study that aims at improving knowledge on the public client’s role as change agent when implementing BIM for industry change. The client organisation in focus in this case-study is the largest infrastructure client in Sweden. The study is longitudinal and covers a period of three years (2014-2017). During this time the BIM Initiation Project was studied by observing two meetings within the BIM Initiation Project's team and two meetings between the BIM Initiation Project and the rest of the client organisation. The case-study was supplemented by reading and reflecting on documents and by doing 11 semi-structured interviews. Five of the interviews were with representatives from the BIM Initiation Project organisation and six were with representatives from the Investment department organisation. The respondents had roles such as project managers, project engineers and BIM experts and the interview analysis was supplemented and contrasted by the document analysis.

The studied client organisation is complex and consists of several departments, sub-units and support-units, and also houses formal and informal networks. Based on the public client’s organizational structure, intra-organizational change may here also be viewed as inter-organizational change, i.e. change between different sub-units.

The public client organisation in focus in the case-study is a large infrastructure client. This organisation is assigned with the development, procurement and maintenance of road and railway projects. This organisation underwent a large reorganisation in 2010 when two percussing organisation were joined together. Currently this organisation is divided into several sub-units or departments. Large Projects and Investment are the two departments procuring and managing projects, where Large Projects are responsible for the largest and most complex and Investment are responsible for the main bulk of projects. Further, the maintenance of built infrastructure is under separate department.

In order to analyse the receptive context for a change towards BIM-usage at this organisation, an example of the actions taken in the change process is described. This example, a workshop aimed at improve BIM usage, reveals many aspects of the current receptive context at this client organisation. This workshop took place in Stockholm, May 2017.

## RESULTS

### Setting the Stage - The BIM Initiation Project

In 2013 the general director at the Swedish Transport Administration made a formal decision to implement BIM in the whole organisation. After this decision a BIM Initiation Project was initiated. This project involved 14 individuals from various departments and sub-units at this organisation. The project continued until late 2014 with the following project goals:

- All construction projects should use BIM in some extent from 2015 and onwards.
- Streamline the client organisations operation.
- Establish this client organisation as a clear procurer of BIM both in design and construction.

As a part of the project, a BIM strategy was developed in which the BIM concept was defined in relation to this organisation. This strategy also specifies different maturity levels of BIM-use and a base level to which BIM should be procured in all new projects. Further this strategy expresses the expected value of a change towards BIM centric work practices. This value is described as increased efficiency, both internally but also in work practices in construction projects. Several uses of BIM-enabled tools were presented, many of which are aimed at the design or construction in projects.

To influence the organisation towards BIM adoption, new guidance documents were devised and these constitute the main deliverable of this project. These guidance documents had their root in BIM pilot projects at Large Projects where BIM had been tried out on a relatively extensive level. In the documents, specifications on BIM use, aimed at new procurements, and guidance for internal work practices at the client organisation are described. The new guidance documents were sent out on a referral procedure, collecting feedback and comments from the rest of the organisation but primarily the Investment department.

At its conclusion, the BIM Initiation Project was reorganised and the BIM implementation continued in a similar form. In mid-2015 the guidance documents was reworked and was implemented into the management system for how construction projects are conducted at this organisation. Following this implementation, the guidance documents have been further developed to meet the critique and feedback continuously expressed within the organisation. Further, the main tasks of the continued BIM Initiation Project has been to acquire support for the BIM issue and promote the use of the new work practices expressed within the new guidance documents.

Two surveys were conducted alongside the BIM implementation process. These surveys had the main purpose of assessing the general perception of BIM-use in construction projects conducted by this organisation. The surveys were aimed at several project participants with varying professions within numerous projects conducted by this client organisation, not only in-house personnel. The surveys were conducted in 2015 and 2016 and the analysis of the results showed a slight downwards trend in the satisfaction of BIM use. The analysis was conducted by consultants procured by the BIM Initiation Project and further showed that this trend was more prominent among the client's project managers. Following this analysis, the BIM Initiation Project conducted a workshop with representatives from both Investment and Large Projects with the goal of uncovering the reasons behind this downward trend. This workshop was conducted in May 2017 with

expressed purpose of identifying potential improvement and to propose concrete actions for more efficient handling of digital information.

### **Observations from the BIM Workshop**

The workshop started with a presentation from the consultant tasked by the BIM Initiation Project to conduct and analyse the survey. At the very beginning of the presentation the reason behind the declining satisfaction with BIM was tried to be explained. A discrepancy between the expected benefits presented throughout the BIM implementation process and the actual outcomes with implementation problems was presented as a main reason for this decline. Therefore the workshop was aimed at uncovering the problems in order to be able to address them.

The workshop participants were divided into groups depending on their profession with project managers, contractors and consultants/designers in different rooms. The task was to, from the perspective of the profession present; prioritise between different implementation problems revealed in the survey and to propose concrete actions of how they can be addressed.

In the project manager group individuals from the client organisations two different project conducting sub-units were present. Additionally, two representatives from the BIM Initiation Projects were present to moderate the discussion. The participants grouped themselves according to their respective department in the meeting room.

The discussion around the most common problems in this group was almost directly interrupted by a BIM-specialist from Investment. This individual questioned the results of the survey as many of the questions had been difficult for project managers to understand, "I don't know if this is suitable questions for project managers". Further he stated that many project managers had forwarded the survey to him as a BIM specialist as they did not have time or the skills to answer it themselves. This was speculated to be one part in the explanation of the negative answers.

In the discussion around the prioritisation of the most common BIM problems, comments regarding responsibility for model information in inter-organisational model use came up. The survey asked about problems with collaborative use of models. This prompted many comments from project managers at Investment: "we do not work that way" in regards to collaborative use of models. The issue of responsibility in regards to models are not relevant for Investment, models are delivered and thereby an actor is always responsible for specific problems or lacking information.

Later a discussion arose around project managers requirements on BIM. There was a difference of opinion in regards to how much contact project managers should have with the model. Some project managers stated that models are a useful tool on all meetings while others stated that project manager's main role is to lead the project team which in turn might have use of models. The main interest of project managers was stated to be the ability to follow the progress of the project. The model in itself is not important in this process, instead what the project managers gets out of the model is relevant. Representatives from Investment lifted problems with the use of models however: "due to software neutral procurement, we have to be able to use seven different viewer programs for models". This situation prompted a discussion about Large Projects and what that department can use models for but how these uses are not possible at Investment at this time.

This led to a discussion about the interests of this client organisation, with a person from Investment stating: "what is it that we want? Is it a good model or is it good work

practices?" With the follow-up from the BIM Initiation Project: "is it not the same?", with the response: "No, we can get a good model, encoded in a specific way, but this models might not ensure efficient work practices. All projects do not have the same preconditions to understand and use the models, in order for project managers to use models the work practice has to be very simple".

The question about the goals with model-use sparked further discussions with a BIM specialist from Investment commenting "what is supposed to be in the model? This question is raised in all projects. Currently we dither here and there, we need to take responsibility and tell contractors what is supposed to be in the model". The use of models is currently developed in the respective procurement documents and the project management are responsible for the definition of how BIM should be used already in the project specification. A representative from Large Projects commented: "But there is a need for acceptance for project conducted over long periods of time, demands are changing and sometimes fast". Therefore specific demands and standardised use of BIM can be limiting in large and complex projects.

The workshop concluded with a summary from the BIM Initiation Project and a statement:

It is important that we are clear now, the more similar we are naturally the better. We will try to clarify the guidance documents and procurement templates more.

## DISCUSSION

Client organisations are argued to be needed change agents in the process of influencing the inter-organisational network that constitutes a construction project (Porwal and Hewage 2013). These actors are argued to possess the needed authority and influence and demand changes by other project participants. Client actors are also described as the actors with the most potential gains from implementation of new technologies such as BIM (Linderoth, 2010; Smith 2014) and should therefore have an incentive to take this role as change agents. However, client organisations are not homogenous entities. Rather, client organisations are a complex network of sub-units with individuals with differing agendas and interests. In order to influence the work practices in construction projects conducted by client organisations, the change process has to be accepted within the context of the client's representatives within these projects. In the case presented in this paper, these representatives are mainly the project managers employed in the two departments: Large Projects and Investment.

Analysis of the receptive or non-receptive context at this organisation indicates how the change process is being perceived by these project managers. Based on the eight factors of receptivity described by Pettigrew *et al.*, (1994), the context of BIM implementation as conducted by the BIM Initiation Project has been analysed. This analysis is presented in table 1.

This analysis shows several problems with establishing receptivity for the change process conducted by the BIM Initiation Project. However, it should be noted that there are large differences between the two departments: Large Projects and Investment. Large Projects have worked more closely with the BIM Initiation Project and have been more flexible in their application of BIM in their projects. Investment on the other hand has very different preconditions and there is a perception that the BIM Initiation Project does not take their issues into account. Thereby, Large Projects express a more receptive context for this change than Investment.

*Table 1: features of receptivity relating to BIM implementation*

| Features for receptive context                 | BIM implementation context   |
|--|--|
| Quality and coherence of policy                | The BIM initiative and associated policies have been developed within the BIM Initiation Project with limited contribution from construction project managers. This has created frustration among project managers indicating a divergence between the vision at the BIM Initiation Project and the reality project managers find themselves in. |
| Availability of key people leading change      | The BIM Initiation Project represents the leadership of the change process. However, this group's legitimacy is questioned by individuals in the rest of the organisation as policies devised within this project sometimes conflicts with other policies at this organisation.  |
| Environmental pressure                         | Even though the BIM implementation issue has a formal decision from the general director, many project managers express that do not view BIM as a prioritised issue in their projects.   |
| Supportive organisational culture              | The referral process in which the guidance documents were revised and the workshop is examples of how the BIM Initiation Project tries to collect feedback. However, there is a view in the rest of the organisation that the BIM Initiation Project does are not connected with the work practices in actual construction projects.             |
| Effective inter-professional relations         | There are large differences between Large Projects and Investment in terms of complexity and size of projects. This has developed a situation where these two departments often have contradictory opinions regarding the change process.  |
| Co-operative inter-organisational networks     | Many of the initiatives and policies devised in the BIM Initiation Project have their roots in the Large Projects department. As there are much dissimilarity between the Investment department and Large Projects the acceptance of these policies at Investment has been problematic.  |
| Simplicity and clarity of goals and priorities | The workshop reveals difficulties for project managers to understand the goal of the change process. Therefore, how to prioritise and support the change process within construction projects have been problematic.   |
| Fit between the change agenda and locale       | There are differences in complexities and preconditions between projects. Especially in Investment there is a frustration that their more constrained opportunities in smaller projects have not been understood by the BIM Initiation Project.  |

In the stream of critical research questioning BIM as an uncontested 'problem solver' it is argued that there is a hype around the concept (Fox, 2014). This hype can be one explanation to why it has been problematic to create a receptive context around the BIM issue. Even if the benefits have not been overestimated, the implementation problems might have been underemphasised. Especially the issue of environmental pressure might have been oversimplified as many project managers are expressing sceptical opinions regarding BIM and are therefore not taking any initiatives themselves. These issues are also linked to problems for project managers to understand the goals of the change process. For the BIM Initiation Project the goal of BIM implementation has been self-explanatory with the consequences that project managers have had difficulties with prioritisations relating to BIM use in their projects.

## CONCLUSIONS

BIM is presented as a technology with potential to increase sustainability and productivity within the construction industry. To enhance the change towards BIM-usage, client organisations are presented as needed change agents. The case of BIM implementation presented in this paper is an example of how a public client organisation is implementing BIM in order to influence both its own organisation, but also the construction industry as a whole. Analysing this implementation from the perspective of receptive or non-

receptive contexts reveals complexities in this client organisation's role as a needed industry driver. In order for a client organisation to influence the inter-organisational network that is a construction project, the change process has to be accepted within the intra-organisation network of the client organisation itself. This paper shows that this intra-organisational acceptance is not trivial and it can be problematic to establish a receptive context around a change process. These results problematize the role of client organisations as change agents in the construction industry and show that this role is accompanied with challenges. More studies are needed to explore how receptiveness can be enhanced within the contexts of large public client organisations in their role as industry change agents.

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# SOCIAL CAPITAL, SOCIAL NETWORK AND DIFFUSION OF BIM PRACTICES

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Building Information Modelling (BIM) practice is increasingly accepted in the construction industry, it can now be fairly interpreted as industry best practice. However, the acceptance process of the practice can be affected by greater social forces, social ties, social structure, and systems of the organization/project team, and these effects have yet to be explored. Based on a critical review of social capital and social network perspective, this study proposes a conceptual framework for analysing the social intelligence and the social network embedded in project teams that may impact BIM practices. The conceptual framework consists of five key determinants: structure of interactions, intensity of interactions, exposure of interactions, quality of interactions, and resources. This study proposes a direction for future research, a case study design, and a structural equation modelling (SEM) technique that will be used for evaluating the conceptual framework. Through this research, industry practitioners can use the framework to diagnose social issues and to leverage the social intelligence inherent in a social network for successful diffusion of BIM practice.

Keywords: BIM, social capital, social network

## INTRODUCTION

Building Information Modelling (BIM) in the Malaysian construction industry can be considered to be an emerging practice, despite it having received fairly extensive attention from both academics and practitioners. BIM practice is often presented as an attractive business proposition to improve productivity, reduce costs, and increase competitiveness; however, despite the huge potential for many areas, commitment to BIM practice remains uncertain across practitioners in the Malaysian construction industry, with the current reported level of usage largely limited to drawings and 3D visualisation, with separate data modelling and information management. It can thus be said to be at an early stage of maturity: at Level 1 (Zakaria *et al.*, 2013) and entering a transition to Level 2 in the very near future. Many construction practitioners are believed to be eager to practice BIM and its applications; however, a lack of well-trained personnel, lack of guidance on the process and legal practice, and lack of support from individuals or government bodies (Rogers *et al.*, 2015) are inhibiting factors.

Existing research has broadly concentrated on the internal adoption, success factors, readiness, and measurement of benefits of BIM (Enegbuma and Ali, 2013; Farzad *et al.*,

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2014; Rogers *et al.*, 2015; Zakaria *et al.*, 2013); however, there is a lack of consideration of its strategic value in an inter-organisational environment. Diffusion of BIM practice in a project team environment remains the least explored area in the research. In addition, many of the perspectives or theoretical background on BIM implementation, processes, and practices previously adopted in the research have been based on the diffusion of innovation theories, acceptance models, and actor network theory. These provide general and background information, but will not provide much insight about the diffusion of the practice, commitment, interaction, and participation of project teams exercising BIM.

This study provides an extended explanation from the social viewpoint of innovation and practice, as based on the assumption that the social benefits, values, and interactions maximise the effective diffusion of BIM practice. This study suggests that the social benefits, values, and interactions of practising and implementing BIM could be thoroughly measured and derived from social capital and social networks that are created by the goodwill, mutual support, trust, shared language, and network exposure of many of the project team members.

The addition of a social network perspective is significant because it more explicitly recognises the influence that others exert on individuals' interactions toward innovation. An innovation can be described as an idea, practice, or object that is perceived as new by an individual or other unit of adoption (Rogers, 1962: 11). A viable framework would also translate more directly into strategic initiatives to provide practical help in addressing the social barriers and issues that challenge BIM practice in the construction industry. A change of perspective is also necessary to create a simplified structure for the plethora of factors associated with new or emerging practice/innovation in the construction industry, to improve the effectiveness of BIM practice.

Social network is a subject of interest in many disciplines. A significant review by Poleacovschi *et al.*, (2017) highlighted the broad variety of social network perspectives being applied to understand knowledge transfer in construction research, and suggested that for a better understanding there is a need to integrate the social network (e.g. strength of weak ties theory) and social capital (e.g. network resources). They found that strong connections between individuals, based on knowledge, saved most time at doing work; however, not all strong connections delivered the same relationship pattern/implication. There are some other social network factors that can be associated with time savings, such as the frequency of communication, types of connections, motivation of interactions, and job role/position (e.g. individuals who are responsible for directing critical tasks).

The overall aim of this research is to establish a viable conceptual framework that incorporates the social network and social capital of the key factors that influence effective diffusion of BIM practice in project teams. Limited by the progress of the research, this paper is not able to provide specific research findings, which are suggested as future tasks. The next sections of this paper provide the theoretical background, propose a conceptual framework, future work, and conclusions.

## **THEORETICAL BACKGROUND**

### **Social Capital**

The topic of social capital has interested academics and practitioners for decades and continues to be of relevance today, as evidenced by its application to various disciplines and numerous subject areas. It should be noted that this is not a new area of inquiry. It also has not adopted a clear and substantive definition (Dolfsma and Dannreuther, 2003), and a study will be developed based on the discipline and level of investigation (Robison

et. al, 2002). In social research, for example, the “capital” dimension of the social is conceptualised as “bonding” and “bridging” (Putnam, 1995), which are considered to be important aspects by which to measure the social capital. Putnam (1995: 67) defined social capital as “features of social organization such as networks, norms, and trust, that facilitate coordination and cooperation for mutual benefit”. Adler and Kwon (2002:13) defined social capital as goodwill that others have toward individuals or groups. Coleman (1990: 302) viewed social capital as function and structure, by which the structure contains different entities having two characteristics in common and they facilitate certain actions of individuals who are within the structure. Burt (2009) regarded social capital as a network of brokerage opportunities that can be obtained from relationships with friends, colleagues, and more general contacts. Similarly, Nahapiet and Ghoshal (1998) viewed social capital as networks and resources that can be delivered through relationships held by individuals or the social unit. Based on these definitions, it can be suggested that social capital is fundamentally about the value of interaction. Social capital lies in the structure, resources, and content of the social relations of individuals, and it affects the information, influence, and cohesion that makes individuals/actors available within the network. This study concentrates on these definitions and the four dimensions of social capital: structure of social interactions, intensity, content, and resources.

#### *Structure of social interactions*

Based on the concept by Coleman (1990), it can be stated that social capital is a form of social structure that has function, in which certain actions facilitated by individual members of the group/organization are defined by the social structure embedded within them. The social structure may exist in formal forms, such as organization, or in more loose social system, such as families and communities. Burt (2009) introduced the concept structural holes. The concept suggests that the diffusion of new ideas, information, and behaviour will be more efficient if an individual can maximize the number of redundant contacts, and concentrating on the primary contact, it saves time and effort in keeping a large network. It will also be effective if the primary contact is connected to a variety of secondary contacts (clusters of people) who have broad resources.

#### *Intensity*

The intensity of the social interactions of one organisation can be used as an indicator of the social capital (Nahapiet and Ghoshal, 1998). Social interaction involves the dissemination of information and resources between individuals or groups who modify their actions and reactions due to the actions by their interaction partner. These interactions involve engaging in intensive activity with people at various levels of an organisation or project environment. Through discourse in a social interaction, knowledge is diffused throughout the whole network. A number of current studies have demonstrated the importance of social interaction on knowledge creation, which provides additional insights into this subject.

For example, Koh *et al.*, (2015) highlighted the intensive social interactions as one of the crucial factors that promote team members’ engagement, learning, and independence at the team level, as well as the organisational level. Similarly, in a study by Molina-Morales and Teresa (2010), the authors investigated the effect of social variables on the firm’s innovation. Their findings suggested a need to incorporate the social interaction on the use of innovation towards knowledge creation. Against this backdrop, the research evidence suggested further evaluation of the influence of social interaction in various innovation environments, especially with BIM technology, for successful knowledge transfer is needed.

### *Quality of content*

The content of the interaction is concerned with effective connections and is a key aspect to the relationships. Effective connections or relationships should be grounded broadly on psychological integration or, in very specific terms, it should be based on the quality of the content, such as trust, intimacy, obligations, and expectations. A study by Bolina *et al.*, (2002) found that effective networks within organisations are dependent on the level of trust between the parties involved. In another study, Molina and Martínez (2010) found that trust is fundamentally a social process, and without trust there will be limited information and knowledge sharing. The creation of a feeling of trust in a team makes people internally submissive and pleasing while giving an impetus to the emergence of much more powerful groups. These findings provide a firm support for the importance of understanding the underlying psychological perceptions that influence one's environment about desired outcomes.

### *Shared resources*

Shared resources include the collective goals and aspirations of the members of the network, and they refer to any resources that could provide representations, interpretations, and systems of meaning among parties (Molina and Martínez, 2010). Knowledge, information, and ideas flow even more easily due to a shared language, codes, and narratives, which are the key factors in this aspect (Nahapiet and Ghoshal, 1998). They also may consist of elements of commitment and cooperation that encourage the sharing of information, mutual morale building, and coaching others to achieve demanding objectives. The shared resources of an organisation or team encourage interactive communication, which leads to a shifting of values by the parties involved toward common ground. For example, a study by Nahapiet and Ghoshal (1998) revealed that social capital is necessary for the development and dissemination of knowledge within organisations. Similarly, Huysman and De Wit (2004), who studied the practices of knowledge sharing in 10 large companies with more than 1000 employees, discovered that the notion of social capital should be seen as an important attribute for continuous transformation, shaping processes and a culture that together forms the intellectual capital of an organisation. The absence of a willingness by employees to share knowledge can cause significant damage to the relationship and consequently affect the efficiency and effectiveness of teams and organisations, particularly during the assimilation of any new knowledge.

### **Social Network Perspectives**

Social network has been developed out of social theory and application, with formal mathematical, statistical, and software applications (Marsden, 1990). In the literature, a social network is often said to be a 'perspective', rather than a theory. The social network perspective contains theories, models, and applications that address the processes of interaction between individuals (Borgatti and Halgin, 2011). Borgatti and Halgin (2011) stated that network theory refers to the mechanism processes that interact with network structure to yield certain outcomes for individuals or groups. One example of network theory is the strength of weak ties theory (SWTT) by Granovetter (1973). When one person in a project team posits an idea, support from the other members of that project team should be readily apparent. Propositions, such as this, can be tested by adopting SWTT. SWTT assumes that social relationships are characterised by infrequent contact, an absence of emotional closeness, and no history of reciprocal favours. This theory posits that people actually frequently depend on other people with whom they maintain only 'weak ties'.

The social network perspective views social relationships between individuals in terms of nodes and ties. Nodes are the individuals or actors that are connected by the ties between them. The ties, or relationships, such as friendship, kinship, and so on, exist between nodes. An additional property is that, taken together, the characteristics of these linkages may be used to interpret the social behaviour of the persons involved. Wasserman and Faust (1994) described a social network as a finite set or sets of actors and the relation(s) between them. The term 'network' might imply that only those linkages that actually occur should be considered as part of the network. Since a network is defined as consisting of a finite set of actors, the boundary of the network should be established. However, according to Marsden (2011), the boundary for the overall network is often difficult to specify. The aim should be to focus on the entire structure of the social group by collecting one or more types of relations that link the nodes or actors within the group. In contrast, egocentric (small world) and/or dyadic approaches are focussed on only those network relations that immediately surround the actors. In this case, the aim is to make inferences about the features of the personal and their personalised network. For example, in surveying one sample of respondents, each respondent identified a set of people to whom they have ties, and indicated the type of relationship, along with the level of satisfaction they have with that relationship.

One consistent finding from the literature review is that a network is more likely to be used to provide information pointing to individuals and others within an organisation because of the adoption of innovations (new technologies, process, and practice). For instance, Valente (1996) noted in a study of personal network thresholds, that the social system in the adoption of innovation includes opinion leaders, peers, and followers who are connected to (or may work with) innovation. Opinion leaders, peers, and followers do not necessarily direct the adoption, but their own adoption behaviour (if combined) can influence the behaviour of others. Further, individuals vary in their willingness to take risks in adopting a new idea or product. Certain individuals accept the risk of adopting a new technology, idea, or product before anyone else. Some people are reluctant to adopt a new idea or technology and prefer to wait until other people have tried it first.

In the context of this research, the Social Network Threshold (SNT) model proposed by Valente (1996) is promising. It introduces a 'frame of reference' with respect to the social system and network that can be used to identify those individuals that will most likely play an important role in promoting adoption. The threshold is the exposure at time of adoption. Exposure is a measure of the proportion of previous adopters in an individual's personal network. Exposure can be estimated by counting the number of adopters in each individual's network that provide information and influence with regard to adoption behaviour. This number can vary. For instance, the individual who is earliest to adopt (or an innovator themselves) will have a low threshold of adoption. The early adopter will accept a new idea almost without intervention, and interpersonal network influences are rarely needed for adoption. Conversely, a late majority individual has a much higher threshold. The later majority individual's peer network must exert a heavy influence to overcome their resistance. In either event, however, an individual is more likely to adopt an innovation if more of the others in his or her personal network have already adopted that innovation.

Not all members of a network are equal. There are typically particular individuals who are more interconnected than others. These individuals are linked to others by patterned communication flows. Valente (2005) suggested a mathematical model as follows:

$$E_i = \frac{\sum w_{ij}y_j}{\sum w_i}$$

where  $E_i$  represents network exposure,  $w$  represents the social network weight matrix, and  $y$  is the vector of adoption. Using this mathematical equation in an example, if an individual  $i$  reports that two out of their three network contacts have already adopted a particular technology before they themselves adopted it, then the network exposure  $E_i$  is estimated at 66 percent (see Figure 1). If only one contact out of three network contacts has already adopted, then the network exposure value is 33 percent.

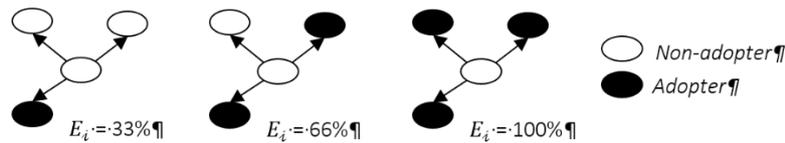


Figure 1: Example of different network exposures (adapted from Valente, 2005).

The SNT model also estimates the number of times that direct communication may have happened between the adopter and their network partners. Network partners are those who act in terms of friendship, direction, and advice, as well as discussion partners. These people may have a position as opinion leaders, peers, or affiliates. Opinion leaders have been theorised by Rogers (1962) as those individuals that have the greatest influence on the rate of adoption of an innovation. Peers are people who have the same position as the adopter, as based on the theory of structural equivalence. Affiliates, as derived from the SWTT by Granovetter (1973), are those who may know many facts about an innovation (e.g., technical staff, customer support service, and technology providers), but who are only loosely connected to the adopter in the network.

## PROPOSED CONCEPTUAL FRAMEWORK

The rationale behind the social capital and social network used in this study is two-fold. First, in the organisation, individuals interact with and influence each other to produce homogeneity of “bonding” and “bridging”. Bonding is channelled through bridging. The concepts of bonding and of social capital in this study refer to a capacity and quality for accessing resources in relationships (e.g. association, mutual benefits, and trust), while bridging refers to a social network or interaction between individuals across levels of structure, hierarchy, power, exposure, or proximity that promotes action. For example, a study by Orlikowski (2000) found that the use of technology in organisations is strongly shaped by users’ understandings of the conditions and functionalities of a technology, actions (e.g. to achieve collaboration or process-support), and consequences of actions. Based on this view, the understanding of how and why people engage with BIM technology and practice can be associated with human actions and choices, and the conditions of technology that have evolved from social interaction. Orlikowski (2000) believed that social interactions can be viewed as support mechanisms when using technology. If supports are embedded and valued within social groups, technology use is alleviated. Consequently, people may choose to enact and adjust their behaviour towards the technology, based on a desire to share files with co-workers, or due to having become more knowledgeable about using that technology through attending training and/or watching co-workers’ demonstrations.

Second, people do not belong to just one relationship or network in an organisation. They can be members of a number of different social networks, with each based on different types of interaction or relationship. For example, Pryke (2005) explored construction

project governance and identified the patterns of interactions between key actors, including clients, consultants, main contractors, and sub-contractors. Three main types of network were identified: contract, performance incentive, and information exchange networks. Pryke (2005) showed that the consultants were involved in all three kinds of networks, often concurrently. However, the degree of involvement varied. The consultants' roles were relatively weak in the contractual network and performance incentives network, but they played a very important role in the information exchange network. A recent study by Poleacovschi *et al.*, (2017) tested the significance of social networks that facilitate the sharing of knowledge as related to time savings on work tasks, and based on these, it was confirmed that the knowledge network and strong knowledge connections are crucial to individual work productivity.

Arguments for using social capital and social network in observing the impact of a social system on the diffusion of BIM practice are clear: the structure, intensity, quality of content, and shared resources, as well as exposure of others, are important to how each individual responds to an innovation or adoption of new practice. To get a complete description of exposure, the research must look at employee-to-employee relationships, such as relations with and the support of, managers, acquaintances with other employees, and other relational variables. Co-workers may form a network based on the exchange of information relating to getting their job done. At the same time, they may also form a different network based on friendship. A network perspective is critical to better understand the decision to adopt, and to shed some light on the role and variety of networks that affect the extent of diffusion.

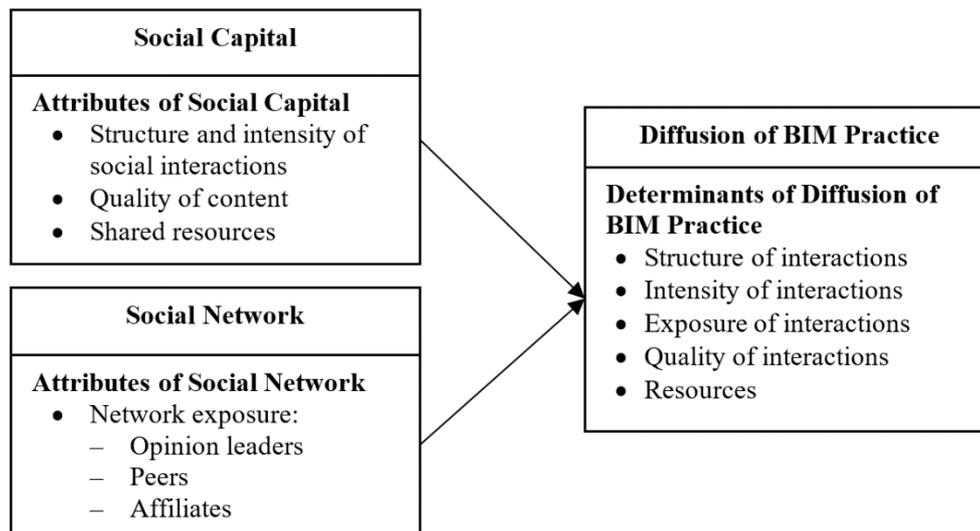


Figure 2: Proposed conceptual framework

Combining social capital and social network perspectives, as shown in Figure 2, a conceptual framework is proposed. The conceptual framework suggests five key determinants for the diffusion of BIM practice: (1) structure of interactions, (2) intensity of interactions, (3) exposure of interactions, (4) quality of interactions, and (5) resources. The structure of interactions refers to the relations between individuals across levels of the organisation, hierarchy, or project environment. The intensity of interactions refers to the weight or frequency of the communication that occurs between individuals and indicates network influence. The exposure of the interaction refers to the number of people in each individual's network that facilitate mutual actions. The quality of interactions is about the effective connections that are based on trustworthiness, norms,

intimacy, obligations, and expectations. Resources or shared resources include knowledge, information, and morale building embedded within the individual's network to achieve common ground. All these broader conceptualisations of the attributes explain in detail the characteristics of the networks and progression that should be considered in evaluating the successful diffusion of BIM practice.

Social capital is distinct from, but seems convergent with, social network perspective. Both are mature and established theories that contribute to the understanding of the importance of several important sociological concepts, such as social structure, intensity, integration, exposure, and shared resources. However, it is necessary to note a few of the weaknesses of the social capital and social network. For example, the parameters or estimations of a social network's exposure are typically based on two variables: exposure level and time of adoption; however, the time of adoption between them is typically not taken into account (Valente, 1996). Thus, the assumption that personal thresholds determine the speed of adoption has not yet been subjected to a robust test. Despite these weaknesses, the concepts and elements introduced through both the social capital and social network literature can usefully contribute to the broader consideration of the diffusion of BIM practice, particularly in terms of the variety of networks, network partners, and the roles of partners within networks at play and relative to diffusion. It also provides a basis upon which to measure the strength and intensity of a network, using the number of times that direct communication occurs between the individuals and their network partners to indicate network influence.

## **FUTURE WORK**

A number of social attributes, based on social network and social capital, have been mentioned in this paper. However, while clearly interrelated, social network, and social capital are rarely studied or applied in concert, integrating these together is a means to enhance the social perspective and social intelligence of BIM. The social intelligence of BIM practice may improve the bureaucratic efficiency and stability of the practice. The social system, structure, resources, and associate networks can all affect the social intelligence, the decision of individuals and the acceptance of a new practice. A new practice may be entirely pleasing when it is adopted by an organization, but concerns about the flexibility, trust, obligations, and expectations may discourage its adoption in a project team. The more a person engages with others, the less potential there is for such disparities to arise. Seeking and receiving help with a new practice from others (e.g. supervisors, peers, and technical staff) can increase exposure to and promote the adoption of a BIM practice. Thus, this study addressed the following overarching questions that merit future research: (1) How can social intelligence of BIM practice be defined? (2) What are the social attributes that influence the diffusion of BIM practice? (3) What are the most promising networks of diffusion for BIM practice? To answer these research questions, a case study design and mixed methods research will be used. Data will be collected using two approaches: interviews and survey. The interviews are necessary at the early stage of this study, as they could help to establish the framework and initial network model, and also deepen the understanding of the proposed determinants. The survey is to test the initial model with a series of explicit research hypotheses. Data collected from the survey will be analysed using a structural equation modelling (SEM) technique.

## **CONCLUSION**

Having considered the motivation for the research and theoretical foundation, it can now be stated that social theory/dimension provides key determinants of the diffusion of BIM

practice. Previous studies on BIM have focussed on a range of implementation factors of BIM application, thereby promoting bias and a limitation of our understanding of the specific social aspect. In this study, an extension to the social network and social capital concepts is proposed as a means to break this impasse. There is an important correlation in how the two theoretical perspectives might be considered in concert and extended with the BIM literature.

In summary, the core ideas in the literature and conceptual framework that have been reviewed/proposed here can be stated as follows: diffusion of BIM practice is directly influenced by social interactions and that social interactions are directly influenced by network structure, intensity, network exposure, quality of interactions, and shared resources. The social interactions fit together with the diffusion of BIM practice to sustain the diffusion process for the BIM practice.

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# **CLIENTS AND INNOVATION**

# PUBLIC COMMISSIONING IN A NEW ERA: PUBLIC VALUE INTERESTS OF CONSTRUCTION CLIENTS

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In the construction industry public and semi-public clients increasingly depend on private parties to achieve project outcomes by subcontracting part of their activities using integrated contracts. Due to their social-political responsibilities, public bodies retain having a special role in ensuring public values. Classifying which public values to pursue, at what moment, in which situation or by what type of service delivery is a core task of construction clients and gets reflected in governance and project mechanisms. In this paper we aim to systematically explore public value interests of public construction clients in their relation to the contractor. This paper presents preliminary results of a set of semi-structured interviews with different actors playing a part in commissioning of organisations with different degrees of publicness. Results show that procedural values related to the public character still get much attention. However, today's more collaborative process of delivering public services seems to have led to a shift in focus towards the product related values of innovation, sustainability and quality. Future research will examine governance mechanisms and frameworks to deal with identified experienced sector-specific conflicts.

Keywords: public value, public construction client, public service delivery

## INTRODUCTION

The construction industry is an important actor in delivering public services which provide shelter, mobility and leisure for the people. Over the last years the public sector has been subject to some major movements of which the displacement between public and private can be considered as most crucial in the construction industry (Clifton and Duffield 2006, van der Steen *et al.*, 2013). Major cutbacks and a changing role of public administration resulted in governmental bodies increasingly withdrawing from direct delivery of public services and programmes. This gets expressed in two ways (Cornforth 2002): First, the development of an increasing number of devolved or quasi-autonomous government agencies to deliver public services. And second, the introduction of market mechanisms into the provision of public services through splitting the 'purchasers' of services from the 'providers' and introducing elements of competition through contracting out of services to (a mix) of private companies, voluntary organisations and quangos. Public organisations increasingly depend on private parties to achieve their goals entering in public-private collaborations, where distribution and supply of services becomes the responsibility of both public and private parties (Entwistle and Martin 2005, Bao *et al.*, 2013). The operational responsibility for creating public values is transferred

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to the private market party and the public party is left with governing- and management tasks, and remains social-politically responsible (Eversdijk, 2013, van der Steen *et al.*, 2013). With the increase in private organisations carrying out 'public' purposes, various constellations of public and private parties as project-based public service delivery organisations are shaped in construction. Specifically there is an increase in integrated contract forms (Clifton and Duffield 2006). The role of public clients in the process of public service delivery becomes more directive and facilitating, and these new structures affect the traditional notion of accountability, bringing along a strong emphasis on performance and outcome (Boyd and Chinyio 2006). Quality assurance by public clients more and more aims at organizing the process (Brown *et al.*, 2006), making it plausible that there is compliance with the process requirements and product requirements, or in other words the procedural values and the performance values (Bruijn and Dicke 2006).

Furthermore, the construction sector is the epitome of a project-based industry, a variety of organisational forms that involve the creation of temporary systems for the performance of project tasks (Holti 2011). These can either be entire firms, multi-firm consortiums or networks (Sydow *et al.*, 2004). The heterogeneous nature of these networks, alliances or partnerships is flexible by nature, constituted by different dimensions in hierarchy, formality (regulations) and collaboration. The collaborative project-based public service delivery creates a high level of complexity for public actors and changes relationships and task- and responsibility division (Bao *et al.*, 2013, de Graaf and Paanakker 2015). Clients are both involved in the goals of the 'permanent' commissioning organisation and the goals of 'temporary' project-related network of public and private parties. The position of an organisation on the public-private continuum, the 'publicness', is (partly) determined by the extent to which organisations are constrained by political control, how organisations are funded and financed, and the extent to which organisations perform public and private tasks (Besharov and Smith 2014). The 'degree of publicness' merely determines the expected contribution to the political or public mandate.

For public construction clients a distinction can be made between 1) government and governed by the public law, organisations that are required to apply public procurement law, and 2) semi-public and private organisation which only have to obey to common law. Classifying which public values to pursue at what moment, in which situation or by what type of service delivery is a core professional task of the construction client and gets reflected in governance, management and project mechanisms. Public value management (Moore 1995, Benington 2007) therefore becomes more important in the commissioning role of public client organisations.

In this paper the following questions are addressed: 'Which public values are of interest for public construction clients in their collaboration with contractors?' and 'Which contextual elements influence the public values that play a role in the current collaborative practices between client and contractor in construction?' The paper starts with a theoretical elaboration of public values in the public construction domain. Then the research approach of the interview series is explained. The findings show preliminary insights of a set of interviews on the interests of public clients and the factors of influence on the current collaborative practices between client and contractor, followed by a conclusion.

## **PUBLIC VALUES IN THE CONSTRUCTION SECTOR**

Due to their socio-political responsibility, organisations with a public character, have a special role in ensuring all public values (Beck Jørgensen 1999). They are expected to

contribute to all kinds of fields, for example social innovation, safety, protection of weaker population and the built environment and to create public value in many different forms. In the construction industry public values manifest for example in the European Procurement Principles. In addition to these procedural type of values, product values - such as sustainability, cultural heritage, quality of the public space, and performance values - effectivity and efficiency - are also essential in the context of performing and completing construction related tasks (Boyne 2003, de Graaf and Paanakker 2015). The government cannot determine on its own what public values are and are not. Public values are, in fact, a reflection of what the society expects of facilities and government (Bruijn and Dicke 2006). They are non-committal for governments, they provide direction (van de Ven *et al.*, 2007).

Public values are values that society believes are important in the in the production of certain products or services and of which they feel it is the duty of the government to ensure the interests (Bruijn and Dicke 2006). For a value to be called public there needs to be a collectivity, a collective benefit - it is about meeting shared expectations - while a private value reflects an individual interest (Van der Wal *et al.*, 2008). However, in practice the line between public and private is drawn differently from country to county, differentiates in different time periods and from sector to sector (Van der Wal *et al.*, 2008). Important to recognize is that private parties may also strive for public values and organisations with a public character may also include private values. Despite, public values do have some specific characteristics. There is value pluralism, meaning that not all values can be achieved at the same time. Public values can also be incompatible; the pursuit of certain values must inevitably comprise or limit our ability to pursue certain other values. And finally, public values can be incommensurable; there is no single currency or scale on which conflicting values can be measured. Where a 'conflict' occurs no rational assessment can be made (de Graaf and Paanakker 2015).

Moore and Bennington are considered the two main contributors to the public value definition in public value management. Moore (1995) speaks of the singular public value. He considers public value as the equivalent of shareholder value in public administration. Public values are designed to provide managers with a notion of how entrepreneurship can contribute to the general welfare. Bennington (2011) refers to the plural public values. He interprets public values as the combination of safeguarding and enriching the public sphere with the delivery of public values. He holds a rather normative description about the rights, benefits, and prerogatives to which citizens should (and should not) be entitled.

Focussing on the obligations of citizens to society, the state and one another, and the principles on which governments and policies should be based. These different descriptions indicate a distinction between value and values. Values is defined by Mills (2013) as 'abstract, humanly held notions and beliefs that provide a broad and relatively universal framing structure to understand particular choices in a wider context of concerns'. Value is defined as 'an attitude or judgement made by a person of some object at issue (whether this is a product, service, process or other person) against some resource' (Mills 2013), e.g. the assessment of an object (Volker 2010). This distinction between value and values is relevant in studying the concept of public value(s) in the public construction domain since public return gets realized through public service delivery. Public parties increasingly adopt private sector ideas. Collaborating with private parties different logics need to be combined, market and society, private and public aims combined (Smets *et al.*, 2015). Good governance is about the management of competing values (de Graaf and Paanakker 2015). Procedural values should be met,

which relate to the way the public sector should act - values relating to the quality of the process, such as integrity, transparency, equality - and which standards of government action should be met. In public value literature Moore (1995) describes the public value chain in which he distinguishes Input Output Outcome and where inputs are transformed into valued social outcomes, in other words achieving public values (Benington 2007). Outcomes are somehow invisible values, think about the perceived quality of the living environment. De Bruijn and Dicke (2006) separate the process from the content. Making a distinction between procedural values - good governance - and substantive public values - the services and goods the state is responsible for, either directly by offering products, or indirect by services and finance. Next to the procedural values and the (substantive) value of 'objects' de Graaf and Paanakker (2015) add performance values of effectiveness and efficiency (e.g. good infrastructure, services, no waste of tax payers' money). A professional construction client needs to find a balance between the procedural, performance and product values and be able to account for the value trade-offs made in establishing this balance.

Several authors published extensive literature studies to come up with lists of public values (de Graaf *et al.*, 2013). Jørgensen and Bozeman (2007), for example, identify eight central public values including sustainability, integrity and robustness. Van der Wal *et al.*, (2008) describe 13 values which, for example, include transparency, expertise, accountability, efficiency and courage. Next to that there are some well-known assessment concepts which specifically address values in the construction sector (Volker 2010). First, GOTIK, a method for controlling aspects related to project management; money, organisation, time, information and quality. And second, the Design Quality Indicator (DQI), a toolkit to measure, evaluate and improve the design quality of buildings, developed by the Construction Industry Council of the UK.

For DQI Vitruvius's *utilitas*, *firmitas*, and *vernustas* are translated into functionality (use, accessibility and space), built quality (performance, technical systems and construction), and impact (form and material, internal design, integration and character and innovation). Furthermore, there are several periodic policy documents concerning the built environment. In this context the Dutch Action Agenda (Bussemaker 2016) appoints for example a number of values woven into its narrative: collaboration, creativity, knowledge, dedication, expertise, wishes, interests, commonality, integrality, customization (involve conditions and stakeholder in task) and motivation in solidarity. In this study these lists have been combined into a compound list of common values in the public construction sector, and separated in the categories of procedural, performance and product values. This list provides the theoretical basis for the method developed for the interview series and is used in the analysis of the interviews.

## RESEARCH APPROACH

The study consists of a set of qualitative semi-structured interviews. Since in the project-based construction industry different (types of) public values needs to be ensured in an organisations differentiating in publicness, we included a wide range of public client organisations in this study (Chi 2016). 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 Government Building Agency, the National Highway Agency, water boards, housing associations and municipalities. Different people representing different decision-making levels, were selected. For each organisation three to four public actors were involved: the general manager (GM), the director of procurement (CPO), the director of real estate and or infrastructure

developments (DD), and or the asset management or maintenance director (AM). This resulted in an interview sample of 23 interviews with a duration of 45 to 60 minutes conducted from February to May 2017. Value cards based on the compound list of possible public values were used to discuss the meaning and relevance of specific public values in different parts of the commissioning role. To ensure reliability of the data all interviews were audiotaped, fully transcribed, checked by the respondent sending them a summary of the conversation, and thematic theoretical coding is applied in Atlas.ti (Bryman 2012). In order to make a comparison between different client organisations, with a different ‘publicness’, as well as between different positions within these client organisations, different analytical tools and documents groups provided by Atlas.ti were used. Code-documents tables were used to look for the values playing a role in the relationship between client and contractor. Next to that the co-occurrence explorer was used to find the factors that influence the decision on values that are strived for.

## **FINDINGS**

### **Public Value Interests of Public Construction Clients**

Answering to the question on which public values are of interest for public construction client in their collaboration with contractors, it can be concluded that much attention is given to procedural values related to lawfulness and the responsibilities of public clients and rather less to performance values of effectiveness and efficiency (see also Table 1). However, it was also found that in the current collaborative practices the procedural values of integrity, lawfulness, reliability and equality are more and more considered as contextual, whereas steering becomes directed at other values, such as innovation, sustainability and quality.

If you're talking about how we do things, I think that it could be a bit more innovative [...] Transparency, and I should say integrity, even though I think this is less important, remains an important theme within the Province (GM, government).

Internally, in public organisations, achieving a particular goal is considered of more importance. This sometimes means that efficiency is overshadowed, also because a lack of pragmatism. In addition, there is more attention to the collaborative nature of the relationship and the resulting implications for both the approach towards the market and the interaction with contractors. Approaching contractors becomes oriented at future tasks and what the market can offer.

We will have to talk to each other about the possibilities. This begins very early with 'This is the task we have, is that realistic? This is the planning to the task, is that possible? These are the risks we identify, what is your perception on this?' In that way, looking at what we should do together (CPO, government).

The changed role division between clients and contractors also determines the way of collaborating with (future) contractors since a certain level of dependency asks for a more open and transparent relationship.

For me, this comes with a bit of transparency, but also: we cannot do it alone, we all play our part in this theatre. So I advocate an open, transparent cooperation instead of a contractual relationship (AM, governed by law).

When shaping the collaboration like this, honesty is one of the ‘old fashioned’ procedural values that provides a boundary. Position the task that we are focusing on centrally, create good conditions that are fair" (CPO, governed by law). Making the desired shift in focus towards different types of values proves to be a complicated process. It was found that the construction sector and today’s contractual governance mechanisms lack flexibility to actually act upon the anticipated changes.

Table 1: Public values of importance in the relation of the public client and contractor, related to job position (GM, CPO, DD, AM) and 'publicness'. I = of interest, S = desirable to safeguard, Bold = specific attention shown to the value

|                           | GM         | DD         | AM         | CPO        | Government   | Governed by law | Semi-public |
|---------------------------|------------|------------|------------|------------|--------------|-----------------|-------------|
| <i>Procedural values</i>  |            |            |            |            |              |                 |             |
| Reliability               | <b>I</b>   | I          | I          | I          | I-S          | <b>I-S</b>      | I-S         |
| Honesty                   | I-S        | S          | I-S        | I-S        | I-S          | I-S             | I-S         |
| Equality                  | S          | S          | I-S        | S          | I-S          | I-S             | I-S         |
| Integrity                 | I-S        | S          | I-S        | I-S        | <b>I-S +</b> | I-S             | I-S         |
| Non-dis                   |            |            |            | I          | I            |                 |             |
| Lawfulness                | <b>I-S</b> | I-S        | I-S        | <b>I-S</b> | <b>I-S +</b> | I-S             | I-S         |
| Collaboration             | <b>I-S</b> | <b>I-S</b> | <b>I-S</b> | <b>I-S</b> | <b>I-S +</b> | <b>I-S +</b>    |             |
| Transparency              | <b>I-S</b> | S          | <b>I-S</b> | <b>I-S</b> | <b>I-S +</b> | <b>I-S +</b>    | I-S         |
| Safety                    | I-S        | I-S        | I-S        | <b>I-S</b> | I            | I               | I           |
| Accountability            | I          | S          | I          | S          | I-S          | I-S             | I-S         |
| Wisdom                    | I          | S          |            | S          | S            | S               | S           |
| <i>Performance values</i> |            |            |            |            |              |                 |             |
| Effectiveness             | I          | I          | I          | I          | I            | I               | I           |
| Efficiency                | I          | I          | I          | I          | I            | I               | I           |
| <i>Product values</i>     |            |            |            |            |              |                 |             |
| Context                   |            | I-S        | I-S        | I-S        | <b>I-S</b>   |                 |             |
| Sustainability            | I-S        | I-S        | I-S        | S          | <b>I-S</b>   | I-S             | I-S         |
| Functionality             | S          | S          | S          | S          | S            | S               |             |
| Innovation                | <b>I-S</b> | I-S        | <b>I-S</b> | I-S        | I-S +        | <b>I-S</b>      | I-S         |
| Integrity                 |            | I-S        | I-S        | I-S        | I-S          | I-S             |             |
| Character                 |            |            |            |            |              | I               |             |
| Quality                   | <b>I-S</b> | I-S        | I-S        | I-S        | <b>I-S</b>   | I-S             | I-S         |

Discussing the actual safeguarding or the desire to safeguard certain values, all values that proved to be of interest are at least mentioned once, see table 1. Only the performance values of effectiveness and efficiency were not mentioned. This can be explained by the use and translation of other values in contracts, for example the quality criteria, the indirect safeguarding of these values:

The effectiveness can be assured by what is in the contract, with the finances in the contract, with the quality criteria stated in the contract, justifying the delivered result. This is not hard to safeguard. (GM, government).

Discussing specifically safeguarding, we experienced some discussion on the possibilities in safeguarding certain values.

The values that are most safeguarded are, for example, functionality, legitimacy or quality. Transparency is much more difficult, because what do you show and what do you not show? (CPO, governed by law) and I think wisdom is the most beautiful value here', but I wonder [...] could you safeguard that? (GM, governed by law).

There are also some values of which safeguarding becomes more important with the increase in public-private collaboration and the role changes that are needed in dealing with the increased complexity of construction projects, such as sustainability and responsibility.

Sustainability is something that needs to be better safeguarded. And taking responsibility. For example, consultants often overlook the development of a particular design or concept, but do not take responsibility for the functioning of the concept once it is finished (AM, governed by law).

In addition, some interviewees question if it is worth to safeguard certain values, in relation to the constraints it will bring along:

I'm not so much in favour of safeguarding, because this limits flexibility (AM, governed by law).

Comparing the organisations with different degrees of publicness and the different job positions (see right columns in Table 1), there are some things that stand out. There is both the interest in and desire to safeguard the values of reliability, honesty and equality with the parties governed by law, and an even more strong emphasis on integrity, lawfulness and transparency with the government. Although there is also special attention to 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, governed by law).

Looking into the organisations with different 'degrees of publicness', 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, governed by law) 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, government).

As we look into the different job positions, there are differences in 'giving meaning'. The general managers speak about what they want to convey to the market and having a certain kind of corporate responsibility. They mention matters of action, code of conducts, acting with conscience and the identification of people with the organisational values. The discussion mainly revolves around intangible translations of values, such as a particular behaviour:

It's quite complicated to be exact, but we do want people to go out in the field with this notion of corporate responsibility. Handle things in a responsible way. This must reflect in actions of each person (GM, semi-public).

The development directors specify the values that they want to pursue in the relationship with contractors more specifically. They talked about providing preconditions, establishing frameworks and practical agreements, but also about translating values into toolkits and procedures:

Over the past year and a half, I have spent a lot of time and effort in ensuring that people know how to handle those procedures, so I steered on legitimacy a lot (GM, semi-public).

The CPO's particularly profiled their understanding of the values merely towards transparency, integrity and non-discrimination, reflecting on what these values mean in European Procurement Law.

### **Contextual Elements Influencing Value Interests of Public Construction Clients**

Answering to the question which contextual elements influence the public values that play a role in the current collaborative practices between client and contractor, analysis showed the importance of four different factors related to (1) changes within the construction industry, (2) politics and responsibility, (3) organisational issues and, (4) the changed nature of the relationship between the client and contractor.

Within the Dutch construction industry tasks nowadays are put differently in the market. You can cluster tasks (e.g. design, construct and maintain), moving away from the standardised separate agreements towards performance based contracts. The responsibilities are then divided in a different way; parties need to learn how to leave

more to the market parties. This 'new' contract forms leave more room for contractors to think along and apply their expertise.

We now say to the contractor 'These are the functional requirements. You just have to maintain it or improve where we indicate it needs to be improved. How you will make that happen does not really matter because we mainly state functional requirements regarding the use of a road (AM, government).

The need to work with these types of contracts relates to the complexity of the current tasks. Growth of the population and growth of cities suggest the need to give more attention to a value such as sustainability. In order to achieve this, public and private parties are depending on each other; innovation in both products and process is needed.

The public character of the client organisation and the public sector reform, also bring along some aspects that influence perspectives on values. One of the main influences is the four year election periods in the Netherlands and the challenges public actors are confronted with in their period of reign.

You never know, things are happening, for example sustainability is one of the things we will need to address in the upcoming ten years. By then we already have had another 2½ Cabinets (CPO, government).

Public parties are put under a microscope, much is expected of them. Despite recent fraud incidents, public construction clients still feel responsible to walk ahead, to play an important role in the construction sector reform and the changes needed to deal with the increasingly complex tasks. This sometimes means that they have to make themselves vulnerable while they are held accountable and closely monitored:

We want to use the wider knowledge more, and this also means that we sometimes have to be more vulnerable and open up to what the market is offering and not always immediately assume that they mainly want to make money out of it (AM, government).

The changes in the construction industry and the role change of public actors also reflects on the public client organisations itself. Transitions in the organisation are both at the level of the structure and processes, and the desired attitude and behaviour of employees.

*That sounds very easy, but a contract is not something you just perform. It is also really another way of thinking. This imposes other requirements on the organisation and the people who work there (DD, government).*

Missions and visions are used to embed the new way of approaching the market within the organisation and its employees:

We have mentioned a couple of values, for example being in charge, but also showing guts to develop things, integration is related to that, and having fun in your job. These are a couple of values of which we say drive the organisation forward (AM, governed by law).

The new required collaborative structures also changes the nature of the relationship between the client and contractor. There is a need for more trust, which is something hard to capture in a contract. It becomes more important to focus on a level playing field, an open, honest and transparent relationship with the market. Changes in playing a certain part in this collaboration are ahead, both for the client:

We are getting a new environmental law, and that also means another role for the government. We also need to anticipate on that (CPO, government), as well as the contractor: It could also strengthen each other. If we now see that market parties become more willing to take final responsibility, we are more likely to enter in longer term contacts (AM, governed by law).

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. Therefore they reach 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 in order 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).

## CONCLUSION

This study contributes to public value theory and the sector specific value debate by providing insight in the value interests of public construction clients in collaborating with contractors. The ongoing shift of focus from procedural values related to lawfulness and responsibilities of public construction clients, towards product values of innovation, sustainability and quality of services, asks for a more open, transparent, sustainable client-contractor relationship. Insights in the contextual factors of the Dutch public construction industry explains how changes within the construction industry itself, politics and responsibility, organisational issues and the changed nature of the relationship between the client and contractor, influence the public values that play a role in the current collaborative practices between client and contractor.

To solve the increasingly complex construction tasks, there is a growing need to collaborate with the market in achieving public values such as innovation and sustainability. Aiming to achieve good governance, the management of - often competing - values becomes part of the core task of public actors. Our results indicate that professionals in client organisations are aware of this shift in values. Hence, they do not explicitly state how they safeguard them. Further research will look into value trade-offs that need to be made and conflicts that are experienced by actors in safeguarding these values. Future research will also look at governance mechanisms and frameworks to deal with the identified conflicts in public client organisations.

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# EXPLORING ALIGNMENT OF PERSONAL VALUES IN A COMPLEX, MULTI-ORGANISATION CONSTRUCTION PROJECT ENVIRONMENT

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The inherent complexity in construction projects is often attributed to their nature as a Temporary Multi Organisation (TMO), and as part of this, the heterogeneity of stakeholders in a TMO team is bound to influence project outcomes, including the increasingly important dimension of sustainability performance. According to values theory (pioneered by Schwartz and others), personal values are a determinant and predictor of attitudes and behaviours. Scholars who have applied this have begun to characterise the link between personal values and pro-environmental behaviours, but the mechanism through which personal values guide behaviour at the organisational/TMO level is not well understood. Here, a case study TMO (a major rail infrastructure project in the UK with a higher than expected sustainability performance) was used as an empirical setting, to explore this problem. The Schwartz Values Survey was used to derive insights on the role of individuals' values, group values, and their relationship to project performance in a TMO setting (n=176). A number of initial findings were derived, including an important point of tension around Schwartz's Self-Direction values category, which warrants further investigation in the context of pro-environmental behaviours on site.

Keywords: sustainability, Temporary Multi Organisation (TMO), personal values

## INTRODUCTION

Values have been related to key organisational phenomena such as sustainability, organisational commitment and values congruency, impacting personal and organisational performances (e.g. Posner 2010; Glazer, *et al.*, 2004). They are a bonding mechanism between individuals, helping organisations achieve their aim and objectives. Values can be defined as “conceptions of the desirable that guide the way social actors select actions, evaluate people and events, and explain their actions and evaluations” (Schwartz 1999: 24). Understanding the values of individual actors within an organisation may therefore help predict and determine their likely attitudes and behaviours, to overcome key organisational challenges. Empirical studies have demonstrated the impact of values alignment at personal and organisational levels and

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their relationship with positive work attitudes and organisational outcomes. However, little research has been undertaken to understand how construction projects deliver sustainability.

This research, therefore, develops new insights on the alignment of personal values in a major infrastructure project by drawing on Schwartz's (1992) Values Survey (SVS) and his theory of human values. Responses from 176 members of the project team are analysed using descriptive statistics and factor analysis. The findings provide evidence of a duality within the Schwartz values model that affects the way in which pro-environmental behaviours may ultimately play out in the construction project context. This study provides insights on the underlying role of values and their relationship with sustainability performance in TMO project environments, and forms the first phase of a major collaborative research project.

## **VALUES THEORY IN THE ORGANISATIONAL CONTEXT**

### **The Construction Project Environment and Sustainability Performance**

Construction projects are arguably amongst the most complex and challenging of all endeavours. The one-off, temporary, and short-term nature of such projects is a typical representation of the construction industry. One feature, which is a particular cause of inherent complexity, is the Temporary Multi Organisation (TMO) (Pathirage, *et al.*, 2007; Fellows and Liu 2008). The team of heterogeneous organisations and stakeholders in TMOs represent a diverse set of concerns and interests. Coupled with dynamic organisational structures, and complicated processes, these projects face a range of challenges and complexities which may hinder project performance, particularly around sustainability (Fellows and Liu 2008). Indeed, despite increasing practitioner and scholarly focus, operationalising sustainability remains a challenge (Myers 2005), and the reasons which underpin why one project outperforms another are not well-articulated. This is of concern, particularly in the context of TMOs, due to the large number of individual actors and organisations involved in executing often large infrastructure projects (such as road and rail). Some scholars take the position that sustainability resembles a set of values (e.g. Pfeffer 2010), and as Ratner (2004) emphasised, it is a 'dialogue of values', embedded in governance and communication processes between stakeholders. However, despite support for such arguments in empirical studies, the role of an individual as a change agent for enacting sustainability has not been well-defined and explored (e.g. Visser and Crane 2010; Ng and Burke 2010). Yet these arguments may explain why some projects perform better than others, arguably because sustainability is underpinned and driven by values (e.g. Florea, *et al.*, 2013; Ratner 2004), but the case has not yet been made convincingly within construction research. The following sections attempt to unpack values theory, as it applies to both individuals and organisations, in light of this industrial context.

### **Values - Personal and Organisational Perspectives**

Values are considered as fundamental determinants of perceptions, attitudes and behaviours (e.g. Rokeach 1973; Schwartz 1992). They are shared socially and operate at different levels (e.g. personal and organisational) (Mills, *et al.*, 2009; Posner 2010). Personal values are relatively stable standards that influence and guide the formation of behaviour (e.g. Fritzsche and Oz 2007; Rokeach 1973; Zhang, *et al.*, 2008). Attitudes and behaviours are, thus, the manifestation of the values that individuals uphold, which influence key personal and organisational endeavours, such as decision-making (e.g.

Liedtka 1989). Values are a key element of organisational culture, and leadership, impacting both individual and organisational performance (Posner 2010).

The success and sustained performance of organisations is therefore arguably linked to the shared values of their employees (e.g. Zhang, *et al.*, 2008). Values, for example, have been linked to organisational phenomena, such as job satisfaction, change, performance and commitment (e.g. Glazer, *et al.*, 2004). Meglino and Ravlin (1998) argued that values can also have implications on interpersonal interactions. That is, individuals with similar value systems are likely to perceive/react to external stimuli similarly, which may in turn improve interpersonal communications and decision-making processes. Furthermore, individuals with shared values are likely to behave similarly, enabling them to predict better one another's behaviour (Meglino and Ravlin 1998). Achieving alignment or congruity between individuals may be a contributor to project success, particularly when addressing sustainability (Karp, 1996). Furthermore, Mills *et al.*, (2009) showed that a universal values structure could be used to measure organizational similarities; importantly, their research was undertaken in a construction context.

### **Values - Theory and Application**

Much research on values adopts a descriptive approach to explain and explore the importance individuals' associate with values (e.g. Rokeach 1973), with less focus on the underlying structure of value systems. For example, Rohan (2000: 260) argued that "... Rokeach's Value Survey is essentially a list of unconnected value words" and: "without a theory about underlying value system structure, it is impossible to understand the consequences of high priorities on one value type for priorities on other value types". However, a notable attempt which has been one of the focal points of contemporary research around values is Schwartz's (1992) 'theory of basic human values' and his values survey instrument. Schwartz proposed that the value system can be structured around two motivational dimensions, that are "cast in terms of conflicts", and: "can be understood in terms of two fundamental human problems that need to be solved" (Rohan 2000: 260). These dimensions are: 'Openness to Change' (OC) vs. 'Conservation' (CN), and 'Self-Enhancement' (SE) vs. 'Self-Transcendence' (ST). Furthermore, the model can be divided into 'personal focus' vs. 'social focus' (Sortheix and Schwartz 2017), where social-focused values regulate how one relates socially to others and maintains cooperative relations. Schwartz (1992) outlined ten broad values types in accordance to the motivation that underlines each one, arranged in a two-dimensional circumplex structure (see Figure 1).

The Schwartz Values Survey (SVS) instrument is composed of 56 values items which are representative of the ten values types. Schwartz's (1992) theory was validated through extensive application, making it one of the most robust and structured approaches to collect, measure and analyse individuals' values. Mills *et al.*, (2009: 7) considered it: "the most advanced values theory to date" with the most comprehensive list of values. De Clercq, *et al.*, (2008) found Schwartz's model as an appropriate and comprehensive framework to study person-organisation fit. Numerous empirical studies have confirmed that SVS can be used to predict behaviours and attitudes. For example, in predicting pro-environmental (sustainability in broader sense) behaviours, ST values were consistently associated with sustainability, whilst SE values opposed pro-environmental behaviour (e.g. Karp 1996; Thøgersen and Ölander 2002). Findings from a number of notable studies (e.g. Stern, *et al.* 1993, 1995) suggest that only values belonging to these segments were related to pro-environmental behaviour, whereas Thøgersen and Ölander

(2002: 626) found that “only one motivational value type (universalism) has a significant influence on environment-friendly behaviour.”

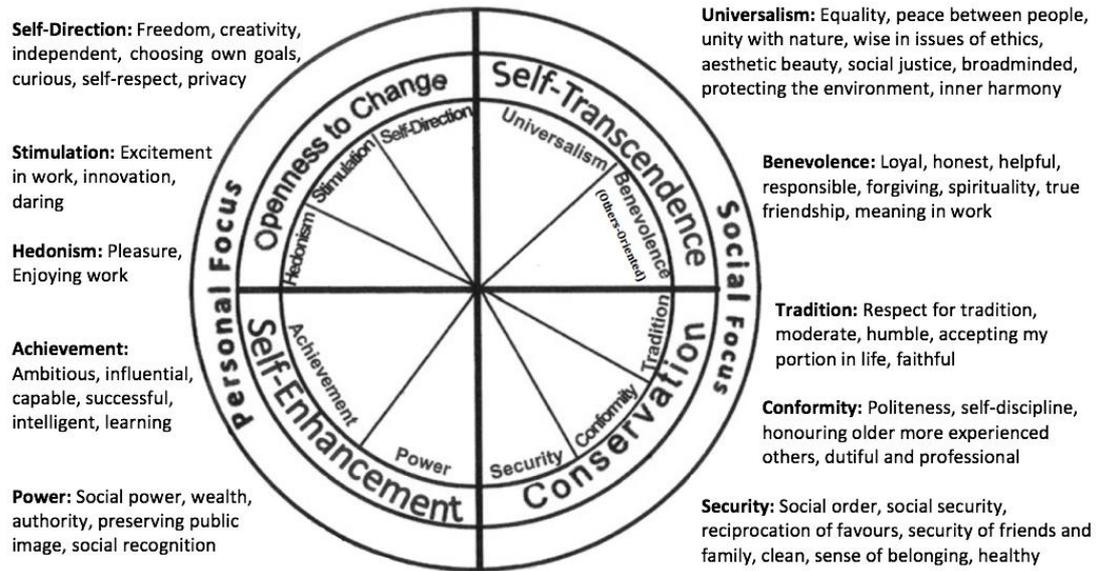


Figure 1: Theoretical model of values (adapted from Sortheix and Schwartz 2017)

In summary, values priorities are likely to provide insights on teams, organisations, and individuals, as well as predict attitudes and behavioural propensities in relation to various organisational concerns. There is clearly merit in exploring the underlying role of personal values, as a means to enhance the sustainability performance of construction projects, and this is the subject of our research. Here, we address the question: to what extent might values priorities and alignments act as determinants and predictors of project performance, specifically in respect of sustainability? The remainder of this paper reports on the use of values theory in an empirical study of a case TMO project in the construction industry. The results are presented, along with a statistical analysis. The outcomes will be used in subsequent research to develop a lens through which we can robustly explore pro-environmental behaviours, which are posited as a contributor to project sustainability performance.

## RESEARCH METHOD

To understand the underlying role of personal values and their likely relationship with project performance, particularly around sustainability in the construction sector, a large infrastructure rail project in the UK was studied. It was a joint-venture (JV) involving three major multi-national contractors, as well as a Client organisation. Given the contemporary and exploratory nature of the phenomenon, a live ‘case study’ was considered the most appropriate research strategy (Yin 1994) to the study of professionals’ values and their influence on project sustainability performance. The project was a very suitable case study because it was a large, self-sufficient, highly-diverse, multi-organisation project (TMO). This case is the subject of a longitudinal study using multiple data collection methods. In this paper, we focus on the results of a questionnaire survey on values, which included a modified version of the SVS (Mills, *et al.*, 2009) that draws on Schwartz’s (1992) theory. As part of the sampling process, only individuals with professional and managerial roles were considered relevant for this study, as their day to day activities (e.g. decision-making, attitudes and behaviours) were, a) likely to be influenced by their personal values and b) influence project performance

directly or indirectly. Hence, all individuals classified as labourers and site operatives were excluded from this study. During the course of the study, the total population on site varied from 270-300; the number varied as staff came and went as work packages were completed. This clearly makes identifying a final figure for the total population difficult and arguably inappropriate for this study. Overall, 231 individuals were considered relevant, and invited to participate (49 from Client, 182 from the JV). The surveys were issued in both hard copy and email format to be completed manually. The SVS questions provided a robust means to measure individuals' personal values priorities. In completing SVS, each participant comparatively rated the importance of 56 values (divided into two lists) 'as a guiding principle in my working life' on a nine-point scale. The anchors of -1 ('opposed to my values') and 7 ('of supreme importance') were used. The other sections of the survey consisted of questions to assess participants' level of awareness around values and sustainability in their work environment (not reported in this paper), and demographic data. Surveys were coded to ensure only the invited individuals participated and that the responses received were representative. The next section presents preliminary analysis of the SVS results.

## OVERVIEW OF RESULTS AND STATISTICAL ANALYSIS

A total of 176 responses to the survey were received, giving a response rate of 76%, which was considered representative of the overall project population, the management levels and the functional groups. Response rates from the two main sub-groups, (Client and JV) were 86% (n=42) and 74% (n=134), respectively. Individuals' values data were analysed and then also aggregated to understand the whole population. The most important values (average score  $\geq 5$ ) to the entire population (in descending order) were: 'security of friends and family' (5.76), 'healthy' (5.67), 'honest' (5.62), 'capable' (5.47), 'self-respect' (5.44), 'meaning in work' (5.43), 'learning' (5.4), 'enjoying work' (5.38), 'equality' (5.37), 'responsible' (5.29), 'dutiful and professional' (5.25), 'successful' (5.23), 'politeness' (5.22), 'intelligent' (5.16), 'loyal' (5.15), 'ambitious' (5.13) and 'helpful' (5.03). The least important values with average scores of less than 3 were 'social power' (1.43), 'spirituality' (2.22) and 'accepting my portion in life' (2.85).

A key observation from the analysis suggested that there is little disparity in values between the two sub-groups, with only 'accepting my portion in life', and 'honouring older more experienced others', for example, being notable exceptions. However, it is most helpful to consider these results at the level of Schwartz's ten higher order values categories. Table 1 presents the average values scores and Standard Deviations (SD) according to Schwartz's (1992) higher-order values dimensions and the ten values categories for the overall project team and the sub-groups.

Some of the priorities of the Client and JV teams were similar. At both project and team levels, the most important segment was ST (followed by OC), whereas SE was the least important. This appears consistent with Schwartz and Bardi's (2001) general findings. Looking at the project via a broader perspective (i.e. social vs. personal focus), the overall project team and the JV team sub-group erred slightly towards a social focus, whereas the Client team leaned towards a personal focus. The close proximity of the average scores warrants further analysis to develop a clearer understanding of priorities within the project group and the sub-groups. Examining the Standard Deviation values suggest that individuals within the project hold a high degree of aligned values (below an arbitrary 1.0 threshold), in six values. However, there was a lack of alignment among Tradition, Power and Hedonism values. The Client team had eight aligned values, whereas the JV team had six. This suggests that both teams displayed some internal consistency, with the

exception of Stimulating and Power values, but the observed differences in values priorities and their alignment could perhaps be an indicator of different cultural paradigms or management strategies. Indeed, observing the alignment and disparity of values between project actors may provide valuable insights to help build TMO projects consisting of individuals from diverse backgrounds (Mills, *et al.*, 2009).

Given the close proximity of the average scores and lack of significant difference between the higher-order dimensions and categories, further analysis was undertaken. Due to the large number of values items, reducing these to fewer groups of variables was appropriate to help facilitate interpretations (Young and Pearce 2013). To identify the underlying structure of the 56 values, exploratory factor analysis was carried out. The basic ‘respondents to variables’ ratio was about 3:1, lower than the recommended ratio of 5:1 to carry out factor analysis, and much lower than the 10:1 that some scholars suggest (e.g. Young and Pearce 2013).

Table 1: Average value scores and Standard Deviations for values dimensions and categories

| Value Category / Dimension     | Project (n= 176) |             | Client (n= 42) |            | JV (n= 134)  |            |
|--------------------------------|------------------|-------------|----------------|------------|--------------|------------|
|                                | Average          | SD          | Average        | SD         | Average      | SD         |
| <b>SOCIAL FOCUS</b>            | <b>4.42</b>      | <b>.82</b>  | <b>4.15</b>    | <b>.66</b> | <b>4.5</b>   | <b>.85</b> |
| <b>Self-Transcendence (ST)</b> | <b>4.52</b>      | <b>.81</b>  | <b>4.33</b>    | <b>.71</b> | <b>4.58</b>  | <b>.84</b> |
| Universalism                   | 4.36             | .96         | 4.21           | .89        | 4.40         | .98        |
| Benevolence                    | <u>4.69*</u>     | .80         | <u>4.46*</u>   | .66        | <u>4.76*</u> | .83        |
| <b>Conservation (CN)</b>       | <b>4.33</b>      | <b>.92</b>  | <b>3.94</b>    | <b>.76</b> | <b>4.45</b>  | <b>.94</b> |
| Tradition                      | 3.61**           | 1.34        | 3.05**         | 1.17       | 3.79**       | 1.35       |
| Conformity                     | <u>4.83*</u>     | .99         | <u>4.47*</u>   | .96        | <u>4.94*</u> | .97        |
| Security                       | 4.54             | .81         | 4.31           | .78        | 4.61         | .81        |
| <b>PERSONAL FOCUS</b>          | <b>4.40</b>      | <b>.76</b>  | <b>4.16</b>    | <b>.55</b> | <b>4.47</b>  | <b>.80</b> |
| <b>Self-Enhancement (SE)</b>   | <b>4.20</b>      | <b>.9</b>   | <b>3.95</b>    | <b>.75</b> | <b>4.28</b>  | <b>.93</b> |
| Power                          | 3.30**           | 1.20        | 3.01**         | .94        | 3.39**       | 1.26       |
| Achievement                    | <u>5.11*</u>     | .86         | <u>4.89*</u>   | .74        | <u>5.17*</u> | .88        |
| <b>Openness to Change (OC)</b> | <b>4.47</b>      | <b>0.81</b> | <b>4.29</b>    | <b>.64</b> | <b>4.53</b>  | <b>.85</b> |
| Hedonism                       | 4.44             | 1.12        | <u>4.39*</u>   | 1.12       | 4.45         | 1.13       |
| Stimulating                    | 4.43             | 1.03        | 4.18           | .91        | 4.50         | 1.06       |
| Self-Direction                 | <u>4.55*</u>     | .89         | 4.29           | .71        | <u>4.63*</u> | .92        |

\* *Most important value categories*

\*\**Least important value categories*

To address this, the 56 values were collapsed to Schwartz’s (1992) ten values types, by averaging the mean scores of corresponding values, which resulted in a ratio of c. 18:1. The Kaiser-Meyer-Olkin value, a measure of sampling adequacy, was 0.885, which exceeded the recommended value of 0.6. Bartlett’s test of sphericity reached a statistical significance of  $p < 0.001$ , thereby confirming the factorability of the correlation matrix. Two components emerged with eigenvalues  $> 1.0$ , explaining 68% of the common variance. To interpret these, an oblique rotation (Promax) was carried out; the correlation between the two components exceeded the 0.32 limit required for interdependency (Hair, *et al.*, 1998). Oblique (Promax) rotation was therefore used for the analysis, and the factors retained exhibited a loading of  $> 0.5$  on their respective components (see Table 2).

The rotation was converged in three iterations. Cross-loading between two components for one variable was observed, which exceeded 0.32 (Young and Pearce 2013). The variable, identified as Self-Direction, was retained because it is likely to provide an explanation about the underlying nature of the project team, and the loading factor difference between the two components was high, at 0.586 for Component One, compared to 0.35 for Component Two. Component One consisted of six items; two were

representative of ST, whilst three were representative of CN. The last item was representative of OC. Interestingly, five of the items here were representative of the social focus dimension. This component was tentatively named “Right Component”, in relation to its position on Schwartz’s model. Component Two consisted of four items. Two items were representative of SE, whilst two were representative of OC. This component is to some extent representative of the personal focus dimension, because Self-Direction value resides under Component One. This component was tentatively named “Left Component”.

Table 2: Factor analysis extracting two components and the corresponding dimensions

| Pattern Matrix     | Component |        | Dimension | Focus    |
|--------------------|-----------|--------|-----------|----------|
|                    | 1         | 2      |           |          |
| 4- Conformity      | .965      |        | CN        | Social   |
| 3- Tradition       | .937      |        | CN        |          |
| 1- Universalism    | .807      |        | ST        |          |
| 5- Security        | .800      |        | CN        |          |
| 2- Benevolence     | .788      |        | ST        |          |
| 10- Self-Direction | .586      | (.350) | OC        | Personal |
| 8- Hedonism        |           | .921   | OC        |          |
| 9- Stimulation     |           | .791   | OC        |          |
| 6- Power           |           | .673   | SE        |          |
| 7- Achievement     |           | .577   | SE        |          |

While the factor analysis outcomes have a clear relationship to Schwartz’s circumplex model, Self-Direction appears to lie at a pivotal (tension) point, particularly because it cross-loads with Component Two, meaning that it effectively acts as a bridge between social and personal focus dimensions. Importantly, this value category therefore requires further analysis, which may help to identify and explain some of the inherent characteristics of both the case project as a TMO and its various teams/sub-groups.

## DISCUSSION

Whilst there has been extensive research on values in different contexts, little to no attempts have been made to explore the role of individuals’ values in TMO projects within construction and how these can be used to harness individual and collective concern for sustainability. Here, we will draw on relevant empirical studies to provide a structure to our preliminary interpretations of the survey findings.

With the exception of a few values categories, there was an overall alignment of values and priorities within the two project sub-groups, and the overall project. Statistical analysis highlighted that ST was consistently the highest scored segment (confirming Schwartz and Bardi’s (2001) results), and the Standard Deviation indicated a strong degree of alignment within the project around this segment. In contrast, SE was judged to be the least important segment. In fact, the ST vs. SE debate has been at the focal point of empirical research around pro-environmental behaviour; ST is very strongly associated with pro-environmental behaviour, whereas SE is not (e.g. Karp 1996; Thøgersen and Ölander 2002). In this study, the results indicate the TMO project team has an innate propensity to behave more positively in relation to sustainability, and the alignment of individuals’ values around the values within this higher order category may be contributing to the project’s sustainability performance (e.g. via decision-making processes). So, future phases of this research will explore this - having completed this SVS and analysed the results, a second empirical phase involving semi-structured

interviews with key actors will be undertaken to characterise the mechanisms through which personal and ‘group’ values work to influence sustainability performance.

The outcomes of the factor analysis outcomes were to a large extent representative of Schwartz’s social vs. personal focus dimension (with the exception of Self-Direction value, which appeared under Component One). With cross-loading exceeding 0.32, it appears that Self-Direction, from a statistical standpoint at least, meaningfully relates to Component Two. This observation can also be seen in the descriptive statistics, which highlighted that OC was the second most important segment within both project and sub-groups. At a category level, whilst aligned at project and sub-group levels, Self-Direction was prioritised considerably higher by the JV team than the Client team. This may signal some unique and/or inherent characteristics of construction projects (generally), notwithstanding probable cultural factors (Fellows and Liu 2008) that may have resulted in this paradox (specifically). More detailed analysis is required to further explore this phenomenon at sub-group levels (i.e. individual contractors and management levels).

Drawing on Glazer *et al.*’s (2004) findings around organisational commitment, may offer helpful insights at this point. Affective commitment (AC) and continuance commitment (CC) have been the subject of increasing research, and are arguably predictable using the SVS. AC is defined as “emotional attachment to, identification with, and involvement in one’s organization”, which is often related to values and objectives congruency of individuals with their organisation (Glazer, *et al.*, 2004: 324). It is thought to be correlated positively with ST and CN values, also referred to as the social focus dimension. In a multi-national study, Glazer *et al.*, (2004) found that AC was positively correlated with social focus values in different countries. There was an exception however (nurses from the UK), which AC found to be more correlated with ST and OC higher-order values.

Our findings do correspond with Glazer *et al.*’s to some extent, in that ST and OC segments were the priorities, but the factor analysis highlighted a fascinating point of tension around the Self-Direction category of the OC segment. Furthermore, the aggregated average scores of social vs. personal focus values (noted in Sortheix and Schwartz 2017) suggested that the project team erred towards a social focus. There is some contradiction here, with Self-Direction likely to be the cause, but such differences and inconsistencies could be related to the highly diverse and multi-national nature of this particular TMO case study. Equally, they may be reflective of intrinsic features in the construction industry, which have previously not been explored in this way.

We acknowledge that these are tentative findings at this stage. These observations will be explored further through our subsequent research, in which the propensity and actual pro-environmental behaviours exhibited by individuals in this case project will be considered through a theoretical framework developed from the SVS results, and data collected by means of semi-structured interviews with key actors.

## CONCLUSION

Despite the plethora of empirical studies around values, there remains a gap around the underpinning role of individual actors’ values on sustainability performance in TMOs, which is a particularly meaningful omission in the construction field. Given the often-dynamic and complex nature of such projects, understanding individuals’ values can be a fundamental step in overcoming values-driven challenges and in turn improve project performance. Enacting sustainability is a typical example of a contemporary concern facing the construction industry. Alignment of individual values is associated with

project success and can act as a determinant and predictor of likely project performance, and arguably of sustainability performance. Using the Schwartz Values Survey on a major TMO case study project provided data on individuals' and groups' values. The survey findings corresponded to a great extent with Schwartz's theory and circumplex model, and factor analysis was used to identify two components which are essentially located on the left and right hand sides of the circumplex. However, Self-Direction, as one of the ten values categories appeared to be a point of tension and controversy in the analysis, which is particularly pertinent as some of the specific values it contains are potentially at odds with pro-environmental behaviours. This may ultimately shed light on some inherent characteristics of construction teams, which may be related to sustainability performance. The next stages of the research seek to explore this and develop a framework to manage this interface within construction project teams.

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# INNOVATION IN THE CONSTRUCTION INDUSTRY: FACTORS, ACTORS AND THE CLIENT'S ROLE

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Innovation in project-based organisations (PBOs), notably in the construction industry, is challenging. Based on a literature review of innovation in PBOs and three empirical cases from the construction industry, this paper explores factors and actors that affect innovation in the ‘loosely-coupled’ construction industry. The literature review reveals the following factors as important for innovation: solution, initiators, impact, driving forces, development and future aim. When analysing the empirical cases, findings suggest that also the number of interdependent actors affect innovation and that the client’s role becomes increasingly important as the number of interdependent actors increases. On generic level tentative findings suggests that there is a difference in scale between process innovations that are systemic or non-systemic dependent upon the number of actors involved. Furthermore, these findings shape directions for future research: to develop better understanding of systemic process innovation in the construction industry; as well as to increase the understanding of how systemic process innovation can diffuse between the interdependent and fragmented actors in the construction industry.

Keywords: client, project-based organisations, systemic innovation, urban development

## INTRODUCTION

Construction projects are complex as was identified already 50 years ago by Cox and Goodman (1956: 43) concluded in their study of distribution of house-building material that “the number of possible permutations and combinations of specific places and entities is enormous, even for one product” (Goodman 1956: 43). Still, construction projects are performed and houses are built, not always on time or budget but the complexity problem is in fact handled over and over again. Dubois and Gadde (2002) suggest that the construction industry should be regarded as a ‘loosely coupled system’. Due to this, issues such as how to enhance innovation (Bygballe and Ingemansson 2014) and how to achieve integration of numerous interdependent actors and processes (Bankvall *et al.*, 2010) becomes a challenging task that needs to be studied from a contingency perspective, i.e. not only by studying singular projects but by studying interdependent projects in their context (compare with Engwall 2003).

The paper draws its findings from a systemic literature review on innovation in project-based organizations (PBOs) from where factors that affect innovation are identified. Due to the ‘loosely coupled system’ view applied here, there is a particular interest on process and systemic innovation (compare with Winch 1998, Taylor and Levitt 2004, Eriksson

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and Pesämaa 2012) since innovation is dependent on coordination and collaboration (Mlecnik 2013). The identified factors are then applied to three empirical cases of construction industry attempts to drive innovation and integration by the development and use of different logistic solutions. The overall purpose is to explore differences between non-systemic and systemic process innovation initiatives in the construction sector and in particular which role the client has for such initiatives.

This paper contributes to research on innovation in the project-based construction industry, which is found to develop and diffuse differently than in the extensively researched traditional production chains setting (Taylor and Levitt 2004, Harty 2005, Lii and Kuo 2016). While construction innovation is increasingly researched, it often has a narrow and single project focus (Engström and Stehn 2016). Research on overcoming difficulties and challenges are suggested for achieving innovation in large projects with numerous actors (Davies *et al.*, 2014). This is why this paper adopts a contingency approach, or project program perspective (Thiry 2002, Artto *et al.*, 2009). The paper will lead to a discussion highlighting the client as a key actor in supporting systemic innovation. Tentative findings presented will also pose questions for future research directions.

To ensure clarity of the paper, the next section will present the research method applied for conducting the literature review and the multiple case study, including discussion of choices made and analysis of the data to validate the findings. Thereafter literature discussing definition, context and management of innovation in PBO is discussed, and factors that affect innovation are identified. Empirical findings are then discussed and analysed from the findings of the literature review, before conclusions and further research directions are presented.

## RESEARCH METHOD

The findings are results of a literature review on process innovation and systemic innovation in PBOs. The literature review took a meta-review approach with aim to document the leading research within the field (Glynn and Raffaelli 2010) and it explore factors to consider in relation to innovation in project settings. The literature review took a systemic approach by using the following steps: design the review, collect literature, extraction and quality assessing, snowballing through references, and analysis. In the design phase, three databases were decided on to retrieve a broad spectrum of potential literature from both technical and management journals, namely: Scopus, Web of Science and ScienceDirect. Following standard practice for literature reviews, a combination of search terms were used to search in title/abstract/keywords from the year 2000 until present; Table 1 presents the combinations (i.e. project AND systemic innovation, project AND process innovation etc.).

In addition to this, criteria for the extraction process were established during the design phase, namely exclusion of articles from low ranked journals and with topics other than innovation in PBOs. Included in Table 1 is a compilation of the number of collected publications per search combination, which totals to 2,527 search results. Apart for eliminating duplicates, conference paper, serials and books the extraction process narrowed down relevant articles by going through title, number of citations and publication journal. This process distilled out 123 articles. After analysing the abstracts, 23 relevant articles were chosen, mainly based on their focus on innovation in PBOs. To reduce the possibility to omit important articles in the field snowballing (Mack *et al.*, 2005) was used by going through the relevant articles reference lists. This yielded another 14 articles, which were included in the literature review.

In the final step, the 37 relevant articles identified were first examined separately and then combined and categorized into three groups: innovation definitions, innovation context, and innovation management. The findings from these three groups resulted in six factors useful for exploring innovations. These factors were then applied to the empirical findings described below to establish tentative findings.

*Table 1: A summary of search term combination and their yielded results*

|                       | Systemic innovation | Process innovation | Technological innovation |
|-----------------------|---------------------|--------------------|--------------------------|
| Project               | 48                  | 397                | 1927                     |
| Construction industry | 7                   | 31                 | 117                      |

The empirical findings presented in this paper are based on a qualitative study using a multiple case study approach (Yin 2014). The study includes three empirical cases from 2016 and 2017 focusing on construction industry attempts to drive innovation and integration by initiating logistic solutions. Cases 1 and 2 are solutions developed by and for contractors alone to support on-site coordination of material and personnel. While Case 3 is a solution developed as a logistic centre by a municipality aimed for all developers, contractors and subcontractors in an urban development project (UDP) supporting optimisation of material flows, waste management, health and safety and coordination between contractors and subcontractors. The municipality initiated and developed the outlines of the logistic solutions and thereafter procured a logistic contractor to further develop and run the logistic centre, known in the industry as third party logistics (3PL).

Two semi-structured interviews with employees responsible for logistics within the respective firm were conducted in Case 1 and 2. The interviews were combined with a three-hour workshop at each company held by the firms' logistic departments. Case 3 includes a total of 29 interviews with municipality's project management, developers' project managers and contractors' site managers, as well as field notes from 10 hours of meeting observations from clients' meetings held by the municipality. The questions explored were how the logistic solutions were initiated, implemented and used and effects on work methods within projects and firms. The developed empirical material was later analysed based on the six factors identified in the literature review to guide tentative findings and suggestions for future research.

## **OVERVIEW OF LITERATURE ON INNOVATION IN PBO**

### **Definitions of Innovation**

By innovation is meant a practice that is perceived as new to an organisation able to adopt it (Rogers 2003). However, as highlighted by Garcia and Calantone (2002) it is important to define different types of innovation both in research and in practice, as many definitions are used interchangeably (Briscoe *et al.*, 2004, Hullova, Trott and Simms 2016). The purpose for making such definitions is to create a common understanding of the innovation discussed, to be able to seek source and nature of innovation and to highlight if certain types of innovation can be fostered by co-operation (Proprius 2002).

There are different ways to classify innovation in PBOs, for example radical to really-new innovation (Garcia and Calantone 2002), incremental to radical innovation (Slaughter 1998), or adopt environment categories (Johannessen 2013). A common classification originating from manufacturing studies is to separate between product and process innovation (Hullova *et al.*, 2016). From research based on manufacturing studies process innovation is commonly seen as a bi-product to product innovation, i.e. when a new

product is changed, parts of the production process also needs to be changed. When looking into PBOs, and specifically the construction industry, process innovation is in contrary to manufacturing seen as something highly relevant and re-occurring in and of itself. The reason for this is that a major part of the costs involved in construction comes from aligning the project and improving the supply chains and construction processes. This is in line with Engwall's (2003) findings of the importance to take history, scope, and environment into account to manage innovation. This contingency perspective is particularly significant in UDPs given the large number of projects, i.e. fragmented and interdependent actors (Winch 1998).

By process innovation is meant new methods that create change in tools and software, or in other words, changes in the supply chain and construction processes (OECD 2015) and by systemic innovation is meant innovation which depends on coordination and collaboration among several key actors during the innovation process (Mlecnik 2013). Systemic innovation success is thus dependent on inter-organisational networks. Such innovation will foster and spread change in systems (Slaughter 2000). The construction industry is, according to Mlecnik (2013), compatible for systemic innovation, in terms of the high interaction between actors and project-based organisations. The results, however, will depend on coordination and collaboration.

### **Context Implication on Innovation in PBO**

The context for innovation is defined as the need for the environment to be receptive to innovation (Pettigrew, Ferlie and MCKee 1992) and alignment with the context is seen as vital for innovation to happen (Taylor and Levitt 2007, Alin *et al.*, 2013). Aligning the innovation to the project would increase the actors' acceptance (Taylor and Levitt 2007). Treating misalignment between innovation and its context includes stability in relations between actors, accessible boundaries between firms and the use of change agents. Adding to this, Alin *et al.*, (2013) investigates the complex process of systemic innovation and aligning it to its project network, suggesting an inter-firm focus for alignment. Inter-firm collaboration to increase innovation is however difficult in the project-based construction industry due to the loose ties between projects and firms (Dubois and Gadde 2002).

Dorée and Holmen's (2004) argue for a distinction between single and multiple actor innovation. Where single actor innovation needs to focus on coupling between a project and its firm, multiple actor innovation also needs to focus on couplings between several projects and different firms, as for example in a UDP. To achieve this, clients are described as an important actor through strengthening relationships, and through creating collaboration and communication channels (Blayse and Manley 2004, Hartmann, Reymen and Van Oosterom 2008). It is also argued that the client must be organisationally ready for process innovation, especially when the innovation development and benefits stretch beyond the singular project, e.g. throughout a program (Engström and Stehn 2016). The client's procurement strategies can serve to enhance the relationships and knowledge sharing can support innovation (Eriksson 2013, Lindgren 2016).

To further discuss the differences between systemic and non-systemic innovation, support can be found in the literature. Harty (2005), for example, separates between bounded and unbounded innovation and equates unbounded innovation with systemic innovation that are able to impact the interdependent and fragmented actors of the industry. Taylor and Levitt (2004) is another example. They categorises innovation depending on its impact on included actors and surrounding and argue that systemic innovation diffuse more

slowly in PBOs due to the impact from regulations, decentralization in PBOs and fragmentation of actors.

### **The Importance of Management to Enhance Innovation**

Gann and Salter (2000) argue for the importance to also address questions regarding management of innovation in PBOs. While Kale and Ardit (2010) focus on the importance of internal influences to diffuse innovation in the construction industry, research also points to the importance of cooperation (Ling 2003, Holmen, Pedersen and Torvatn 2005, Bosch-Sijtsema and Postma 2009) and communication (Widén and Hansson 2007, Larsen 2011) to enhance innovation in PBOs. These factors are found to be of increased importance for systemic innovation. Another important aspect highlighted by Larsen (2011) is awareness. In a fragmented network of actors, the awareness of innovation must be a key management task, to create a common understanding of the innovation. Hence, the management of innovation in PBOs commonly includes initiation, design and diffusion. From the findings presented in this section six factors can be identified which together describe innovation and how it will affect and is affected by involved actors, see Table 2. These factors will be used in the next section when outlining the empirical findings.

*Table 2: Identified factors to describe innovation in PBOs*

| Categories | Definition | Context   | Management  |
|------------|------------|-----------|-------------|
| Factors    | Solution   | Initiator | Origin      |
|            |            | Impact    | Development |
|            |            |           | Future aim  |

## **RESULTS AND DISCUSSION**

### **Defining the Logistic Solutions from the Cases**

Today we equate all available solutions; we must differentiate depending on applicability in type of project... [Logistic Manager at contractor, Case 1]

This quote highlights the desire to further explore and develop construction logistic solutions. It also shows the importance to realise that each solution needs to be adjusted to its specific context. The empirical findings in Table 3 are presented from the six factors identified in the literature study. A conclusion drawn from Table 3 is that there are differences between Case 1 and 2 and Case 3. To begin with, Case 1 and 2 represent solutions for single projects from a single actor's (i.e. contractors) perspective. Hence, they can be understood as single actor innovation. Case 3, on the other hand represent a solution for many interdependent projects and actors and can be understood as a multiple actor innovation.

The main difference discovered when comparing the two types of logistic solutions is number of actors involved, which is much higher in Case 3. In Case 3 the municipality procured a 3PL solution in the early stages which they made mandatory for all actors on-site. In Case 1 and 2 on the other hand the contractors developed their solution in-house for their own projects and the solutions are flexible to which projects and actors need to use it. A possible consequence from this is that the solution developed in Case 3 can spread across the industry but will have great need for inter-organisational processes such as coordination and communication (Mlecnik 2013). In contrast, the solutions in Case 1 and 2 are flexible to customize between project and actors, but will not be presented to, and hence have impact on, a larger number of actors. This finding is in line with the

cases driving forces; while Case 1 and 2 focuses on simplifying projects and improve financial result with more efficient logistic, Case 3 is more focused on environmental and development aspects:

It is important for the municipality with large urban development projects, a place to drive innovation in the industry. [Project manager at municipality, Case 3]

The municipality must see public welfare instead of financial aspects, a tool to reach the environmental goals. [Client Support at municipality, Case 3]

*Table 3: Summary of logistic solutions in Case 1, 2, and 3 from the factors*

| Factors        | Case 1, Single actor  | Case 2, Single actor  | Case 3, Multiple actor  |
|----------------|---|---|---|
| Solution       | Designed in-house including purchased software                                    | Designed in-house including influence from software of the market       | Designed by municipality and logistic consultants, procured with public procurement                           |
| Initiators     | Purchasing department for single project  | Management focus on a single project                                    | Management of UDP (municipality)  |
| Impact         | Affect the procured suppliers and subcontractor                                   | Affect the procured suppliers and subcontractor                         | Affect clients, suppliers and all levels of contractors<br><br>Force increased collaboration between projects |
| Driving forces | Financial incentives<br>Solution to simplify complex projects                     | Financial incentives<br>Create project specific solution for one client | Minimize disturbance in the city<br><br>Lower climate influences  |
| Development    | Possibility for continuous alterations and customization                          | Possibility for continuous alterations and customization                | Alterations possible after contract period, during new procurement process                                    |
| Future aim     | Increase use of solution in all larger projects and offer solution within concern | Offer solution within concern and to UDPs (similar to 3PL)              | Develop the solution and make standard in UDPs in the municipality  |

### **Number of Actors to Define Innovation in PBO**

Based on these findings we can establish that both single and multiple actors' solutions can be defined as process innovations (OECD 2015). The new solutions for logistics coordination, during planning and production, creates a need for updated processes, such as increased communication and integration between contractors and suppliers, planning tools (software systems) for on-site deliveries, and integrated waste management. However, from the empirical findings we can also observe a difference in the number of involved actors between single actor solutions (Case 1 and 2) and multiple actor solution (Case 3); see Figure 1a and 1b for visualization. For the single actor innovation in Figure 1a the logistic solutions focus on the on-site actors. The single project perspective makes innovation difficult to adopt in larger complex settings (e.g. UDPs). This suggests that single actor solution should not be seen as systemic innovation. Turning the focus to Figure 1b, the high number of involved actors implies a systemic innovation (Taylor and Levitt 2004, Harty 2005), on account of the possibility for a large diffusion of innovation. On the other hand, the fragmentation of actors (Winch 1998) and the 'loose couplings' between projects in the UDP (Dorée and Holmen 2004) may hamper such diffusion. A

focus on coordination and cooperation for systemic innovation can help reduce this problem (Mlecnik 2013). In other words, multiple actor innovation in the construction industry needs to apply a contingency perspective and use a program perspective rather than a narrow single project perspective.

### Client's role for innovation in PBO

Having defined the construction logistic solutions as different innovation types there is a need to also acknowledge the context and management of innovation. In all three cases, innovation was initiated and developed top-down, always initiated on a management level (see Table 3). This is in contrast to the findings that highlight the importance of context (Engwall 2003, Harty 2005, Taylor and Levitt 2007, Alin *et al.*, 2013).

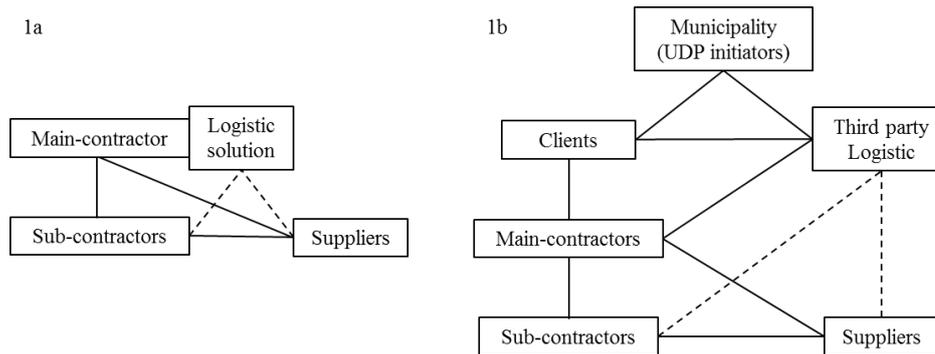


Figure 1a and 1b: Actors involved in single and multiple actor logistic solutions. Full line implies a contractual relationship, while dashed line implies an informal relationship.

Guidelines from related work also suggest a need for increased focus on awareness (Larsen 2011), cooperation and communication (Ling 2003, Holmen *et al.*, 2005, Widén and Hansson 2007, Bosch-Sijtsema and Postma 2009) for innovation with increased complexity. When the number of actors increase, as visualised in Figure 1, the need for a broader (contextual) perspective on development and diffusion of innovation becomes crucial.

Based on the reasoning above, the conclusion is that context and management is increasingly important for innovation in PBOs when the number of actors increases. It can be argued, based on Figure 1, that the client has a central role to communicate innovation in an UDP. The client also has contractual possibilities to create the context and management for innovation (Bosch-Sijtsema and Postma 2009, Larsen 2011, Eriksson 2013).

## CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

Innovation in the project-based construction industry is dependent on factors such as solution, initiators, impact, driving forces, development and future aim including the number of actors. As the literature suggests context and management are both important and they must differ depending on number of actors involved. From the discussion the client is identified as an important actor for a multiple actor innovation, identified as systemic innovation, with the possibility to affect the context and management for innovation. For urban development projects the client has a central role to implement and diffuse innovation. An additional conclusion is that systemic innovation in urban development projects needs to take a broader perspective than only the individual project. To develop and diffuse innovation the whole context of the urban development project must be considered with all its different actors, projects and processes. Hence, a program perspective must be taken. In comparison, single actor innovation, e.g. the contractors'

own solutions, can be more flexible and adopt innovation on a per project basis with little effect on other actors, but also with limited possibility to diffuse the innovation more broadly among other actors.

From the tentative conclusions presented above the papers contribution is to present questions for future research direction. A first possible direction is to develop the understanding of the phenomena of different innovation in PBOs on a project, program, and portfolio level. This could also lead to research to increase the understanding of how systemic innovation can diffuse between the interdependent and fragmented actors in the construction industry. By developing the multiple case study with deeper data collection and analysis per case and include more cases from urban development projects the tentative findings from this paper and the question for further research can be explored.

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# **COLLABORATION**

# INTEGRATED PROJECT EMERGING WITHIN THE DAILY PROJECT LIFE THROUGH ACTIVE PARTICIPATION

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Construction projects have confronted challenges like fragmentation with integrated project methods that enhance collaboration. These integrated projects follow a collection of features such as alignment of interests, open communication, team working, early involvement of key participants and multi-party agreement. These features are often discussed at the project level while the practices of collaboration remain less clear. Further, collaboration as a phenomenon is multidimensional, and therefore research has vaguely applied the concept. To understand more precisely how collaboration is performed in integrated projects, we conducted a qualitative case study of a hospital project. We analysed collaboration with the framework of participation. We found project and meeting features that facilitate participation. We also found three practices of participation where individuals actively performed collaboration. These participation practices included actively questioning common understanding, actively overcoming the organizational boundaries and actively offering knowledge. Our findings contribute to construction management research by exploring the project practices of collaboration in integrated construction projects.

Keywords: Integrated Project Delivery, collaboration, activeness, knowledge creation

## INTRODUCTION

Construction projects have confronted challenges like fragmentation with integrated project methods that enhance collaboration. These integrated projects follow a collection of features such as alignment of interests, open communication, team working, early involvement of key participants and multi-party agreement. These features are often discussed at the project level while the practices of collaboration remain less clear. Further, collaboration as a phenomenon is multidimensional, and therefore research has vaguely applied the concept. To understand more precisely how collaboration is performed in integrated projects, we conducted a qualitative case study of a hospital project. We analysed collaboration with the framework of participation. We found project and meeting features that facilitate participation. We also found three practices of participation where individuals actively performed collaboration. These participation practices included actively questioning common understanding, actively overcoming the organizational boundaries and actively offering knowledge. Our findings contribute to construction management research by exploring the project practices of collaboration in integrated construction projects.

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## INTRODUCTION

Some of the challenges that have hindered construction projects are confronted with project delivery methods that aim to enhance collaboration between companies (Lahdenperä, 2012). These project delivery methods have been called, for example, Integrated Project Delivery (IPD), alliance project, project partnering (Lahdenperä, 2012) and relational contracting (Suprpto *et al.*, 2015). These methods include a set of features such as alignment of interests, open communication, team working, early involvement of key participants and multi-party agreement (Lahdenperä 2012). These are not mandatory features but chosen and adjusted for each project. Still, collaboration is one of the main principles of integrated project method especially to manage complex projects (Rutten *et al.*, 2009). Unfortunately, the literature on integrated projects is scattered because studies do not refer to same concepts but discuss, for example, team integration, partnering, relational governing or multiparty collaboration. To clarify collaboration that is produced with integrated project and its daily project practices, we investigate within this study the daily practices of collaboration in the context of integrated construction project. The daily practices refer the way individuals perform practices instead of project principles such as open communication (Lahdenperä, 2012) or joint working (Suprpto *et al.*, 2015).

In management research, collaboration has been discussed vastly with various definitions (Bedwell *et al.*, 2012) and already for several decades (e.g. Gustafson and Cooper 1978; Zuckerman 1967). Diverse research areas have approached collaboration differently and it is often understood as a quite complex phenomenon (Bedwell *et al.*, 2012). Sometimes collaboration is seen equal to the idea of working together or interacting. However, we consider collaboration as a separated from the phenomena of working in the same space, around the same problem or interacting. Because these actions can be performed less or more collaboratively, they cannot be the definition for collaboration. Previous studies have suggested participation as a mechanism of collaboration (McCaffrey *et al.*, 1995). Participation means that collaboration occurs when individuals take part in decisions (McCaffrey *et al.*, 1995). This line of literature explores participation at the organization level and lists following characters as relevant for a participative organization: formal strategy, direct involvement of a wide range of participants, enabling participants to have an influence on decisions and discussing issues that are relevant (McCaffrey *et al.*, 1995). Enforcing individuals' participation in decisions can embrace complicated situations because through participation individuals can bring their knowledge to the decision-making process. This participation enables a wider knowledge base for decisions (Ashmos *et al.*, 2002; McCaffrey *et al.*, 1995). Participation can be observed as the opposite of bureaucracy and control (Ashmos *et al.*, 2002; Chompalov *et al.*, 2002). While controlling aims to predictability and accountability, it can form isolation and resentment (McCaffrey *et al.*, 1995). Yet, these two aspects exist in a spectrum and can have many forms even in one organization. In the context of collaboration between organizations, participation is also related to contracts, financial risks and rewards that can ease or prevent participation. By following Ashmos (2002), we suggest that participation can be useful for managing complex projects as participative systems enable absorbing complexity.

Based on the above-mentioned theories, we suggest that at the individual level participation would mean an individual to be able to influence common issues. Thus, bringing individuals together does not necessarily form collaboration if they do not aim to influence common issues. The volume of participation can occur at higher or lower levels (Chompalov *et al.*, 2002). Individuals can participate through communicative processes that are dialogical (Hardy *et al.*, 2005; Tsoukas, 2009). Participation can

enable, besides influencing also knowledge transfer over boundaries that can form situated understandings (Bechky 2003; Gherardi 2006). Relying on these observations, we can conclude that participation is easily reduced if collaboration is performed in sequences where individuals bring solutions to the next person in the process and where they cannot influence others' work. This sequential working occurs sometimes in construction projects when the design is done first and then the construction follows.

Various descriptions of collaboration have often passed the core activity of collaboration in the daily performance. To understand how an integrated construction project embraces collaboration through participation, we ask how participation is realised in integrated project for achieving collaboration. To overcome ideas of collaboration as something abstract, we aim to gain knowledge of the daily project practices.

### **METHODS**

We conducted an interpretative case study of a hospital construction project. The case project is one of the first projects that applied integrated project methods for a complex construction project in Finland. As integrated projects are quite new in Finland, the project members learned during the project new project practices of collaboration. The owner of the future building chose to use integrated methods to overcome the risks of surpassing the budget and schedule caused by defective collaboration. The owner did not have earlier experience of such a construction project, for this reason, the owner hired consultants to help to initiate a new type of collaboration and gathered knowledge by visiting similar projects abroad. The owner chose the partner organizations by considering their ability to collaborate. The owner and the chosen organizations (the architect and engineering design company, the general contractor and the contractor for building service engineering) formed a virtual organization connected with a contract. Yet, the owner was the most influential stakeholder. The project will complete a hospital building with 47 000 square meters. The design phase began in April 2015 with signing the contract, while the construction began in January 2017.

The research data comprises the observation of 11 meetings and 21 semi-structured interviews including building owners (4), architects (8), HVAC and electricity designers (from the same company as architects) (5), contractor (2), contractor for building service engineering (2). We collected the data between November 2016 and January 2017. The average length of an interview was 40 minutes and the thematic questions concerned collaboration practices that the project members had performed and experienced in the project. We wrote field notes from the observations and recorded two meetings to understand the interaction and work practices. In addition, we collected project documents to gain knowledge of the formal descriptions of the practices. Since integrated project method was new to the interviewees, they were aware of the practices related to this project method. Project members also discussed over the project collaboration practices as part of developing the project delivery.

For the analysis, we transcribed the interviews. While the interviews were conducted in Finnish, the quotations in this paper are translated into English by the author. The collected data were examined and iteratively processed to understand the network of practices. The analysis followed the thematic process (Braun and Clarke, 2008). The analytical thinking began while collecting the data (Gioia *et al.*, 2012). The initial coding was formed with interviews and collated to themes (Braun and Clarke, 2008). Then, the themes were defined and named (Braun and Clarke, 2008). The aim of the analysis was to understand practices performed in daily project life rather than high abstract

constructions (see Sandberg and Tsoukas, 2011). Finally, the found practices were compared with the literature of collaboration.

## **FINDINGS**

### **Project Features Facilitating Participation**

We found the following project features that aimed to enhance participation: multi-party contract; early involvement of contractors and engineering designers; including different organizations into decision-making, risk management and project planning; including end-users to design, establishing rules for communication; part-time co-location and establishing a chat connection. These project features have been identified in the previous literature as well. However, the details of these features vary between different types of projects as concerning for example the co-location and decision-making processes.

### **Facilitating Participation in a Meeting**

We found that the meeting practices varied depending on the topic of the meeting and depending who was managing it. The project included one person who had knowledge on facilitation methods and who used those methods and sometimes consulted others on facilitation methods. We describe here a meeting held in the co-location that concerned a purchasing process for a construction phase. The aim of the meeting was to discuss how the purchasing should be done by using an integrated project style. At first, it was shortly discussed how the meeting should proceed, how the notes of the meeting would be done. The project manager of the contract led the meeting. After introducing the meeting, he stood up, walked to a flip chart, and began to write the issues that should be considered in purchasing. At the same time, he led the discussion and allowed others to participate by asking their opinions. Topics that were discussed included the role of designers, the process of approving designs, the type of workshops for purchasing, differences of purchasing between normal and integrated project, and the value limit for things that the purchasing group would process. In addition, it was also remarked that the virtual organization did not own anything. After the meeting officially ended, the participants continued to discuss in smaller groups. This meeting is an example of a process where the individuals define project practices according to the principles of integrated project. All the participants in the meeting had an opportunity to say something and they were encouraged to speak by asking questions.

### **Participation Practices for Common Project Knowledge**

With the help of the interviews, we further analysed the practices that the individuals performed and experienced specifically in the integrated project. These practices included ways to cross organizational boundaries, beyond the predesigned formal practices. These practices required active involvement from the project members to actualise the participation. These practices are presented in Table 1.

### **Actively Questioning Common Understanding**

The first practice that related to the integrated project was actively questioning common understanding. This practice includes practices in which individuals pose questions to raise conversation. According to the interviewees, some of the questions were uncomfortable but sometimes they could raise trust. The project members' earlier experience was mostly from traditional projects where individuals mainly concentrate on the work tasks that are directed to their organization. Table 1 presents three examples of this practice; a need to have the courage to bring up defects, asking if everything has been

considered and asking opinions. Table 1 shows a quotation from the data that presents the need to have the courage to bring up defects. In this quotation, a project management consultant described how trust (as an important part of integrated project) is built with posing questions and answering to them, even when it might question one's or others' work. The interviewees described questioning and bringing up concerns to require courage. Thus, questioning the project work is not something that occurs automatically or is described in a manual. Individuals need to come up with a thought and express it when they feel it is a suitable time for the question. Following the quotation, bringing the concerns and questions to common knowledge enhances trust compared to passive presence. The quotation remarks that individuals expressing openly their concerns and doubts is not automatic, because it can feel uncomfortable to do even when it can improve project performance. Besides being influenced by the integrated project principles, this practice was described to be influenced by the common contract that enforced interest on others' success and formed an understanding of the value of everybody's opinion.

### **Actively Overcoming Organizational Boundaries**

The second type of practice that related to the integrated project was individuals actively overcoming organizational boundaries. This practice included practices in which individuals could have an influence on tasks that were not mainly on their responsibility. This influencing was assisted with bringing all stakeholders early to project for planning, design and decisions. The multi-party contract enabled a task division which was also less strict than in traditional projects. This also meant that the work was visible to others earlier than in a traditional project. Table 1 shows three examples of this practice; bringing one's work under the eyes of others, making tasks to overlap and commenting issues not in one's expertise as examples of the practice of actively crossing organizational boundaries.

The first quotation from the data in this theme presents an example of bringing one's work under the eyes of others. In the quotation, an architect describes how during the very beginning of designing when there were only the characters of spaces and rooms, the other stakeholders were already watching these plans and commenting them. This meant that, for example, the contractors commented the assumed prices of the plans. In the spirit of the integrated project, the individuals were expected to participate in the work that is traditionally performed by only one stakeholder. The interviewee described this participation to be partly unpleasant because others were commenting his/her incomplete work. This quotation shows a situation that was new for the project participants and that offered a possibility for them to be a part of constructing a common understanding of plans and designs. The quotation shows how openness with one's work enabled individuals to participate in the work that was mainly performed by the other stakeholders. Thus, an integrated project required opening one's work to others and working on issues that did not follow the traditional division of work.

### **Actively Offering Knowledge**

The third type of practice that related to integrated project was individuals actively offering their knowledge to a project. These activities included not just offering solutions that had been applied in previous projects, but investigating, comparing and explaining one's reasons for one's solution. These practices supported forming new solutions for the project. According to interviewees, in traditional projects where organizations have separate contracts with fixed costs, the organizations are less willing to suggest creating new solutions because it would mean more work for them.

Table 1: Participation practices to overcome organization boundaries for integrated project

| Quotations from the interviews   | 1st cycle theme                              | 2nd cycle of theme                            |
|--|--|---|
| Trust, you need to work for it all the time and have the courage to say, for example, if you feel that you don't trust what I am doing, you need to bring that up and handle it openly. It is hard for Finnish people to take critic, the central piece of alliance is collective trust, and for that, you need to have the courage to bring those things and have the courage to take them, it does not mean that you are bad at your work. (Project management consultancy)  | Need to have the courage to bring up defects | Actively questioning common understanding     |
| Contractors did the main part; so I was mostly observing, as a cost inspector, questioning and watching the process if everything had been considered, and on the other hand watching it for our company. (Project management consultancy)   | Asking if everything has been considered     |   |
| Make others to have commitment, also demanding the decisions and statements... when we go further then the blaming begins and sort of only doing what has been discussed to be done... for the alliance, it suits challenging each other all the time. (Architect)   | Asking opinions                              |   |
| Basically, we started to design immediately and begin with the characters of spaces before any layout... Our plans were visible to everyone even when we were in a really early phase. Everyone have been able to comment our design, it has been this big brother-type ... and we were like in an aquarium; we design and everybody says immediately this works and this does not, this costs a lot. (Architect)  | Bringing one's work under the eyes of others | Actively overcoming organizational boundaries |
| It [communication], over company boundaries, happens more, the roles get a bit mixed, in the traditional [type of project] is quite specific that you do this and that is your playground, but in an alliance they mix a bit, people may, overlapping the task fields. Encountering happens there. (Project management consultancy)  | Making tasks overlap                         |   |
| When you are in APG (alliance project group) you should be able to deal with multidisciplinary issues and comment them, surely, I have to admit that I am quite on my discomfort area, I do not understand anything about the strength of concrete studs, I am from another field. In normal projects, we are not making proposals to similar issues. (Building services engineering)  | Commenting issues not in one's expertise     |   |
| Table 1 continues  | 1st cycle coding                             |   |
| After going through things in the technical section, a solution comes out, all kind of investigations; investigation after investigation on the technical side, investment and life cycle costs and compare them to the alliance targets... at the design phase all system solutions were needed to justify. (Structural engineering)  | Conducting investigations                    | Actively offering knowledge                   |
| When we think costs of investments, contractor has a central role in acknowledging the prices, but it is not only if we shall purchase for example a door with a glass window, contractor can tell that a door without a window is x euros, and a door with a window costs y euros, when the group is composed architects offers a prospect how it aesthetically influences with natural light and users tell how they observe through the door do not need to go in, everybody has their role and opinion and then it is decided together...large panel thinking these solutions. (Contractor for building service engineering) | Comparing options together                   |   |
| Many times, situation comes where you say this cannot be done, after this you need to explain. (Project management consultancy)  | Explaining reasons for one's solutions       |   |

In Table 1, the practice of offering knowledge included conducting investigations, comparing options together and explaining reasons for one's solutions. Presented in Table 1, the quotation of conducting investigations is described by a structural engineer. The quotation includes a description of the project including many investigations (compared to previous experiences) to evaluate the most suitable solution related to project the targets of an integrated project. There were different types of investigations related to

technical, life-cycle and costs solutions that were compared. This meant that creating project solutions included different organizations and that the knowledge of one organization was presented to others to enable comparison between solutions. One interviewee described that the discussions in the project concerned the core ideas and not just decisions while the development would occur somewhere else.

### **DISCUSSION AND CONCLUSIONS**

The present qualitative case study has aimed to increase knowledge on collaboration in integrated projects with the help of the concept of participation. We identified project features facilitating participation, facilitating participation in meetings and three participation practices. These elements form network of participation practices where practices influence each other in the context of a construction project. The three participation practices included actively questioning common understanding, actively overcoming organizational boundaries and actively offering knowledge. These participation activities enable forming collective knowledge for the organizations involved in the project. The interviewees experienced these participation practices as different from the previous more traditional projects.

The project features influence active participation practices. For example, involving stakeholders early in the project enabled different organizations to participate in the design phase and the multi-party contract increased the interest in the work of other organizations. The features of an integrated project influence the daily practices of participation but do not determine these practices. Further, facilitating meetings also supported participation practices. The difference between this project and the previous more traditional projects was that the individuals performed practices when they were more involved in the common knowledge. This participation was sometimes uncomfortable, but it enabled creating new solutions among different organizations and being involved in the common issues to a greater extent than before. The project features that can reduce active participation are processes where the work is done in sequences of different stakeholders working alone and handing over their solutions to the next in the process.

Management initiatives enforcing participation are often combined with controlling mechanisms. In the case project, the management formed possibilities for participation, but at the same time, the project was managed with controlling mechanisms such as planning, defined decision processes and contractual restrictions. Thus, participation was not always as extensive as it could have been. For example, the board committee worked as partly separated from the other project members. Control might create predictability, but it can reduce participation and thus collaboration. Yet, collaboration can also occur independently without management (Beck and Plowman, 2013).

This case project illustrated active forms of participation. Offering one's knowledge, overcoming organizational boundaries and asking questions is not new in research (e.g. Hardy *et al.*, 2005), but these actions can be done in many ways, which is rarely indicated by scholars. Existing literature does not describe the effort that is required for intensive collaboration. The findings suggest that organizations and individuals need to perform active participation in forming integrated collaboration. When applying the concept of participation, collaboration means individuals are able to influence common issues instead of only working together or being present. This collaboration can be done face-to-face or digitally, but the individuals are required to be able to take part in decision-making.

Integrated projects have been described as a collection of features such as teamwork quality, joint management, commercial community and involvement of relevant stakeholders that integrate organizations into a project (Lahdenperä, 2012; Suprpto, 2015). These features are more principles than detailed instructions. Based on our findings, the integrated project can be understood through active participation of organizations and organizations influence on a common project. Yet, the usefulness of participation has its limits and can cause complex and slow processes. Integrated projects should be discussed not only as enabling collaboration. It is also relevant to discuss how the collaboration is enabled and how it is controlled as these are not necessarily separate options. Participation in the project can be the concept that assists forming a measurement framework to investigate the level of collaboration.

Our results suggest that managers should support not only joint working but also the active participation of individuals to common issues over organizational boundaries. The practices of collaboration are not something that always automatically occur but might require support from management. Our study enables to develop theory and analyse deeply collaboration within one case situation. Future research should investigate the relation of control and participative collaboration to understand the suitable combination of these two in construction projects.

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# ADAPTING NOVEL RESEARCH TECHNIQUES TO ANALYSE COLLABORATION IN OFFSITE MANUFACTURING HOUSING CONSTRUCTION INNOVATIONS

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The Australian housing sector continues to function in a traditional, inefficient, craft-based manner. A few exemplary supply chains have addressed these challenges through innovative offsite manufacturing (OSM) techniques. Despite its benefits, uptake of OSM in Australia remains limited. A fundamental challenge to OSM is the lack of collaboration across the deeply fragmented housing construction sector. While collaboration is critical in these settings, theoretical work on the topic remains limited. This paper's aim is to examine collaborative practice in innovative housing construction supply chains in Australia using an innovative methodology that supports actor-network theory with causal loop diagrams. Drawing on qualitative data from five OSM supply chains, elements that influence the creation stage of collaborative networks were identified, along with inter-relationships between them. Actor-network theory is applied to initially structure the identified elements into a tentative sequential process. Relationships between elements including their causal influence, feedback loops and polarities are then proposed through a causal loop diagram. The outcome is a model of collaboration in OSM settings that identifies key elements in the critical first phase of network creation to enable innovations in OSM. The model can readily be translated into practitioner materials that build collaborative capacity in the construction industry.

Keywords: actor-network theory, causal loop diagram, qualitative systems dynamics

## INTRODUCTION

Housing indicators have historically been robust in Australia (Kitson *et al.*, 2015), but alarming trends in the last few decades clearly indicate that the housing sector is under acute stress. Dwellings in Australian cities are among the least affordable in the world (Demographia 2016), compliance levels with environmental standards have been dismal (Pitt and Sherry 2014) and average construction time has lengthened by 40% in less than two decades (Gharaie, Wakefield and Blismas 2010). Many of the current housing challenges can arguably be traced back to the housing construction industry's lack of efficiency and severe fragmentation (Loosemore, Dainty and Lingard 2003). One

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proposed solution to these deep-seated issues is offsite manufacturing (OSM), where parts, components, systems, or entire housing units are manufactured in a controlled environment away from the traditional construction site (London, Khalfan and Pablo 2015). We have examined five OSM housing construction supply chains closely in the course of a three-year national research project. Our research into these OSM networks was based on two premises: that OSM innovation can fuel large-scale industry transformation, and that extraordinary levels of collaboration are needed to drive these OSM innovations. In this paper, we focus on the latter. Specifically, our aims here are to (1) to contribute to developing an enriched theoretical model of collaboration in innovative housing construction supply chains, and (2) to report on our experimentation with a social science methodology that is not widely utilised by construction management researchers. We demonstrate in particular that supporting actor-network theory (ANT) with key elements of causal loop diagrams (CLDs) can provide researchers with a detailed methodological toolkit for generating rich descriptions that capture in fine-grained ways the diverse conditions that influence the creation of innovative housing construction networks, along with the relationships of causal influence that exist between them.

## **COLLABORATION IN HOUSING CONSTRUCTION**

Collaboration is a key strategy for supply chain integration (Simatupang and Sridharan 2005), and has been a subject of considerable interest in the area of construction, where fragmentation is a recurring issue. In most cases, collaboration is a term that is simply mentioned as an activity or practice (Mao *et al.*, 2015) or implied in discussions that foreground supply chain integration (Kim, Kim and Cho 2015). In other cases, researchers have attempted to propose brief definitions of the term (Isatto, Azambuja and Formoso 2013). In a very limited number of construction studies, researchers have begun to explore collaboration in systematic ways (Walker and Walker 2015), however this pool of research remains surprisingly underdeveloped. In a broader multi-disciplinary review of collaboration literature, we have found there is deeper theoretical development, but much of the work on collaboration is still grounded on a narrow and limiting set of assumptions that fails to consider important characteristics of the construction industry (London and Pablo, in press). Yet collaboration in construction is an area that warrants attention, given that housing construction projects involve high levels of interdependence among actors. In such cases, collaboration has been described as “the only viable response” (Gray 1985: 916). We argue that using a network approach, specifically actor-network theory, can enrich theoretical conceptualizations of collaboration in ways that are appropriate for construction settings.

## **USING ANT SUPPORTED BY CLD**

### **Actor-Network Theory**

Actor-network theory is an analytical approach that assumes that much of reality is the outcome of human and non-human actors interacting in heterogeneous networks (Callon 1999, Latour 2005, Law 1992). Networks develop through a complex, non-linear process called translation. Translation begins when a prime mover seeks to create a network by *enrolling* different actors. These initially disparate actors begin to *converge* and function as a single unit; the programs and goals of the network then *stabilize* into routines; then the network *expands* across time and space (Callon 1999). Each stage of ANT can be further broken down. Network creation, for example, involves a prime mover framing a problem and a solution to be addressed (problematization), defining the attributes of actors needed to address it, along with their potential roles (interdefinition of actors),

employing strategies to convince actors to take part in the network on the grounds that it is the only way that they can achieve their own goals (obligatory points of passage), cutting actors away from competing roles and identities (*interessement*), and convincing at least some of these actors to become part of the network (enrolment) (Callon 1999).

We have in other work used the ANT concepts above to expand existing understandings of collaboration in construction. ANT concepts such as general symmetry, multiplicity, and convergence, for example, can lead to an understanding of collaboration that encompasses humans and non-humans, layers of overlapping networks, and complex notions of coherence instead of conformity (London and Pablo, in press). The strengths of ANT as an analytical approach rest in part on its commitment to detailed empiricism. ANT researchers are expected to commit to the “careful tracing and recording of heterogeneous relational networks” (Doolin and Lowe 2002: 76). To achieve this, researchers seek to formulate rich descriptions of actors and of associations between them. Ideally a description is developed to the point of saturation, that is, descriptions of elements within the network are so exhaustive that there is no need for additional descriptions from outside the network. At this point, descriptions and explanations become one and the same (Latour 1991). This ANT ideal is sound, yet implementing it raises methodological difficulties. Ponti (2012) points to a key challenge: while ANT commits deeply to detailed empiricism, it does not prescribe any one data analysis technique for achieving this. Ponti (2012) thus proposed that this gap could be addressed by combining ANT with a tool known as event structure analysis. We take up a similar argument, arguing that ANT researchers can benefit by supporting the use of ANT with another specific tool, in this case systems dynamics and causal loop diagrams.

### **Systems Dynamics, Causal Loop Diagrams, and Possible Links to ANT**

The term “systems dynamics” refers to a method that seeks understand, model and learn from the dynamic complexity of human and social systems in ways that allow people to address multifaceted problems. The process of modelling a dynamically complex system begins with identifying a problem, then expressing it in terms of an initial set of variables progressively expanded through an iterative mapping process that seeks to explicate cognitive models. A map can be devised using various tools; the tool we use here is the causal loop diagram. Causal loop diagrams (CLDs) are made up of three components: variables, links between variables meant to suggest causal influences, and polarities of links (positive or negative). Several components can be linked together in a loop (Stermann 2000).

While CLDs have historically been understood as a quantitative analysis tool, we propose here that it is a tool that can support ANT, an approach underpinned by dominantly non-realist, qualitative assumptions. To justify this we make three points. First, CLDs can be mobilized in quantitative as well as qualitative ways and quantitative mobilizations, while dominant, are not always “better.” For example, researchers have found that traditional CLD modelling requiring full quantification of variables and links is, in many cases, an unrealistic goal. The extra effort required to achieve this may also not be value-adding, particularly when complex efforts of quantification are founded on multiple uncertainties and questionable assumptions (Wolstenholme 1985). Thus our second point: qualitative CLDs, initially seen as pathways to quantitative models, are increasingly seen as valuable in themselves. Qualitative models represent complex problems in succinct ways, enrich understandings of problem contexts and guide discussions and agendas (Coyle 2000). In this case, we argue specifically that CLDs allow ANT researchers to discern causal chains in studied phenomena, in ways that allow ANT researchers to “write rich descriptions that

‘show’ fluid associations among things, revealing what gives actors the energy necessary to act” (Ponti 2012: 2). When the underpinning associations in a collaborative network are causal in nature, CLDs can capture these in vivid ways. This leads to our third point. In such an undertaking, analysis hinges on what is meant by “causal”. In this study, we align ourselves with qualitative mobilizations of CLDs, thus we necessarily move away from positivist accounts of causality where events A and B are linked by law-like relationships that can be expressed in a mathematical formula or graph. In ANT generally and in this study specifically, causality is assumed to be underpinned by the idea of multiple determination: events are “caused by the interaction of multiple causal powers”, potentially “frustrated by the operation of conflicting powers” and are without “guarantee of empirical regularity” (Elder-Vass 2015: 13). This notion of causality, we argue, can still be captured by CLDs, but to do so we must revisit CLD building blocks (the variable, the link, and the polarity), which tend to be understood from mainly positivist positions. We do this in the methodology section. In summary, then, we are mobilizing CLDs to create a qualitative model that reveals chains of causality in a way that explains the conditions leading to the creation of a collaborative network, thus supporting the ANT goal of developing a detailed description/ explanation of associations between actors in a studied phenomenon.

## **METHODOLOGY**

We develop a model using ANT and CLDs based on findings from our three-year national research project that examines five Australian-based networks that have embarked on innovative offsite manufacturing initiatives. These networks were led by organizations acting as prime movers, and these organizations were selected to achieve maximum variation (Flyvbjerg 2006). Specifically, these lead organizations varied in size (one micro, three small/ medium enterprises, one multinational), maturity (two start-ups, two in the growth stage, one mature), level of OSM, and purposes for moving into OSM. Data was gathered primarily through 29 semi-structured interviews, but we also visited sites and viewed videos of OSM operations. Interview questions were intentionally framed in a broad way, with initial questions focusing on human and non-human actors, drivers and barriers to OSM, as well as drivers and barriers to collaboration in OSM projects. Human actors were identified based on actors’ meaningful involvement in an OSM project. Non-human actors were identified first through frequency of references to them, for example participants mentioning equipment, funding, factories, and drawings as critical to the network. Their significance was further validated through our observations during site visits, as well as through analyses of videos and photographs. Data was analysed using NVivo, and a thematic analysis of data from across these cases yielded 102 different themes. To give some very brief examples: questions on drivers to OSM yielded themes such as increases in speed, customization, and worker health and safety; drivers of collaboration included themes such as positive attitudes towards change and the presence of a strong champion.

While our initial analysis yielded a detailed list of themes, they were not, at least initially, linked in any meaningful way. To being this “linking” process we used the idea of translation as an organizing device for initially discerning more straightforward relationships of sequentiality (Pablo and London 2017). Translation, as we mentioned, can be divided into stages (Callon 1999), but other researchers suggest there are other more finely-tuned ways to break it down. Pentland and Feldman (2007) and Ponti (2012), for example, propose that translation can be broken down more minutely using events as a unit of analysis. An event involves at least two actors and an action that takes place between them (“Company X uses funding to buy equipment”). Events contribute to the

advancing of a narrative or story, and can be sequentially ordered around the question “What happens next?” as a network unfolds. While Pentland and Feldman (2007) deliberately focused on events that were fleeting in duration, they also noted the importance of routinized patterns (extended events) in organizational life.

In this study we move from seeking relationships of sequentiality to relationships of causality. We thus propose here that a viable unit of analysis is something similar to Pentland and Feldman’s (2007) routines, and we refer to this unit as the “condition”. A condition in this study has three characteristics. First, it involves actors and actions that are linked in sustained, repeatable, recognizable patterns. Second, a condition *tends to influence* other conditions, but again, in line with our tempered definition of causality, this is a general tendency not guaranteed to have empirical regularity (Elder-Vass 2015) and does not require unilateral determination. Third, a condition can be described as “increasing” or “decreasing”, but in ways that reflect general direction, not precise mathematical formulae. To reflect these characteristics, then, a first step we took was to reframe our themes to reflect these. For example, a theme originally framed as “Presence of a champion” is now called “Commitment of champion to OSM solution”. Once “conditions” were in place, we were prepared to analyze possible causal relations between them.

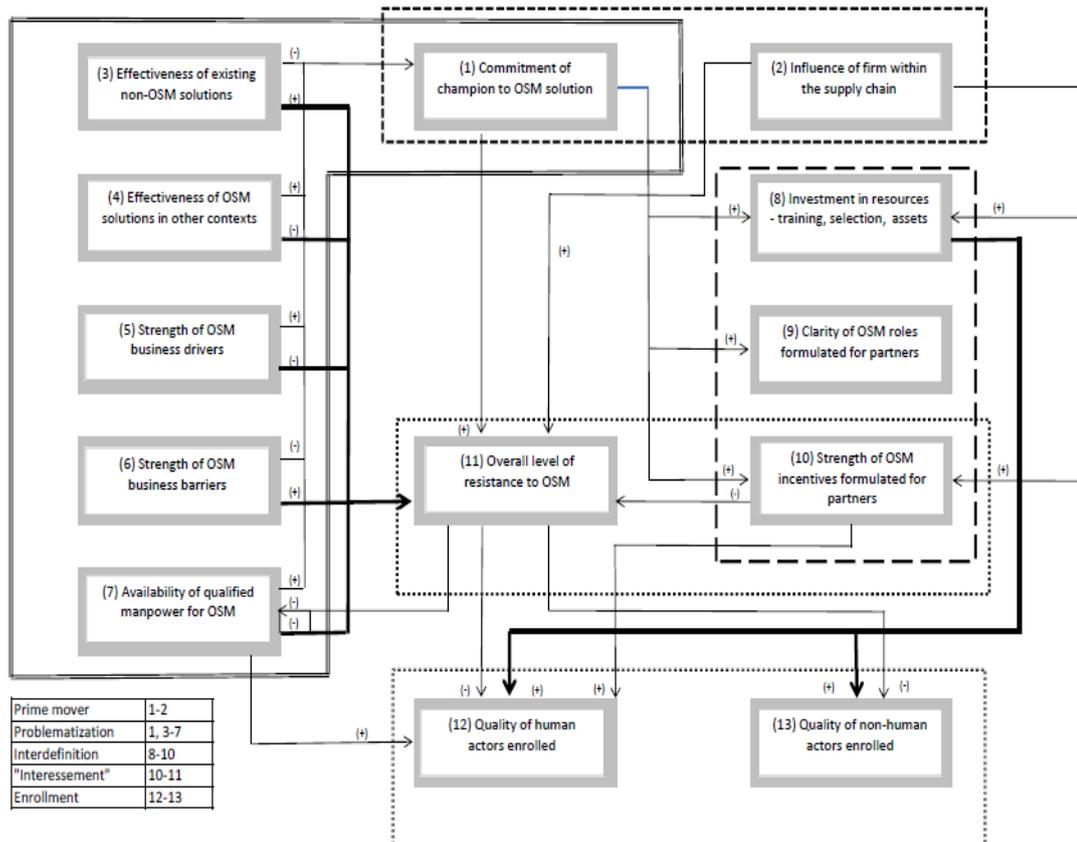
## FINDINGS AND DISCUSSION

Having clarified the conventions we used for building qualitative CLDs (defining causality, renaming themes), we then sought to identify the chains of causal conditions leading to the creation of a collaborative OSM network. Our initial analysis of arranging conditions based on sequentiality (Pablo and London 2017) was thus fine-tuned, moving away from the question “What happened first/ next?” to asking “Does a change in Condition A *tend to influence and change* Condition B?” A similar question guides event structure analysis (Ponti 2012), but we have modified the question to accommodate the definition of causality we discussed earlier. Initial responses were formulated by the research team based on participant narratives. Causality in participant statements could be discerned in various ways, for example in accounts like “Project Leader X was very positive about OSM” [therefore] “we all got on board”. Links between conditions proposed by the research team were then presented to industry partners for feedback. Based on our five case studies, we propose that there are 13 causally-linked conditions leading to network creation (see Figure 1).

Figure 1 was based on findings from all five case studies. Due to space limitations, however, our explanation of how we arrived at it is limited in this paper to discussions of two contrasting case studies. Case Study 1 involves a multinational firm that has moved from purely traditional building to incorporate innovative OSM techniques. It has successfully created a collaborative network that now makes use of prefabricated cassette floors. Case Study 2 involves a start-up that sought the acquisition of disruptive European technology to prefabricate wall, roof, and floor elements for bespoke houses. It ultimately failed to create a network. We present the different conditions for network creation, along with detailed supporting data from both case studies to illustrate each condition, in Table 1. The causal links between conditions are further explained in narratives below. Embedded in the narrative are symbols like “3→1”, which means Condition 3 tends to influence Condition 1. For the sake of brevity our narratives focus on selected links between conditions. That said, the links that we do not explain can nevertheless be inferred from the complete Figure 1, particularly after we walk readers through narratives.

In Case Study 1, the conditions for successful network creation can be explained as follows. Ineffective construction solutions led a champion to commit to OSM, based mainly on concerns about worker safety (3→1). The champion sought to enrol OSM actors with a specific emphasis on seeking the best people through stringent selection (1→8).

Figure 1: Proposed causal loop diagram of network creation.



The success of this process was buttressed by the company’s strong track record for innovative building methodologies (2→8). While existing networks like partner, regulatory and financial networks were still be programmed to run along traditional building practices leading to resistance (6→11), the influential position of the organization, bolstered by its track record, tempered this resistance, thus conservative supply chains and regulatory networks were over time made “ready” and accepting of the change (2→11). The enrolment of human actors proceeded in a relatively unimpeded manner not only because of focused recruitment/ selection efforts (8→12) and because overall resistance to OSM had been addressed (11→12). Non-human actors like equipment were recruited unproblematically because of intentional efforts to invest in OSM resources (8→13), and because potential resistance in key networks (for example banks) had been addressed (11→13).

Network creation took a different and largely unsuccessful route in Case Study 2. The champion’s commitment to OSM was also strong, grounded in issues linked to quality and precision (3→1). The champion sought to enrol best people through planning efforts that would position his firm as the employer of choice (1→8). However, the potency of efforts to enrol OSM assets was diminished because the company was new and lacked a track record of successful projects (2→8).

Partner networks were also resistant as in Case Study 1 (6→11), but unlike in the previous case, the new, fledgling company was in no position to champion this change (6→11). The enrolment of human actors, while buttressed by promises by the company to uphold innovative human resource practices (8→12) was met with limited success, with overall sentiments of scepticism remaining and very few actors finally entering into limited “soft” agreements to participate in the future (11→12). Such future participation was also contingent upon the acquisition of new equipment, but resistance from banks has prevented this (11→13). As of this writing, network creation continues to flounder; the “champion” that had led many efforts has now left.

Table 1. Causal conditions for network creation

| Conditions                                      | Case Study 1  | Case Study 2  |
|---|---|---|
| Effectiveness of existing non-OSM solutions (3) | WEAK. Existing solutions require manual building at heights. Lead company and key managers were led to ask questions: “how do we build even faster again and do it even safer? How do we keep all the guys off those top floors?”   | WEAK. Existing non-OSM solutions tend to be slow and imprecise. Lead company concludes: “...taking nothing away from what builders are doing, they’re never going to be as accurate as what our machines are... So, at the end of the day what we’re producing is going to be of high quality but done a lot quicker.”  |
| Commitment of champion to OSM (1)               | STRONG. Leaders thus looked to OSM. They “were very positive and they were looking at ways of, let’s have the attitude of what can we do to make it work, and not find ways of not making it work.”   | STRONG. Leaders looked to OSM. “A Melbourne based company, really passionate about the creation of jobs... saw [OSM] and said ‘yes, I like this.’ And then came back and did some economic studies around the whole process and around the industry changing.”  |
| Influence of firm within the supply chain (2)   | INFLUENCE ON SUPPLY CHAIN STRONG BASED ON PAST SUCCESSFUL EXPERIENCE. Leaders then sought to champion OSM across the supply chain gradually: “...we’ve been out there spruiking what we’ve done over the last couple of years with industry, with the organisations such as FWPA, Timber Australia... we’re not afraid to give the information out there so that people can come along and say, look, this can be done by other parties as well at the end of the day.” | INFLUENCE EMERGING BUT MOSTLY SPECULATIVE, BASED ON FUTURE EXPECTATIONS. Leaders sought to champion OSM: “[We] worked with the City A and City B Councils on putting some papers together and they did some studies and the economic climate of jobs and positions for the west, right through that whole region. And the automotive fund and all that side of it.” |
| Strength of OSM business barriers, for example  | WEAK. Because of the championing efforts over time, OSM solutions were not seen as radical departures and could be accommodated under existing regulations. “Because it had to be an  | STRONG. Despite championing efforts, the lead firm’s OSM solutions were seen as new and could not be accommodated under existing regulations. “The business case stacks up and that’s what they like  |

## Novel Research Techniques and Collaboration in Off-Site Manufacturing

| Conditions  | Case Study 1   | Case Study 2   |
|---|--|--|
| regulatory barriers (6)                                 | alternative solution to our current building codes so we had to take the building surveyors through a whole journey to say, yes, this is equivalent to a concrete building from a fire perspective, from an acoustic perspective, from a longevity perspective.”   | about it. So it’s now convincing them to say okay - it’s actually there, everything’s in place. But banks are all scared because of your 9/11 and all that good stuff that happened way back. They’re not taking that risk anymore.”   |
| Investment in resources training, selection, assets (8) | HIGH PRIORITY PLACED ON FINDING THE RIGHT PEOPLE. To get started on OSM, lead firm decided to pursue only the “best” people: “...we will use the connections that we have around the table that we have right now. So I would go to Company X and say, I’m about to go WA [Western Australia]. Who are the best and most capable frame and truss manufacturer in WA?... So it’s word of mouth, it’s reputation and we will go and obviously assess that supplier ourselves.” | HIGH PRIORITY PLACED ON FINDING THE RIGHT PEOPLE. To get started on OSM, lead firm decided to position itself as “the” preferred employer: “It’s all around about setting up people around the community of what people would bring on board. What’s the training skill? What’s the employer of choice meant to be like? So we’ve done a lot of that planning upfront, really saying what is the business going to look like?” |
| Overall resistance of the supply chain (11)             | LOW LEVELS OF RESISTANCE. Lead firm and key managers presented OSM as something new, but nevertheless “I keep telling everyone that the technology is there, the supply chain is there.” Partners, though daunted by the newness, responded positively to the lead firm’s confidence by saying “saying “Yes of course we can do it”, [but then] “had to go away and work out how to do it.”  | HIGH LEVELS OF RESISTANCE. Lead firm and key managers presented OSM as something new: “...we start from ground zero...so forget all the rules that were put in place - - - and come and rebuild the rules with us.” Partners remained intimidated by the level of change: “And I think... the automotive guys ...we’ve spoken to and different other guys - they’re (sic) going to be hard to transition their mindset.”       |
| Quality of human actors enrolled (12)                   | SUCCESSFUL ENROLMENT OF COMPLETE TEAM OF QUALIFIED HUMAN ACTORS. “So we went out to the largest frame and truss manufacturers who had the best detailers in their, I guess, pool of employees. We went to a flooring company who had the ability and cashed up to be able to do all the independent testings that we wanted to be done. And we had the best engineers on board.”   | TENUOUS ENROLMENT OF SMALL TEAM OF HUMAN ACTORS, RECRUITED BASED ON FAMILIAL TIES. “So we’ve soft saved quite a few people that we want to bring on board...when we’ve got our financing resorted then we’ll start the on-boarding process, but we have probably five people at the moment that are fully dedicated, full-time... most of them are from my family...”  |
| Quality of non-human actors enrolled (13)               | SUCCESSFUL ENROLMENT OF CRITICAL NON-HUMAN ACTOR/ EQUIPMENT. “(Partner Company X has also) gone and actually bought and spent a couple of million dollars buying equipment ...Now, that puts them in a fairly unique position. because that means if someone wants to compete with it they’ve got to go and invest in this equipment...”   | UNABLE TO RECRUIT NON-HUMAN ACTOR/ EQUIPMENT. “...there’s probably two major things that prevents the banks from funding the equipment and one is that they don’t understand it and its specialised equipment, it’s new to the market, they don’t know what the resale value is...”  |

## CONCLUSION

The main contribution we have made is to implement CLDs qualitatively, in pragmatic ways that support the ANT goal of developing descriptions/ explanations of associations between actors in a network. We have explained how the qualitative mobilization of CLDs using the notion of conditions, along with an understanding of causality built on multiple determination, can be compatible with the qualitative assumptions of ANT. As a result of using this novel methodology, we made a second contribution: a detailed

conceptual understanding of what is involved in OSM collaboration at the network creation stage.

Figure 1 thus provides a multifaceted response and a detailed explanation to the question “What are the conditions that influence the successful creation of a collaborative network of quality human and non-human actors for innovative OSM initiatives?” The detailed causal chains in Figure 1 can, in future work, become the basis for detailed narratives which, being endowed with significant interpretative flexibility, can be used as the basis for developing a wide range of practitioner material. In our study, we have begun to use Figure 1 for the development of training materials to develop collaborative capacity in the industry. That said, this study also has a few key limitations. First, our findings were limited to discussing network creation. This is not because it is the only important stage, or even for that matter a clearly and separate ANT stage, but because of space limitations. Second, we are not making the broad claim that the use of CLDs and ANT are always epistemologically compatible. Positivist mobilizations of CLDs may not be compatible with ANT, but because this study uses CLDs in non-positivist ways, it is beyond the scope of this study to work out if such a reconciliation is possible.

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# WHAT'S THE BENEFIT - A PERSONAL STORY OF A RESEARCHING MANAGER?

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Reflecting on my auto-ethnographic study over the last 5 years I seek to explore if and how pursuing auto-ethnography impacts on the work of a practitioner like me. I try to highlight how my research efforts also contributed to my managerial practice. Reflecting on my field-note writing and exploring a single field-note I show how pursuing auto-ethnography caused a shift in my thinking from straight forward problem solving to problematizing and the appreciation of alternative views. Doing auto-ethnography required me to observe not only my environment but also myself and to write about both. The writing triggered a reflexive process of ever deeper questioning of my own conduct and role within my business. I realised the how little I know and that there are always alternative interpretations of events. In turn, I understood that I should not search for the right way to solve problems but instead stay open and attentive to alternative interpretations. I developed a deeper understanding of the limits of my knowledge, scepticism about it, and an openness to alternative interpretations of my experiences. This form of reflexivity supports me running my business more adaptively. Through auto-ethnography I achieved this form of reflexivity and therefore it had a positive impact on my managerial practice.

Keywords: auto-ethnography, practitioner-research, practice relevance, education

## INTRODUCTION

I write because I want to find something out. I write in order to learn something that I did not know before I wrote it. (Richardson 2001: 35)

After almost five years of my doctoral journey, I wonder what I have learned over this period. I would not hesitate to say that I learned something but when I ask myself: 'Honestly, what did you learn and was it worth all the effort?' I begin to struggle to find proper answers. My feeling says that it was a worthwhile experience but is this just a feeling or more? To answer this question, I seek like to reflect on my auto-ethnographic journey more thoroughly.

Back in 1999, I started my own construction business, which employs now about 40 people most of them bricklayers and carpenters. In my position as owner/CEO, I fulfil exclusively administrative tasks. A big part of them is to negotiate on an almost daily basis. Since I did not always achieve what I expected to achieve in these negotiations; I developed some interest in the subject of negotiation. Out of this interest in negotiations and a vague desire to learn I embarked on a part-time doctoral program.

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My research project is an auto-ethnographic study into trust and negotiations. Predominantly, I study my experiences as a businessman. Drawing on Emmanuel Lévinas' work, I seek to understand how and why we trust. Within this context, I realised that pursuing postmodernist informed auto-ethnography deepens my understanding of my role as business owner/CEO. Therefore, I am focussing on the learning of and the benefits for me as a practitioner in this paper.

I start by looking at the 'cost' of being researcher and practitioner; then I explore my field-notes and reflect on an example in depth. I seek to answer how the auto-ethnographic work had an impact on my professional work in business. Doing so I will understand whether my auto-ethnographic journey was worth the effort seen from a professional perspective.

## **COMMITMENT**

Running a business is a full-time job. Before enrolling into the PhD program, I worked 50-60 hours a week. I often spent 3-4 days in office and the rest on building sites or in meetings. To squeeze in this schedule a PhD, I inevitably needed to cut some time out of it. It is more easily said than done. What kind of tasks may I delegate to others? Which meetings may I attend and which not? During the intense research phases, I spent most weeks only 2 in office the rest of the week I attend business meetings, visit building sites, and work quite long hours in the library on my PhD. Most Fridays and almost all Saturdays I work in the library. However, Sundays are sort of 'holy' - no work, no research, just family.

The time I spend in office and on building sites has significantly decreased which turns out to be problematic because it meant less connection to the daily business in my company and my staff. Still, I need to some extent overlook and understand what is going on in my business because I am the one who steers the vessel called the company. Of course, I rely on others to fulfil their responsibilities; I rely on their accounts to take decisions. Although I provide my staff with freedoms to decide, certain decisions stick with me. I always liked to take these decisions on a broad base of information. However, the broadness of my information has been compromised during the years I studied for the PhD. I simply spend not enough time in business. It resulted in losing control of things in my business; I had to hand over responsibilities. But on the other hand, I do explore my business practice more thoroughly by which I gain control but in another sense. Since, this ethnographic exploration consisted of observing, writing, and reflecting I gain new insights into my role and my business.

## **WRITING NOTES - THE PRIMARY TASK IN FIELDWORK**

Participating in the activities of and observing one's field of research is common to all ethnographers. Writing field-notes is the common means of recording these observations. The difference in auto-ethnography is that the auto-ethnographer's field of research is his or her own environment - her or his 'backyard' (Wolcott 1999). It is my construction business and me in my role as owner and CEO. My experiences, what I do, think, and feel is the content of my field-notes. When I get time and energy, I sit down on the computer, tablet or phone and write. It often happens in the evening. Sometimes, I use my voice recorder and talk my initial thoughts into it and transcribe and expand them later. It is almost like writing a diary.

By writing about myself, I am forced to observe and to think reflexively about my actions. Doing it properly, I inevitably come to the point where I question my actions and their impact and repercussion on the people around me.

## TENDENCY TOWARDS THE NEGATIVE IN FIELD-NOTES

Skimming through my field-notes without going into too much depth, I realise that most of them deal with conflicts, frustration, bad mood, anger and so on. It looks as if my business life were a mixture of frustration, anger, and conflict. But it is not. I am very often quite satisfied with what I do in my job. Although I am sometimes disappointed with some staff members, most the time, they do a pretty good job; most of my clients are fair and honest; to work with the majority of people in and around my business is great fun. However, as long as everything runs fine it does not make its way to my field-notes. I am not the first to recognise the tendency toward the negative or problematic (Illouz 2015) but why is that so?

One aspect of it might be that the positive experiences do not bother me too much. I am much more moved by frustration and anger than by joy and success. Am I taking the positive for granted? Emerson, Fretz and Shaw (2011) advise ethnographer to follow their sense of significance, to follow what they think or feel is important. But it is perhaps at this point when this sense fails to some extent. Of course, the negative emotions are not insignificant, but neither are the positive ones. Without some joy, fun, success, and satisfaction running my business would be a pure hardship, but it is not. Most days I like to go to the office and enjoy myself in my role as CEO.

Further, it is perhaps the engineer in me that focusses on the problems. Positive experiences do not pose a problem to be solved; there is not a lot to improve. But with negative experiences things are different. Here the engineer in me can do something. As an engineer, I am trained to solve problems rather than problematize positive things. Hence, I focus on the things which do not run well and try to make them work better.

Another aspect is that I am not as moved by the positive things as by the negative ones. When I clients praise our work, emphasises the value of our relationship, and pays the bills in time, I do not have to worry. But if the client does not like our work, sees no value in our relationship, and stops paying our bill that becomes a problem very soon. The profit margins in the German construction industry are not too big. A margin of 3-5% of turnover is the average. Hence, an unpaid invoice can become a major setback. When two or three clients are not paying their invoices, the annual profit can be jeopardised rather quickly. In this sense, Emerson, Fretz and Shaw's (2011) sense of significance seems to guide me to what is important but although numbers and profitability are very significant to businesses they are not everything.

In field-notes, this turning away from numbers takes place very fast. It is often the case that my field-notes begin with a problem related to economic issues. For instance, a client does not pay the bill; our offer is too expensive, things go wrong, and we lose money. But the field-notes often turn away from the purely economic issues to the human side of my enterprise (McGregor and Cutcher-Gershenfeld 2006). Events of economic significance often triggered my writing, but the possible ways to deal with the problem I found in the rather social, inter-human realm. I try to demonstrate a shift in emphasis by the following journal entry.

*Autumn/Winter, 2015/2016 - Context assembled from notes of previous days:*

*A couple of days ago, rain went through the provisional roof at this building site. The other company commissioned with the demolition work had built the provisional roof in spring. It was a wooden framework with a cover of waterproof polypropylene membrane. Throughout the summer, the membrane was exposed to intense sunlight, and this fact took its toll on the stability of the membrane. Now it was not strong and durable anymore but crumbling and porous. Although it was not our job to maintain the roof, we had to lift it at the edges to*

*build our walls and a concrete ceiling. Because we touched it once, the site manager sought to hold us accountable for the incoming water from the rain of the last days. Which meant, he wanted us to become liable to the client for significant damages. Within this background, I wrote*

*Field-note*

*In case something goes wrong all the responsibility lies with the one who took action. Like in this case. It seems as if the site manager did not care for the provisional roof. I think he should have let someone replace the crumbling membrane weeks before. Only now he realises that he missed some of his responsibilities. With his back to the wall, he is actively shifting responsibilities to us. Perhaps we should make clear to him: that won't work. He cannot put us forward in order to obscure his responsibility. But on the other hand, we had told him that the membrane had to be replaced, but we could have mad much more noise, we could have insisted on replacing it. But we didn't.*

Within this field-note, I already began to reflect on the writing itself. Some lines further down within the same field-note I began to look at it from a distance. I wrote:

*What happens some moments ago was a quite good example of how auto-ethnography works for me as a business practitioner. By describing the event, writing down observation and experiences, noting thoughts, I inevitably ask myself about the underlying reasons.*

I am confronted with the things I do not understand. I can write them down, and the very writing is a sense-making process.

## **MAKING SENSE OF MY EXPERIENCES**

I write because I want to find something out. I write in order to learn something that I did not know before I wrote it. (Richardson 2001: 35)

The journal entry was my way of making sense of my experience - a form of writing as a method of research (Richardson and Adams St. Pierre 2005). Richardson and St. Pierre use it for research purposes; in my case, although my commitment to pursuing auto-ethnography triggered the writing, it served me as a way of understanding situations I faced in business. Predominantly writing served my business ends and the research outcome became secondary; sort of a by-product.

There are quite a few notes which I created in the middle of the night. I pulled out the laptop, iPad or phone and write something into my Evernote notebooks called 'field-notes' or 'journal.' It serves me as means to calm down. The issue at hand leaves my head and goes into the words I am typing. I write what I think, however immature and little thought out this might be. But the ideas develop while writing. Often, I compare the recent experience with older ones, look for patterns. Sometimes I develop alternative explanations. Quite often I come up with a course of action for the next day(s). I go to bed afterwards having relieved my mind from thinking about the issue because I figured out what to do next (Ellis 2009).

While writing field-notes or journal entries, I am not so much interested in the research questions which steps in the background and become a by-product of these sessions. The main purpose is the relief. I want to get the problems off my mind, not to be bothered by confusion anymore. It is the writing through confusion and anger and finally coming to grips with complexity which Adams (2012) describes. Still, I am aware that even years of writing will not bring me to final closure (Adams 2012). I am aware that in future, I will still be stunned by how others act and will have my difficulties dealing with it. But the skills of writing, especially reflexively writing will help me to cope with future challenges and to think of ways to progress. It is action research for me as an individual (Ellis 1999).

Although, I come up with ways of dealing with problems auto-ethnography reaches deeper; it always goes beyond what seems obvious. It is in the example above first about the damage caused by the broken membrane, then about site manager's conduct, and finally about what we could have done differently or how we could solve the problem. Re-reading it, I cannot help but think about possible implications for future projects. For instance, whether we as a company should act more proactively, should I have trained my staff more in this regard, should we take a more responsible approach as outlined in the last section of the field-note above when I think about whether "we could have made much more noise". Then it is going beyond what seems obvious. It is the second, third, or some later thought that might reveal insights, valuable for me.

Writing about an event, I often come to different possible interpretations. Not too long ago, I sought to solve a conflict with several parties involved. The house owner, his lawyer and his architect, my material supplier, and I met months before to discuss and to work out a solution to some cracks in the walls of a house. After a couple of months with only a little or no action between the parties, a single phone call I made triggered an exchange of emails and letters. One of the emails from the architect caused some anger in me because I understood the architect had an interest in undermining any settlement of the conflict. When I talked to another person involved in this conflict, this person's explanation was somewhat different addressing the email rather to an attempt to obscure the architect's accountability. However, both interpretations could explain the architect's intentions, both on their own but also together. It looks as if the picture became only messier for me, and indeed it did. But instead of calling it messier, I would prefer richer. Subsequently, I see future actions of this person through an additional lens - that of the other person's interpretation. Perhaps even more importantly, the second explanation did provide an example that the first explanation could be wrong or at least not the only possible. Therefore, any number of other interpretations might be possible.

The richness is a very valuable part of doing ethnography, and in particular doing auto-ethnography, I do regard messiness, not as problem or threat, which I did before, but appreciate enrichment of my thoughts. By interpreting a situation in different ways, I create options for me and, hence, prepare myself better for possible twists and turns in unfolding processes.

I was not used to this way of thinking before. By the time, I started my PhD I wanted clear answers. I wanted to know who is accountable for what and hence hold this person accountable. This way of thinking was in line with the experiences I made during my time in business. It often boiled down to the question "Wer ist schuld?" [Who is guilty?]. I tended to search for a clear verdict - right or wrong. I thought in terms of finding "'the' answer." (DiCarlo, McGowan and Rottenberg 2014: 254).

This clarity is achievable about a technical question. I may say whether a concrete beam has enough iron in it to sustain the anticipated loads - I find "the" definitive answer. Regarding technical questions, my positivist thinking worked fine. But this thinking becomes very problematic regarding conflicts as the one briefly described above. I do not have objective data about the conflict - it's all my tainted perception - and it is only limited 'data', it is only a small fraction of the whole conflict that I can observe at best. Every claim to know something must be followed by an "as far as I can see" and "in the way I see it." I had to adopt another stance; I had to search for "'an" answer.' (DiCarlo, McGowan and Rottenberg 2014: 254) Soon, I realised that postmodernism worked better for me in relation to human interaction.

## **RELEVANCE TO PRACTICE**

Antonacopoulou (2010) talks extensively about how to create practice-relevant research. To her, scholar, business executives and policymakers practice research in their own fashion. Important to her is the collaboration of them. This gap between researcher and business executive is in my case inherently close. From time to time, I wear the researcher's or the CEO's hat, put more emphasis on being one or the other, yet I am always one person with only one mind.

Then, I do not think about knowledge-transfer. I am not transferring anything to anybody. What I do is applying knowledge from one field - that of research - to another field - that of my business practice. When I learn a skill like reflexivity (this assumes that reflexivity is a skill which is debatable) or writing (which I would consider a skill) - so when I learn a skill for research purposes I do inevitably apply this skill wherever I find it reasonable and helpful. It is of course very helpful to apply rigorous argumentation when one deals with a lawsuit.

To develop a well-thought through argumentation is a feature of all research attempts; it is not particular of auto-ethnography. Special to auto-ethnography is to observe me, to write about myself and to think about me reflexively. To learn these skills is inevitable for an auto-ethnographer. Also, auto-ethnography is more about exploring. I tap an unknown potential; I enlarge my understanding of a situation, I create possibilities. It is not the limiting of 'the' answer but the opening of 'an' answer which leaves space for any number of different answers.

Finding an answer, however, had also a tranquillizing side-effect on me. Writing field-notes in the middle of the night had a lot to do with my emotional reaction to stress and conflict. Luckily, it did not happen too often, it was, however, my way of dealing with emotions. I found a way to calm down. For research purposes, I had to observe my emotional reaction, write and reflect about them (Grosse 2015). In this regard, being researcher and businessman made up for the practice-relevance for me. Others may find it at best interesting, inspiring or helpful but I am the one who benefits most when I learn to deal with my emotions. I use it without any intention to do research.

## **LIMITS OF KNOWING**

But, perhaps the most important part is not to know what I know, but to know the limits of my knowledge. What can I know? What can I see? What do I observe? What is the basis of my decisions? What do I not know?

Often the writing about an experience opens my view on how little I know about the event. I have just seen what happened in front of me. With some luck, I may have an idea of the other players' context. But then the limits of my knowledge become visible to me. I just know very little of them, even if we have a long history of common projects. Even if I have the feeling to know them quite well, the other always escapes my grasp (Lévinas 1961). I am not the architect or the supplier and will never be. Hence, I will never know what it feels like to walk in their shoes. It situates my knowledge as a subjective and inherently incomplete matter. I know only from sensing others in our interactions. I am always a subject that claims to know, but whether I know, anything remains to be seen.

Over the last five years, my very focus has shifted. Using a metaphor, I went into the bedroom looking for red sock and guess what I found, red socks. That happened to me as ethnographer as well. I looked at negotiations and had the concepts of cooperative and

distributive negotiations brought forward by Fisher and Ury (1981) in mind. And of course, I saw them reflected in my field-notes. Later, I thought more about trust and trust was one of the observations in the field. Later I 'observed' what Lévinas (1961, 1974) termed Same and Other, Saying and Said while reading in his works.

These shifts in emphasis are what guides my observations. Richardson (2001) talks about colleagues although they were claiming to write from a neutral position they wrote about issues which touched them personally. It is very similar in my case, I wrote about phenomena I read beforehand. I wore some special glasses. That is unavoidable; I am never free of these influences. Prior interpretations of the world shape later ones (Iser 2000). However, the more I think about it, the more I understand how limited and tainted my vision is.

Applied to my daily work, it alerts me to jump too fast to conclusions. As I had one interpretation of the architect's action in the conflict, after the phone call I became aware of another person's take on his actions. However fast I may need to act in urgent situations, I must be prepared to revise my course of action. There is always something, what I cannot see. Every conclusion I draw is only temporary and is in itself the source of and subject to scepticism (Lévinas 1974). This scepticism is not going away - which is a good thing - because I do not need to search desperately for 'the' answer. Perhaps, the architect's motives are something completely different. I do not know and probably will never know. That gives relief, although I keep on asking.

It does redirect me to McGregor's question "What are your assumptions (implicit as well as explicit) about the most effective way to manage people?" (McGregor and Cutcher-Gershenfeld 2006: xxiii) Is it really about effectively managing people? It sounds as if people were objects to be moved from here to there. It is a view of people - human beings by the way - that I find more and more difficult. The others around me shape my own self without them I would not be what I am (Lévinas 1961). Hence, I am required to respect their otherness. I am supposed to let them be individual human beings.

My thinking shifted from trying to control others to the idea to live and get along with others. I began by searching for a way to negotiate with other so that I am more successful (as I termed it at the start of my journey). The idea behind was clearly to get the things I wanted to get. I sought to control the negotiation process and therefore control the business partners, clients, suppliers, employees, etc.

After five years of auto-ethnography, for me, management is essentially not so much about control and power as it is about navigating. I may have the power to choose between alternatives, but I seldom have the power to create alternatives. These alternatives are to some extent given. The power that lies with me is to discover these alternatives. I may react to a given context, which I may influence to a very small extent, but which has a lot to offer to me. I can decide which action I take, which route I go. Doing auto-ethnography did contribute to my ability to observe, to uncover, and to judge. This shift from "the" to "an" answer is, as Wolcott (1999) says, a way of seeing. Auto-ethnography is for me not about finding the solution but finding new possibilities (DiCarlo, McGowan and Rottenberg 2014).

More than a single answer, the multiplicity of perspectives is the richness of auto-ethnography. 'The' answer is a form of control. While reading Lévinas (1961, 1974), the notion of controlling people became more and more problematic to me. Controlling others is to make them like me. It is not only unachievable; it is very undesirable. Others are an infinite spring of inspiration as long as they are not like me. The other sees things

differently, the other challenges my worldview, the other is what I am not and therefore valuable without limits for me.

For example, most of my employees are craftsmen. Although I am trained carpenter, I would not call myself a craftsman anymore since I finished my training 24 years ago and had not worked as carpenter ever since. I have some idea what it means to work on building sites, yet the experience and the skills are not present to me anymore. By this difference, they can provide me with insights into the work on building sites which would be otherwise hidden to me.

My professional work is often demanding in psychological and emotional terms, but it is not demanding in physiological terms; for my employees, it is often the other way around. They are tired of lifting heavy materials. Neither of us really feels the way the other does. But trying to make me aware of that difference can help me to appreciate their work. One must not forget, they make it possible for me to research.

Only through our differences, it makes sense to cooperate. I have the skills to work as CEO of my company, and they have the skills to build foundations, walls, ceilings - that I have not anymore. We can find common ground. This common ground is the appreciation of the Other, the very act of taking responsibility for the Other.

## **THE SUBTLE KIND OF PAY-OFF**

Da steh ich nun, ich armer Tor! Und bin so klug als wie zuvor. (Goethe 1979: 17)

I tried to demonstrate a development within myself during the last five years. I learned a lot, but still, I feel like Goethe's Faust - "Here, I am as clever as before." Although I reach a deeper understanding of my environment, I am as often puzzled as I was five years ago. The difference is that I know that it is not going to change. I cannot achieve a full understanding of my environment. I see the world in a peculiar way, and each other person does see it differently. It is just impossible to understand the infinite other readings of the world. That does not mean that I am not interested in others' interpretations, but I am not desperately trying to make sense of their action. I know the Other "is not wholly in sight" (Lévinas 1961: 39).

I rather direct my efforts to be comfortable with my lack understanding because I am supposed to work with people on our building sites which are different. And who in the end escape my final influence, I do not have them at my disposal. Functioning of the team is then less my control over them but rather my way of dealing with them. I want them to achieve something - something with which I am comfortable.

For me, it took time to appreciate the messiness, the richness and I must admit it was not always easy as some field-notes in which I just had let off steam show. Still, I fall back into believing that there is a silver bullet to solving conflicts, although I learnt there isn't one. But to see that I am never completely 'right' and that the notion of 'right' is very problematic indeed demands more tactful acting (Van Manen 1995) and some forgiveness. If my best efforts do not lead me to do the 'right' things how can I expect others to do what I think is the 'right' action? If they do not act as I expected, I must be prepared to revise my interpretation and forgive. Not that I must forgive everything, but if I cannot unambiguously answer a question, I cannot judge someone's action unambiguously. Hence, there must at least be a bit of forgiveness. That leaves the space open for maintaining and rebuilding relationships.

## SUMMARY

During my research journey, I constantly changed the researcher's and practitioner's perspectives. Often research stepped in the background and became a by-product. Field-note writing initially used for research purposes turned out to be of great value for my professional practice, even dealing with daily struggles. Using auto-ethnography, I learnt, to be attentive, to write, and to think reflexive. Whether a manager needs write is not up for debate. In recent years, scholars emphasised the use reflexivity or critical reflection in management (e.g. Rigg and Trehan 2008). Following them, my personal experience confirms that the ability to pay attention and to be reflexive are essential management skills. So-called soft skills are required to manage building site and construction businesses. Observing is the foundation for any appropriate reaction to changing circumstances. Doing auto-ethnography trained me to observe not only others but to be attentive to my own actions and reactions. This connection between the self and the environment makes it possible for me to be reflexive.

On the one hand, reflexivity gives me some sovereignty to admit that I lack some knowledge or skill that I am not always in charge and on top of things. I become aware that my observation may lead me to conclusions which no one shares. Observing myself did not make me a better manager, but more conscious of my own shortcomings even to the extent that I recognise that I will never be fully aware of my shortcomings. There will always be a more appropriate way of doing things than the one I chose to go.

On the other hand, auto-ethnography opens a vast array of alternative understandings of my environment. Reflexivity forces me into a recurring scepticism. Hence, I permanently search for and deal with alternative views and interpretations of events. Seeing myself and my business within an environment of ambiguous and sometimes obscure relation makes a difference to the way I approach my role. My thinking shifted within this five years from wanting to know 'what's right and wrong' to 'what's appropriate'. Further, I think more in terms adaptation to things I do not know.

Pursuing auto-ethnography is not the only way to come to this understanding but it is the one that I chose, and that worked for me and my professional practice. Hence, I can recommend it to other managers if they are keen to embark on a reflexive journey.

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# JOINT VENTURE HOUSING PROJECTS IN DAR ES SALAAM CITY: AN ANALYSIS OF CHALLENGES AND EFFECTIVENESS

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National Housing Corporation (NHC) a public sector in Tanzania, adopted Public Private Partnership (PPP) strategy since 1980s, with the aim of re-developing its condemned buildings, increase its property portfolio and market share. However these Joint Venture (JV) projects encountered a number of challenges causing some projects to fail. This study aims to identify the challenges and assess the effectiveness of NHC-JV projects. In other words the study entails to know if the JV projects were beneficial to the corporation and the public at large. The following criteria such as quality of buildings increase in rental income, tenants' satisfaction and timely completion will be used to measure the success. A mixed method approach was used to collect data. The sample was purposely selected. The study was further reinforced by theory of constraints and equity theory. The obtained findings indicates that NHC-JV projects were not as effective as planned due to non-adherence to the rules and regulations, bad determination of initial shareholding ratio, weak contracts and inadequate management of the projects. Nevertheless some benefits such as improvement of the quality of buildings and increase in rental income were realized. Hence, this study recommends careful selection of potential partners, close monitoring and evaluation of projects.

Keywords: joint venture, housing projects, partnership, Tanzania

## INTRODUCTION

The current National Housing Corporation (NHC) in Tanzania is the outcome of the decision of the Government to dissolve the Registrar of Buildings (RoB) through Act of Parliament No. 2 of 1990. Under this Act, the responsibilities of RoB were vested with the new NHC. The Corporation was charged with the responsibility of providing and facilitating the provision of houses and other buildings. Generally, the establishment of NHC was a government response to mitigate the alarming housing problem that faced the majority of African urban dwellers. In this respect, NHC was charged with the role of providing affordable housing to the urban poor, redeveloping the acquired buildings due to the fact that most of these buildings were constructed during the colonial era and were therefore dilapidated and classified as condemned.

Between 1962 and 1974, the Corporation constructed a total of 14,145 housing units under slum clearance, rental and tenant purchase schemes. At that time the NHC

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financed its projects through various ways including, Government subventions, grants, equity funds and loans. Between 1975 and 1989, the NHC managed to construct 1,894 housing units. This decrease was attributed to the government budget decline, increased construction costs and high inflation rates that resulted from economic crisis. The figures indicate that the contribution of NHC to the housing sector after 1974 was not significant. Consequently, the units constructed were very few as compared to the population influx of people in urban (Kavishe, 2010).

In Dar es Salaam, for instance, most of the buildings in the city centre were proxy to condemnation and others including Alcove premises were condemned which means they were unfit for human habitation (Maagi, 2010) The run-down buildings in urban centers made the area look ugly. Furthermore in 1992, the government issued Circular No. 1 which required public parastatals to operate commercially (NHC, 2006) Thus, no more subsidies were given to NHC. Hence, the above reasons stirred NHC to adopt Joint Venture (JV) strategies as a means of redeveloping its estate. Therefore this study seeks to identify the existing challenges and assess the effectiveness of these projects in order to reveal if they were beneficial to NHC and the public at large.

### **Historical Context of NHC's Joint Venture Projects**

#### *(a) Before the Repeal of the 1971 Acquisition Act (1980 - 1990)*

The strategy for redeveloping prime plots hosting condemned buildings in partnership with potential real estate investors was initiated by the defunct RoB during the 1980s. This institution devised a public- private partnership in this endeavour. Later on the strategy also involved buildings which were no longer in conformity with best land uses. During this period a number projects were implemented. However, at that time there was no clear JV policy to guide them. As such, the terms and conditions for participation in these undertakings varied from one project to another depending on the cost magnitude of an individual project. To a greater extent, the terms and conditions were holistic, governed by trust between partners.

#### *(b) After the Repeal of the 1971 Acquisition Act*

After the repeal of 1971 Acquisition Act, and the enactment of the NHC Act No.2 of 1990 at the time when investor's confidence in economic liberalization was gaining roots, there was increasing pressure from private investors seeking to invest in commercial property development in partnership with NHC. The influx of prospective investors necessitated the need to have guidelines/policy that would spell out terms and conditions of participating in JVs with NHC. Hence, the first version of the JV policy was approved by NHC Board of Directors on June 11, 1993 (Kavishe, 2010 and Maagi, 2010). Henceforth, the Board of Directors had a mandate to make improvements on this policy whenever such a need arises. Since then the NHC has executed a substantial number of projects under JV strategy currently recorded as 187 projects (Maagi, 2010).

However, the decision of NHC to enter into JVs with the private sector for redeveloping its plots has raised an alarm among the members of the public as to whether NHC adequately benefits from this arrangement. Similarly, widespread delays in completion of projects are another point which raises questions as to whether NHC benefits from such projects. The society also goes further to query whether the projects have significant impact on real estate development sector. It is along these lines that, this study intends to examine the JVs challenges and their effectiveness.

## **THEORETICAL FRAMEWORK**

Considering the widespread delays in completion of projects experienced by NHC-JV projects alongside other challenges, Theory of Constraints (TOC) and Equity theory provides the theoretical departure of this study. According to Mabin (1990) the major component of the TOC is the Thinking Processes (TP) because it provides a road map for change by addressing three major questions; (1) What to change (2) To what to change to (3) How to cause the change. Equity theory refers to a situation where a partner assesses its own inputs and returns against the other partner's in an alliance Adams (1965 cited in Zhang and Jia, 2010) and Scheer *et al.*, (2003). If a partner notices some inequity in the relationship will respond negatively.

## **LITERATURE REVIEW**

JVs has been referred to as the collaboration of at least two organisations or business with the aim of sharing resources, knowledge and risks in order to accomplish mutually agreed objectives (Abd-Karim *et al.*, 2014) The JV partners considered in this study come from different sectoral background and these are public and private sector. A study by Li *et al.*, (2005) acknowledged JVs as a type of Public Private Partnership (PPP) For instance a recent study by Akintoye and Kumaraswamy (2016, p.6) defines PPPs as "joint ventures in which business firms co-operate". But it is worth noting that not all JVs are PPPs.

Drawing from previous studies JVs have become popular for a long time both in developed and developing countries (Adnan, 2008 and Ma and Voo (2014) Likewise a study by Hong and WM Chan, (2014) confirmed that, over the past two decades there is an apparent growth of research on JVs due to their increasing popularity. Growths of technology, access to new markets, competitive challenges, government policy, business capacity, or economies of scale have formed part of the increasing JVs (Adnan and Morledge 2003 and Abd-Karim *et al.*, 2014).

A comparison study undertaken by Ma and Voo (2014) identified four major reasons for establishing JVs in Malaysia including sharing of risks, resources, experience and the transferring of technology and knowledge whereas in Australia three reasons were identified including; transferring of technical expertise, sharing of resources and attaining financial support. In Tanzania the major reason for the NHC to form JVs with the private sector was mainly lack of funds to redevelop their condemned properties and the fear of losing their condemned properties (Maagi, 2010 and Kavishe and An 2016) Experiences from other countries demonstrate that the struggle for promoting land market, meeting housing demands for different group of people especially deprived ones, improving public services and enhancing the private sector in promoting property markets are among the reasons which influence creation of JVs (Sengupta, 2006) It is observed that reasons for creating JVs in the real estate sector may vary locally, regionally or nationally depending on the projects goals.

Since JVs involves two or more different organizations with different values and culture, managing and monitoring of such projects and sharing decision making makes them difficult and very challenging (Adnan and Morledge, 2003) A review of literature has identified a number of studies which have reported on the challenges leading to poor performance in JVs (Minja *et al.*, 2013; Abd-Karim *et al.*, 2014; Ma and Voo, 2014) For example, a comparative study between Malaysia and Australia demonstrated that, "difference in organization policies", "lack of mutual understanding between partners", "inconsistent management styles" and "lack of mutual agreement upon conflict resolution mechanisms are the key challenges in JVs (Ma and Voo, 2014) Whereas within the

Tanzanian context Minja *et al.*, (2013) identified the following as top three ranked challenges "identification of possible risks", "inability to interpret JVs agreement" and "operations by different contractors". A recent study by Abd-Karim *et al.*, (2014) admitted that "conflicts" is the main cause of failures in JVs. Additionally Mahmud and Zhi, (2009) identified 'obstruction', 'multiple or differed objectives', 'inadequate communication and coordination', 'governmental policies' and 'basis for determining ownership'. To summarise on the identified challenges, it is noted that human related issues (conflicts, incompatibility, disagreement, and poor communication) appear as the key challenges. Additionally, these challenges imply that, poor project management skills and partnership skills are the root causes.

Since the study also assess the effectiveness of the NHC-JVs, it is therefore important to consider factors contributing to JVs success. Numerous studies (Famakin *et al.*, 2012; Vivek and Richey, 2013; Ma and Voo, 2014; Alrashdan and Almujaed, 2017) have identified that partner selection, regulatory compliance, mutual commitment, trust and understanding, communication, compatibility of objectives; equity, appropriate risk allocation and management are key conditions to the JVs success.

## **RESEARCH METHODOLOGY**

The perspective of TOC as stated in section 1.2 support the need to undertake this study as it provides a road map for change. The aim of the study is to identify the challenges facing the NHC-JVs and assess their effectiveness. Therefore, to obtain the targeted information a convergent parallel (concurrent) mixed method approach was adopted. Questionnaire survey and semi structured interviews were used to collect data. The goal was to obtain different but complementary data to answer a single research question. The justification for adopting the mixed method approach is nested within its ability of increasing the validity and reliability of the results (Easterbrook *et al.*, 2008) and through offsetting the weakness of each tool (Kothari, 2004) The collected data was analysed independently and both the quantitative and qualitative methods had the same priority status (Molina-Azorin 2007).

Measure of central tendencies was employed to questionnaires and content analysis was used for interviews. Purposive sampling was adopted in order to obtain stakeholders involved in the NHC JVs projects in Dar es Salaam City. Also this approach has been widely adopted in public private partnership (JVs) research studies see (Zhang, 2005, Osei-Kyei *et al.*, 2017) The rationale for choosing Dar es Salaam as the study area includes: accessibility to conduct survey in order to obtain required data; also about 60 per cent of JVs projects, and NHC head offices are located in Dar es Salaam. Therefore the targeted population included NHC staffs who have participated in the JVs projects, NHC private partners and tenants. With the help of the NHC-JVs manager a total of 187 projects were identified but these were into different stages, 29 were completed, 48 were under construction, 100 were under preparation whereas 10 were stalled. However, in order to accurately answer the research questions only the completed projects were studied.

### **Population Sample**

Out of 25 questionnaires sent, 18 were returned as seen on Table 1 below. Responsive responses came from 1 Engineer, 8 Architects and 9 Quantity Surveyors who are construction related professionals thus enhancing the validity and reliability of the data. Tenants had poor survey response, some claiming to misplace the questionnaires and others not getting the time to respond. Therefore 4 tenants preferred to be interviewed

after several follow ups were made. Other interviewees were selected from the management staff of the NHC and private sectors. Due to private partners confidentiality aspects, only 6 agreed to take part and preferred the interview approach. While the questionnaire participants were NHC staff involved in similar projects and tenant of these NHC-JVs. The sample involved respondents of various levels of education attained, relevant working experience and positions at their work places. These characteristics were important as different categories of respondents might have different views based on levels of education, experience or work positions. The profiles of interviewees according to their positions were as follows: from the public sector interviewee A was a JV manager, B was a regional manager, C and D were JVs coordinators. From the private sector all 6 (E through J) interviewees were company owners (Managing directors) These position levels demonstrate that all interviewees were at management level and provided vast depth of knowledge on project management. Additionally their experience in managing JVs ranged from 5 to 20 years. This profile tells us that, respondents were qualified to provide the answers and hence enhancing the validity of the findings.

*Table 1: Summary of respondents*

| Respondents    | Questionnaires |          | Interviews |
|----------------|----------------|----------|------------|
|                | Distributed    | Received |            |
| Public sector  | 20             | 17       | 4          |
| Private sector | 0              | 0        | 6          |
| Tenants        | 5              | 1        | 4          |
| Total          | 25             | 18       | 14         |

## **FINDINGS**

### *Challenges facing the implementation of NHC joint ventures*

In response to the question about the status of the NHC-JV projects, it was specified that during the survey period NHC had a total of 187 JV projects which were into different stages: 29 were completed, 48 were under construction, and 100 were under preparation whereas 10 were stalled due to various reasons. This status clearly indicates the existence of challenges to its performance. Through open ended question respondents were further asked to identify the barriers inhibiting the delivery of NHC-JV projects from their experience point of view. These challenges were listed:

### *JV Policy flaws and loopholes*

The 2006 policy of NHC requires the partner to finance the project 100% while NHC contribution is limited to the project land which accounts for only 25% of the project costs. This blanket of 25% applies to all projects as NHC shares regardless of the magnitude and locality of the project. 60% of questionnaire respondents and all interviewees (n=4) from NHC admitted that, "JV Policy did not consider the valuation of land in determining NHC shares in JVs projects. Therefore 75:25 ratios were used to all projects regardless of the size and locality of the project". Also interviewee J who was a lawyer by profession stressed that, "NHC-JVs policy was inadequate because NHC is entitled to hold a 50% share in projects requiring big cash outlays, which NHC could not afford to finance. However, the policy stipulated for, NHC to start with minority shares of not less than 25% but with the right to acquire another 25% after 12 years. It was then revealed that some contracts stated that at the end of the 12th year if NHC fails to increase its share to 50% then the property will be fully owned by the private partner. These loopholes benefited most investors since NHC was not capable of increasing its

share within the stipulated time because of its poor financial situation. This finding agrees with (Mahmud and Zhi, 2009; Minja *et al.*, 2013).

#### *Project financing*

90% of the private partners admitted that financing of the JVs project was very difficult because of these given reasons: (a) Partners were not allowed to use the title deeds to acquire loans from the banks (b) The interest rates from the banks were very high (c) The financing of the project was 100% left to private partners (d) NHC as a public body did not make any efforts to support the projects or even secure subsidies from the government except on tax exemption on imported materials.

Equally interviews from the public sector claimed that some partners faced financial difficulties few months after the start of the project which led to delays, poor performance and unsuccessful delivery of the projects during project implementation. This happened as a result of private partners submitting false financial report implying mistrust. These results are consistent with (Maagi, 2010; Abdul-Aziz and Kassim, 2011; and Kavishe and An 2016) Example misinformation on private partner financial capacity was ranked the 5th and appeared significant.

#### *Risk sharing*

It was reported by Interviewee A and B that in most cases private partners tend to avoid risk in their business and in some situations they are not willing to take any risk element because they feel it reduces profit and may increase the possibility of failure. For instance interviewee A highlighted that some risks were not identified similarly most private partners were not willing to invest in other regions apart from Dar es Salaam and Arusha due to fear of market risk. This finding was also ranked first in the similar study from Tanzania (Minja *et al.*, 2013). Equally, a Malaysian (Mahmud and Zhi, 2009) study identified similar finding.

#### *Loss of rental income*

Respondents from both the public (n=4, 100%) and private (n=4, 66%) commented that NHC loses more rental income from the properties committed to partnerships. The loss occurs when NHC terminates tenancies and demolish properties while financiers are not yet ready for takeover or when there are delays to accomplish the construction process. This challenge implies lack of adequate planning and communication as is ranked 1st in Kavishe and An (2016) and poor risk identification as attributed by Minja *et al.*, (2013) Thus, NHC should put in place a clear strategic plan that will clearly describe the responsibilities of both the public and private partners. A good plan or contract will include a clearly defined method of dispute resolution.

#### *Getting vacant possession of plots resulted into conflicts*

Majority of the partners 90% attributed this has been a major challenge as tenants and ex-owners of properties refuse to vacate the plots or buildings even after being given official notice to leave. When redevelopment has to begin, still they continued to resist orders for vacation of premises. As a result, conflicts arises where the private partners have in most cases undertaken the role of evicting these occupants and this process has proved to be lengthy and costly as some cases were taken to court. In the literature review conflict appeared as a major challenge in JV projects (Abd-Karim *et al.*, 2014).

#### *Stalled projects*

The study also revealed that there are a number of projects which have been stalled as reported earlier mainly due to financial difficulties facing the partners. NHC respondents revealed that, their experience shows that most of the projects which failed to take off on

time belong to indigenous investors bearing in mind that partners had to finance the project by 100%. The aspect of poor risk management and financial incapacity further reveals their negative impact. Based on the equity theory, Scheer *et al.*, (2003) claims, equity improves firm's level of commitment and involvement, which promotes collaboration however he warned that a presumption should not be made that firms/parties always behave in line with the equity theory predictions.

#### *Poor communication*

All NHC respondents claimed that both JV agreement and NHC policy insists on mutual involvement of the partners in decision making in issues such as appointment of contractors and consultancy, share apportionment, property management etc. However, private partners tend to operate not in favour of the JV agreement and policy. The study observed that in many instances, partners make their own decisions over the project without involving NHC. For instance Partners may decide to rent part of stalled projects without NHC's consent. Furthermore it was noted that some private partners made changes on the design without getting public partner concern. A vivid example was proved in 2013 when the private partner was permitted to erect 10 floors instead the developer erected a 16-storey structure which collapsed and resulted into hazardous situation. This finding implies that NHC had inadequate project management and monitoring (Kavishe and An 2016) More so, private partners had the freedom to select their own contractors and make own decision on the JVs project. These findings also demonstrated the existence of 'inequity' from the Equity theory (Adams 1965 in Zhang and Jia 2010) among the Tanzanian NHC-JV partners.

#### *Assessing effectiveness of NHC JV projects*

Assessment of any project performance should consider whether there are areas or indicators of changes and improvements that benefit the beneficiaries of the project. It further considers how well the production of project results contributes to the achievement of the project purpose. In this study context the success (benefits) of the NHC-JVs was measured under the following key criteria: (a) Property value (b) increase in rental income (NHC revenue) (c) tenants' satisfaction (d) Housing Development and (e) timely completion

#### *Enhancing property values*

Interviewee A and B confirmed that, based on the valuation report done in 1996 for old buildings by different valuation firms, values of the new buildings have increased over a hundred folds. The 2009 survey done by Proper Consult (T) Limited shows that the increase in value of new buildings see Table 2 are accredited to many factors including modernizing services and facilities of the building such as provision of swimming pools, air conditioning, lifts and other facilities. It is no doubt that the JVs buildings are more worthy than the previous buildings constructed by NHC itself. This finding agrees with benefits identified by Norwood and Mansfield, (1999).

#### *Increase in rental income (NHC revenue)*

94% of questionnaire respondents identified that through JVs, the NHC managed to increase its rental income because the new properties were modern and new. This finding was further evident by Interviewee (A, B, C, and D) who attributed that, "the increment is facilitated by the privilege played by the private sectors as partners are able to charge market rent rates as opposed to NHC's rates". Table 2 below justifies the growth in rent considering the annual collection before and after redevelopment for second and third projects listed. Financial strength has been identified in the literature among the benefits for JVs (Girmscheid and Brockmann, 2010).

Table 2: Comparison of Property Market Values in 1996 and 2009 (Tshs' Million)

| Plot     | Location        | 1996  | 2009   | % increase | Annual rent before | Annual rent after |
|----------|-----------------|-------|--------|------------|--------------------|-------------------|
| 16/1-4   | Pugu road       | 198.4 | 4096.2 | 1964       | N/A                | N/A               |
| 39A      | A.H.Mwinyi road | 192.4 | 3100   | 1511       | 1,885.7            | 115,992           |
| 16&18/30 | Swahili/Naru    | 162.0 | 4831.4 | 2882       | 11,490.8           | 12,7920           |
| 92       | Dakawa-Chang    | 105   | 2100   | 1884       | N/A                | N/A               |

Source: NHC Valuation Reports of 1996 and 2009 Notes: Exchange rate (£1 = TZS 2786.76) as produced by OANDA website 05/03/17.

#### *Housing development*

As defined clearly in Section 4 of the National Housing Act No. 2 of 1990, one of the major responsibilities of the new NHC was to facilitate the provision of high quality houses and other buildings for use by members of the public for residential, business, industrial and other purposes. Interviewees C and D identified that by 2010 NHC managed to construct 234 apartments or units under JVs as compared to only 71 units that existed in the old buildings. The increment of housing units is about 230%. Residential units marked the highest increase in number from 39 to 181 units which is equivalent to 364%. This finding implies that, through housing development there is a boost to local economy as evidenced on section 4.2.5 and is consistent with Vivek and Richey, (2013).

#### *Tenants' satisfaction and environmental sustainability*

Most of the NHC plots committed in JVs are those which host abandoned buildings typically in poor condition. Interviewee respondents (tenants) claimed that rehabilitation and redevelopment of such buildings have brought them back into a condition that is suitable for human habitation. Tenants strongly affirmed that "NHC-JV properties are of better quality and standard compared to the non JV projects but the rents have also increased to reflect the value". On the other hand, the replacement of old buildings by rehabilitated or redeveloped new buildings has changed the impression and appearance of towns and has created environmental sustainability. Therefore these results supports the 2030 agenda for sustainable development (JVs considered as tools for strategic change) to successful achieve the 11th goal (Make cities and human settlements inclusive, safe, resilient and sustainable).

#### *Economic growth*

NHC JV projects have provided employment opportunities; add business premises, storage facilities and hotel apartments which promote the tourism industry. For instance, through JVs NHC built DURBAN and TANSOMA hotels located in the Dar es Salaam City Centre. JVs have significantly contributed directly and indirectly towards poverty reduction through raising individuals' income levels and increasing productivity of the labor force. This finding agrees with (Adnan and Morledge 2003 and Abd-Karim *et al.*, 2014)

#### *Timely completion*

Majority of partners acknowledged that JV projects experienced huge delays because of various reasons such as tenants delay in vacating the old properties, partners facing financial difficulties as well as incompetent contractors selected by private partners in order to save cost. It has been identified that majority (over 60%) of NHC JVs faced delays and some ended up being stalled for a long time. However, very few projects undertaken by committed partners were completed on time. For instance Interviewee E claimed to have hired strong team of consultant and clerk of work to report on daily

performance of work. The above findings are consistent with studies such as Adnan and Morledge (2003)

## CONCLUSIONS

The purpose of this study was twofold; firstly, to identify the challenges facing NHC-JV projects, and secondly, to assess the effectiveness of the projects. The identified findings have important implications for JV partners and managers. It was revealed that the NHC-JVs encountered a number of challenges including: inadequate financing capacity, risk sharing, loss of rental income, conflicts in getting vacant possession of plots, stalled projects and poor communication. Regardless of the existing challenges the study acknowledged that some benefits such as improvement of the quality and value of buildings and increase in rental income, tenants' satisfaction, timely completion and progress of housing development were realized. However, based on equity theory the challenges demonstrated the existence of 'inequity' among the Tanzanian JV partners with the private partners given the upper hand in dealing with the majority of the issues.

The study's results are expected to assist both local and international practitioners seeking to undertake JVs in Tanzania. Secondly, an increased awareness of the challenges affecting the utilisation of JVs would enable the practitioners to develop appropriate coping mechanisms for overcoming the identified challenges. From a theoretical perspective, the study enabled the testing and confirmation of the Theory of Constraints and Equity theories within a lesser investigated context of Tanzania.

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# INTEGRATING IPD AND EXPLORING POTENTIALS

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At the beginning of the 21st century, a new process innovation surfaced in the construction industry in the form of a new delivery system called IPD - Integrated Project Delivery. IPD has the potential to solve the construction industry's biggest problem of delivering a product that not only satisfies the client and users, but also the value chain. However, the knowledge of IPD and its five defining elements, contract, culture, organisation, Lean Construction and Building Information Modelling, is fragmented so the aim of this research is to integrate this and explore potentials. The method used is a thorough literature review. The results of this research consist of a detailed description of the IPD system and each of its five elements. The discussion revealed that IPD has a potential for being further integrated by perceiving it as a Virtual Enterprise and hereby enabling the use of experience and knowledge from business research. Furthermore, the discussion showed that IPD can act as an innovation supporter. Finally, the research concludes that a large unexploited potential within integration and innovation is recognised in the IPD system which can be unleashed through further research and experience with adaption and implementation.

Keywords: IPD, Integrated Project Delivery, innovation, virtual enterprise

## INTRODUCTION

The construction industry (CI) has a long and somewhat tiring history of falling behind other industries' performance in terms of delivering high quality products that fulfil client expectations on time, on budget and with high productivity. One of the main reasons for the CI's low productivity is its lack of innovation (Winch 2003) and the inability to fully satisfy client expectations due to buildings' evolvement from simple structures towards high-performance products (Fischer *et al.*, 2014). The OECD defines process innovation as: A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software, and the CI has undertaken several of these to accommodate the challenges. Some of these innovations are known as Design-Built, Partnering and Concurrent Engineering. All improving the CI's ability to deliver the products demanded by today's construction clients.

The latest process innovation within the CI is Integrated Project Delivery (IPD). This delivery system has the potential to improve project performance through a collaborative approach aligning the incentives and goals of the project team through shared risk and reward, early involvement of all parties, and a multiparty agreement (Kent and Gerber 2010). Kim and Dossick (2011) found that five elements, contract, culture, organisation, Lean Construction and Building Information Modelling (BIM), contribute to the integration of IPD. Furthermore, the Simple Framework Diamond (SFD) (Fischer *et al.*,

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2017) is represented through the elements by having contract as the framing integration agreement and the other elements working as fundamental nexuses for the four quadrants of the SFD, i.e. Lean Construction as nexus for quadrant 1, culture for quadrant 2, organisation for quadrant 3 and BIM for quadrant 4. Kim and Dossick (2011) say about the elements: these enhance one another's effectiveness such that the whole is greater than the sum of the parts, and Fisher *et al.*, (2014) elaborate on the contract itself: By itself, the IPD contract accomplishes little. Just as a skeleton creates the potential for motion by providing a structure, an IPD agreement creates the potential for success by providing structures that allow other elements of IPD to function effectively. Fisher *et al.*, (2017) finish with saying: These elements are supported by the integrated agreement that removes barriers to collaboration and enables the project team to function as a virtual organisation.

The IPD system is basically founded on the idea of obtaining the benefits from being and acting like one single company (Fischer *et al.*, 2017). To understand the IPD system, one could perceive it as a Virtual Enterprise (VE). The VE is a customer solutions delivery system created by a temporary and reconfigurable Information and Communication Technology (ICT) enabled aggregation of core competencies, like IPD. The core competencies come from people in different enterprises with a set of specialist skills and the knowledge necessary for the creation of a high value customer solution. ICT is what the CI refers to as BIM, and is, in the CI, an important enabler for the creation of a VE and hereby the Virtual Organisation (VO). The VO organises and structures the highly skilled people in the VE. Furthermore, the VO holds the adaptability to secure the competencies needed to deliver high efficiency and effectiveness in product design and production while, at the same time, delivering value for money.

Because the IPD system can be perceived as a VE, it is possible to use other industries' knowledge and experience in innovative delivery systems. This development is important because until now, several organisations have supported the advancement of IPD and provided insights and understanding (Thomsen *et al.*, 2010; AIA 2012). Several studies have demonstrated its benefits (Suttie 2013; Mesa *et al.*, 2016; Cheng and Johnson 2016), but the number of projects using IPD remains relatively small, and the major breakthrough has still not occurred. The IPD system's development and breakthrough have a large potential due to the change in competition taking place in the CI. Currently the competition is company vs. company, but the future competition in the CI will move towards supply chain vs. supply chain like other industries recognised decades ago. This future state can be seen as a paradigm shift within the CI. These supply chains have the structure of a VE with a VO. If these organisations want to survive, they need a competitive advantage and this is achieved through innovations. The innovations could be both product and process innovations, and the relative importance of these changes as the industry evolves. To enable these innovations, a strong support framework is needed. The framework should support and encourage ideation through communication, collaboration and a no blame culture, much like IPD.

The purpose of this study is to identify how literature has described and used IPD. The research focuses on the five elements: contract, organisation, culture, Lean and BIM, and on how these key elements are defining for the IPD system's current state. With an outset in a literature review which presented the five elements defining the IPD system, this research had the following research questions: A) How can integration of the project organisation and communication be accomplished by deploying the VE paradigm? B) Can IPD support innovation?

## METHOD

This research is based on a literature review. It explores and investigates how the literature in the CI treats and defines the five elements that make a project delivery system integrated. The five elements, found by Kim and Dossick (2011) and within the SFD Fischer *et al.*, (2017), are contract, culture, organisation, Lean Construction and BIM. The paper and book (*ibid.*) were used for initial research and ensured that the literature review was focused on the specified topic. The study was undertaken as analytical research, where facts and information from already available material are analysed and evaluated. The research was exploratory since the objective was to answer research questions and from these develop a hypothesis, rather than verifying it. This section presents the methodology for choosing, describing and classifying key elements and main concepts.

The literature study was structured into five phases to select and find relevant papers. The papers were, after each phase, divided into four piles A+ to D with A+ being papers used directly in this research. To form a base of evidence, Levy and Ellis (2006) were used as a guide to a secure a structured and valid approach.

In phase 1, primary keywords to be used in online search engines were defined. Keywords and search engines were selected based on the above-mentioned paper and book, prior experience and discussions with colleagues. Keywords chosen: IPD, Integrated Project Delivery, Integrated Project Delivery + name of element and construction and/or project + name of element. Online search engines chosen: Scopus.com, scholar.google.dk, IGLC.net and Business Source Complete. Phase 1 resulted in a total of 300 papers. Phase 2 focused on titles and keywords. Clear criteria for excluding papers for phase 2 were defined. Exclusion criteria: language other than Danish and English, IPD related content older than 2003. Phase 2 resulted in a total of 200 papers. Excluded papers went into pile D. Phase 3 consisted of reading abstracts. This phase did not have a clear criterion for exclusion. This phase was based on a subjective evaluation of the abstracts and thus the paper's relevance. Papers were included if they focused on IPD directly or addressed one of the elements in the context of IPD. Phase 3 included 40 papers. The excluded papers from phase 3 went into Pile C. Phase 4 involved reading the full papers. It had a subjective inclusion criterion and if doubt about relevance were found, the supervisor and academic peers would partake in the final decision. Phase 4 included 23 papers that went into pile A. Excluded papers went into pile B. Phase 5 consisted in reading references. This phase had identical inclusion criteria to phase 4. This phase found another three papers that were included in pile A.

To secure the quality of the 26 papers in pile A, metrics and indexes were chosen. The primary aim was to find peer-reviewed papers with a high impact factor level. Furthermore, the individual number of citations contributed to the full picture of quality. It was noticed that papers in the CI generally have low impact factors and other metrics and indexes.

The Thomas Reuters WOS and the Danish bibliometric indicator list were used as a supplement. Finally, the H-index of authors was used in combination with these metrics. The use of metrics reduced pile A from 26 papers to an A+ pile containing 21 papers, all used in this research.

## RESULTS

This section presents a literature review on IPD and the five elements. The literature used addresses one or more of the elements in or outside an IPD context.

### Contract

IPD is based on trust, collaboration, coordination, risk sharing and innovation (Fischer *et al.*, 2014). One of the key elements of delivering an IPD project is the contract between the participants. In general, two broad classes of contracts are used: transactional and relational contracts. Traditionally, Design-Bid-Build and Design-Build projects are based on transactional contracts, however, the need for relational contracts arises because the transaction costs increase due to the rising uncertainty and complexity in construction projects (Matthews *et al.*, 2003).

Traditional project delivery practise shows four consistent problems (ibid.): Good ideas are held back, limited cooperation and innovation, inability to coordinate and focus on sub-optimization by project participants. Relational contracts used for IPD projects can mitigate this by creating a contractual incentive for corporation through a shared profit pool. The shared profit pool is based on the contractual compensation structure in the relational contracts where profit is distributed according to all verifiable costs that each signing partner in the IPD project can present. Profit is calculated at project level at the end of the project and divided based on the contract controlled by the Core Group. This model creates an incentive for the whole project team to super optimize the project with respect to the project scope.

The Core Group consists of the representatives from the partners who signed the relational contract, and will include at least owner, constructor and design professional (AIA 2012). The purpose of the Core Group is to secure a successful project through integrated governance, management of information infrastructure and leadership of the organisational change towards functioning as an IPD project organisation (Knapp *et al.*, 2014). The number of signing partners often exceeds three because it enhances collaboration and brings important skills to the table (Cheng and Johnson 2016). The Core Group's size and skills should be closely examined because the Core Group's ability to work as a team is closely related to the IPD project's success (Seed 2014; Knapp *et al.*, 2014). The three main multiparty IPD contracts used today are the AIA Document C191-2009 created by the American Institute of Architects, Consensus-DOCS 300 created by the Association of General Contractors (AGC) in 2007 and, finally, the Sutter Health's Integrated Form of Agreement (IFOA). If other parties aside from the Core Group should be included in the agreement, modifications are needed. Procurement in traditional delivery methods uses appointment criteria such as low bid or best value total cost. The IPD contract uses qualification based selection where price is not a factor in the final selection criteria (Mesa *et al.*, 2016).

There are two risk allocation strategies according to Mesa *et al.*, (2016): shared risk and split risk. Traditional contracts use split risk among the project members. By using risk transfer, a culture of idealistic behaviour is reinforced and very little is done to proactively avoid risks by treating the causes of the risks (Fischer *et al.*, 2014). IPD contracts use the shared risk strategy where the client, the design team and the contractor collectively manage and appropriately share risks, frequently through a shared contingency (ibid.). Due to the risk allocation clauses in the IPD contracts, certain issues arise relating to project insurance among the project members. Traditional insurance

companies will not cover IPD projects due to the contract's no suit clauses (indemnification clause) (Fish and Keen 2012).

Disputes within traditional transactional contracts are often caused by the contract structure. The IPD system has a documented positive effect on conflict resolution (Mesa *et al.*, 2016). There is no formal conflict resolution method associated with IPD, but dispute resolution through discussion and agreement within the Core Group is beneficial (Matthews *et al.*, 2003).

### **Culture**

Culture can be defined as a social domain emphasizing the practices, discourses and material expressions of an organisation. Cultural change refers to the change of the construction industries' ability to change its traditional methods, as many architects, engineers and contractors are accustomed to their own narrow leadership. Cultural change is crucial for the realisation of IPD (Thomsen *et al.*, 2010; Suttie 2013). Open communication and trust form the basis for achieving high performance (AIA 2007; Chinowsky *et al.*, 2008). This was demonstrated by conducting a Social Network Analysis of information flow between project participants on a large-scale traditional construction project. IPD practices promote an increased number of participants in design and, thus, IPD increases the need for coordination and better communication in the project team (*ibid.*).

Involving team members in early goal definition and performance evaluation enforces the cultural change needed in an IPD organisation (Thomsen *et al.*, 2010). Trust, cooperation and a no-blame culture among the project participants are revealed as some of the most influential drivers of project delivery performance (Mesa *et al.*, 2016; Ghassemi and Gerber 2011). Findings show that successful IPD projects are achieved through proper selection and involvement of all main players as well as ensuring that these main players achieve trust in each other (Ghassemi and Gerber 2011).

### **Organisation**

An integrated organisation in IPD is a collection of people organised in an integrated structure that is aligned to the project. Essentially, it is a group of individual organisations - and their employees - that embrace a common set of values and goals and act as if they were one company - a virtual organisation we call the Project (Fischer *et al.*, 2017).

This integrated organisation is the key to efficient project delivery, which optimizes value for the client and minimizes expenses. In IPD, early integration of stakeholders and value creation are managed through integrated governance. IPD enables the client to use the whole project organisation (IPD's value chain) in the initial project phases (value co-creation) to discover needs, requirements and value within the project scope.

The IPD organisation needs to restructure the way in which sharing information is performed. Sharing information is the backbone of the IPD organisation. Information must remain consistent across all trades. One study found that architects and engineers spend 54% of their time managing information when they work in fragmented teams (Flager *et al.*, 2009). BIM, 3D visualization and Co-location are some of the tools to implement this infrastructure and advance information flow (Suttie 2013).

The IPD project organisation is much more efficient in handling changes than traditional project delivery methods due to the relational contract, organisational structure and its large flexibility enabled by common incentives (Matthews *et al.*, 2003). IPD's high

efficiency is proven in case studies where IPD systems and traditional systems are compared (Suttie 2013; Mesa *et al.*, 2016).

### **Lean Construction**

Lean Construction is an array of tools and processes that enable people to utilize their knowledge to design and produce products according to customer needs without embedding any waste. Cheng and Johnson (2016) conclude that: IPD sets the terms and provide the motivation for collaboration; Lean Provides the means for teams to optimize their performance and achieve project goals and (ibid.) further found that: The powerful complementary strength of IPD and Lean supports success.

Lean tools such as the Last Planner System and Target Value Design are usually brought in to the IPD contracts as agreed upon management tools (Knapp *et al.*, 2014). The unifying and complementary effect is achieved because IPD organisations acknowledge that IPD behaviours and processes (collaboration and Lean) are a result of choosing the right people and continued education (Ghassemi and Gerber 2011; Fischer *et al.*, 2017). Seed (2014) adds that the success also depends on choosing a project manager with a skill set matching the requirements of IPD projects.

Cheng (2016) concludes that IPD and Lean are effective, but the identification of the precise mechanisms for collaboration is still ongoing. Tillmann *et al.*, (2012) discuss Lean's importance for collaboration in IPD, and many case studies document how the synergy between Lean and IPD improves collaboration and efficiency in IPD projects (Fischer *et al.*, 2017; Cheng and Johnson 2016; AIA 2012; Kim and Dossick 2011).

### **BIM**

BIM is the digital tool that binds the information flow of an IPD system together and creates the platform for VDC, integrated information and collaboration. Fischer *et al.*, (2017) crystalize the connection between BIM and IPD: The importance of integrated information to IPD cannot be overstated; it is the backbone and the source of truth and insight ... There are several aspects of what we call integrated information which includes ... Extensive use of 3-D models, a robust information technology (IT) infrastructure...By using BIM, teams can make decisions after analysing many options, not just on the basis of a handful of options. BIM allows the team to explore many design options rapidly and consistently, discuss how different designs will add value (or not), and how they will affect performance targets. Simulation allows teams to understand the impact of a scenario later down the line, and begin either modifying plans, or prepare interventions to mitigate negative impacts and risks. Fischer *et al.*, (2014) also emphasise the importance of BIM's role in IPD projects with the argument that BIM binds human and technological collaboration together. Furthermore, case studies show BIM's decisive role in collaboration and communication within IPD projects (Fischer *et al.*, 2017; Cheng and Johnson 2016; Cheng 2015; AIA 2012; Kim and Dossick 2011).

## **DISCUSSION**

The discussion takes its outset in the five elements observed in the literature study. Focus is on framing the future state of IPD through two research questions.

### **1 - How can integration of the project organisation and communication be accomplished by deploying the VE paradigm?**

Whether an individual pursues own goals or common goals depends on the perception of how dependent each person is on others. If individuals experience the context in which they are included as interdependent, it is more likely that their goals will be positively

related to each other, and they will understand that fulfilling own goals is directly connected to the degree to which they help others achieve theirs.

In IPD projects, this positively related context is structured through the first element, the relational contract, which contains an incentive to pursue the described and wanted processes and behaviours. The challenge is to communicate this interdependent relational context to the whole IPD project organisation, insuring integration and coherence in the whole project team, and not just to the negotiating PMs from each IPD partner. Communicating this context means communicating the full content of the five elements in a simple and logical way. This can potentially be accomplished by deploying the VE paradigm, thus perceiving the IPD project as one company.

By perceiving IPD through the lenses of a VE, platforms used within the business world to communicate structure and goals become available. The platforms proposed are the Business Model Cube (BMC) (Lindgren and Rasmussen 2013) and the vision, mission and value statement.

The importance of a vision, mission and value statement to secure team coherence and results in IPD projects has been emphasised several times (Fischer *et al.*, 2017; Paolillo *et al.*, 2016), but the means to communicate the actual structure of the unique virtual organisation and enterprise (individual IPD projects) in a simple structure are missing. The BMC could potentially deliver the solution with its seven generic dimensions: 1) Value Proposition 2) Customer 3) The Value Chain 4) Competences 5) Network 6) Relations and 7) The value formula. Ashcraft (2014) furthermore states that understanding the business model of an IPD project is an important part of creating the right contract structure. The following section provides a short proposal on how IPD can be described through the seven dimensions of the BMC.

1) The value proposition in IPD is the value targets agreed upon by the IPD signing partners and the owner. 2) The customer dimension represents the customers' world and perception of construction, together with a clear view of the end user. 3) The internal value chain could be displayed through Porter's value chain. This model describes a range of support activities that enable primary activities. The drivers for the support activities could, in the context of IPD, be the five elements or even be partly found within these. The five elements of IPD would in Porter's model work as enablers for the primary activities which would be represented by each partner in the IPD's value chain. 4) The competence dimension highlights each IPD partner's core competencies, showing the whole VO how each of them bring unique enablers to project success. 5) The network dimension has a key message that is to explain that no business is an island, meaning that no company, whether they join an IPD project or not, is able to deliver high value to a customer alone. 6) This dimension shows that relations are used for creating, capturing, delivering and receiving value, meaning that every partner including the owner has a responsibility to deliver value to the project. The explanations of both network and relations should be done in the context of Lean and BIM explaining how the given project handles this. 7) The value formula dimension disseminates the whole incentive structure of the contract.

If the BMC were to be brought in as an integrated tool in the contract negotiations this would potentially lighten the task of integrating the project organisation and communication because using the BMC as an integrating tool for the VE and hereby the IPD could create continuity in the communication of the context described earlier.

## 2 - How can IPD support innovation?

For IPD to support Innovation, IPD must support actual innovation enablers in the CI. Some of these enablers have been identified in the following research.

Research done on User Driven Innovation (UDI) by Wandahl *et al.*, (2011) and innovation in the construction material industry by Wandahl *et al.*, (2014) show that both have a list of well-defined enablers. Furthermore, Employee Driven Innovation (EDI) has been investigated in large project organisations by Sørensen and Wandahl (2012) and Sørensen *et al.*, (2014). This work showed that EDI also has a list of innovation enablers. The four studies all have unique enablers for innovation, but comparison of the studies revealed a list of 10 overlapping enablers:

1) Management (focus, support, resources), 2) Common incentives (shared risk and reward), 3) Trust, 4) Communication, 5) Collaboration, 6) Culture (no blame), 7) Network (use of external partners), 8) Process (a formalised innovation process management by a facilitator), 9) Knowledge sharing, 10) Employees (the right skills)

Several of the innovation enablers have a clear possibility of being supported by the five elements of IPD, which suggests that IPD can work as an innovation supporter from a theoretical point of view. The only enabler that is not supported by the current state of IPD's five elements is a formalised process to facilitate the innovation process. A solution to this last enabler could be found in an agile and iterative process. This process, also known as Scrum, supports the innovation process and works as a facilitator (Wysocki 2012). Parts of the Scrum concept have already been discussed as a tool for integrating the project organisation (Fischer *et al.*, 2017) but not as a means to support innovation in the CI. Furthermore, IPD's ability to support building innovation is presented in case studies by Cheng (2015) presenting EDI in IPD projects. The respondents emphasise that the innovative solutions found for each given project were enabled by good collaboration and communication in the delivery team which was working towards a unified goal as a team.

Cheng (2015) also suggests that IPD can support innovation. And a way to ensure that IPD fully supports the innovation enablers in the future could be by informing future partners in IPD projects about the importance of innovation to reach their project goals as emphasised by Paolillo *et al.*, (2016). This information could motivate the signing IPD partners to ensure that the structure of the contract describes and incentivises the right processes and behaviours to support the innovation enablers identified here. Future research should look more into this.

## CONCLUSION

The key elements of integrating an IPD project, i.e. contract, culture, organisation, Lean Construction and BIM, were identified through the work of Kim and Dossick (2011) and Fischer *et al.*, (2017). These elements have been shown to enhance the effectiveness of each delivery team member such that the whole is greater than the sum of its parts, all contributing to the success and integration of IPD projects.

It was found that by deploying the Virtual Enterprise Paradigm, IPD has a potential for further integrating the project organisation and communication, creating an interdependent context for the project team. This context could help IPD increase value output. Furthermore, IPD was found to potentially support nine innovation enablers in the CI. IPD's ability to support the individual innovation enablers has not been proven, only IPD's ability to create building innovations is documented.

The research concludes that there is a large unexploited potential within integration and innovation in the IPD system, which can be unleashed through further research and experience with adaptation and implementation.

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# INFLUENCE OF MULTIPARTY IPD CONTRACTS ON CONSTRUCTION INNOVATION

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Construction is often cited for challenges in adopting new innovations, slow diffusion of innovations through the industry, and significant barriers to adoption for firms. These boundaries that divide firms by area of expertise, timing of involvement, and alignment with project goals offer little incentive for seeking innovative solutions, or may even penalize firms that pursue innovative solutions. The rise of multiparty contractual agreements have enabled discussion regarding means of increasing collaboration, decreasing the negative effects associated with fragmentation, and ultimately increasing the potential for innovation in the delivery of construction projects. This paper seeks to analyse the barriers associated with innovation in the construction industry and explore the opportunities for improving the adoption and diffusion of innovation through the use of multiparty Integrated Project Delivery (IPD) contracts. We seek to study these opportunities and barriers using the lens of innovative capacity, defined as the abilities and willingness of firms to engage in inter-organizational, collaborative and distributed novel activities. With projects viewed as multi-organizational instances of work, the use of these new contracts offer interesting new potential for collaboration and innovation. Insights from a case study IPD project are provided based upon a lessons learned workshop for a first time IPD owner with their signatory team members, facilitated by an IPD expert.

Keywords: IPD, innovation, case study, innovative capacity

## INTRODUCTION

The construction industry has been noted by many for its lack of innovation. While there have been advances that suggest the potential for innovation in general, the nature of the procurement and contracting models common in capital facilities projects situate the risk for pursuing innovative products or processes heavily with designers and contractors, the competitive models for procuring firms limit the potential gains for firms that pursue new ideas. This paper delves into the use of multi-party Integrated Project Delivery (IPD) contracts as a potential enabler to addressing the long-standing limitations of the construction industry procurement models through the lens of innovative capacity. A case study is introduced where an institutional owner, with an interest in innovation to drive improved project outcomes, employs a five-party IPD contract.

The use of IPD contracts has been increasing over the past decade in the USA. The creation of standardized contract forms by such agencies as The American Institute of Architects (AIA, 2009) and the Associated General Contractors (AGC, 2009) suggest the

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growth and recognition of the organization and contractual terms. Kent and Becerik-Gerber (2010) differentiated IPD from traditional delivery systems based upon three attributes: use of a multiparty agreement, early involvement of all parties, and shared risk and reward amongst contract signatory firms. In more recent work by El-Asmar *et al.*, (2013), it was shown that the 12 IPD projects outperformed the 23 non-IPD projects on six out of nine performance areas, including schedule, quality, reduced project changes, communication, labour, and environmental outcomes.

In a similar study, though not focused exclusively on IPD, Franz *et al.*, (2017) identified the use of integrated methods and the development of cohesive teams the primary drivers of more successful cost, quality, and schedule outcomes in a study of 200+ completed building projects. The development of integrated and cohesive teams were found to be enabled through project delivery strategies that included early engagement of the builder and specialty trades, transparent financial contracts for contractor reimbursement, and qualification-based selection of the builders and trade partners. The University of Minnesota, in conjunction with the Integrated Project Delivery Association (IPDA) of Canada and the Lean Construction Institute (LCI), just released their third round of IPD case studies (2016) with a focus on the "How and Why" of IPD success. The authors highlight a few notable findings and observations: 1) the "uniformity of success" across the projects regardless of type, region, and owner, 2) the consistent emphasis on selecting and building a successful team, and 3) the criticality of identifying the means and methods to collaborate identified, but was a unique set of tools, for each project. These studies suggest that strategies that enable the team to collaborate more effectively will lead to more successful projects. However, they and others stop short in identifying how the potential for innovation may be enabled by integrated teams and methods on the studied projects.

### **INNOVATING IN CONSTRUCTION PROJECTS**

Macomber (2003), uses game theory, financial modelling, and return on investment analysis to demonstrate the lack of incentives for construction industry firms to invest significant funds into the pursuit of innovative solutions. In his summary and discussion he identifies four areas that offer potential opportunities for innovation in the industry, supply chain optimization, knowledge management, BIM, and "wrap-up" financial thinking; all of which rely upon inter-organizational collaboration. As Henisz *et al.*, (2012) define in pursuit of a unified theory of project governance, the construction industry suffers from horizontal, vertical, and longitudinal boundaries that limit the potential for collaboration, much less innovation, across firms. This aligns with findings by Gann and Salter (2000) that project-based firms need to work across organizational boundaries and networks of suppliers and partners to support innovation. Similarly, Egan (1998) suggests integrated contractual arrangements, such as design and build, supply chain management, and partnering, as drivers for innovation in construction. Ozorhon (2013) found a common root of innovations in four case study projects through the need for a driver, in his research the pursuit of sustainability goals that was championed by the owners, to align the teams' objectives for pursuing innovative solutions on design and construction projects.

These studies suggest consensus around the barriers to innovation being rooted across a range of cost, risk, leadership and structural organisation issues. More broadly, construction management research is no stranger to discussions of innovation. Debates tend to follow the interventions of governments to improve the productivity and value of national sectors, often with a particular concern about the fragmentation and the way

construction parties relate to each other. The traditional adversarial relationships, and the high degree of conflicts and disputes are seen as root causes to the perceived problems of the industry (Blayse and Manley, 2004).

Research on innovation in construction is extensive, but also heterogeneous and often non-cumulative. We would categorise it into four main areas:

1. *Team and Actor Willingness*: Research that identifies structural characteristics and various barriers to, and challenges of, innovation. Much of this rehearses well-understood features of construction, such as fragmentation and specialisation, competitive tendering, improving project to firm learning, site-based conditions or economic pressures (e.g. European Commission, 2009; Blayse and Manley, 2004). Often recommendations, whilst well evidenced, are generic and speculative, such as increasing collaboration and enabling earlier supply chain involvement. Whilst these are useful in identifying the potential benefits that IPD and other collaborative contracts might offer, there is less attention to the specific activities and outcomes that might generate opportunities for innovation.

2. *Innovative Tools and Processes*: Research that deals with single or specific types of innovations, such as new technology use, whether process technologies such as BIM, products such as low carbon materials or building technologies, or new processes such as Integrated Project Delivery / Public Private Partnerships as innovative contract forms or Lean construction (e.g. Nam and Tatum, 1989; Baxter and Berente, 2010). These studies provide insight into processes through which innovations are embedded or implemented into practice, they inevitably prioritise one particular solution or innovation over a more systemic mapping.

3. *Contextual and Institutional Barriers*: Demonstrator / proof of concept research, such as sustainable innovation, low carbon homes, IT use and prefabrication processes, which larger scale implementation or exploitation are left as 'next steps' (e.g. Shapira *et al.*, 2014; Thuesen and Hvam, 2011). Whilst instructive on the utility of specific innovations these studies tend to neglect (intentionally, for the most part) the organisational and institutional contexts required to enable successful implementation, or support broader spread of innovative processes or technologies. We might argue contractual arrangement can form part of this context.

4. *Spread and Management of Innovation*: Research that seeks to explain the specificities of construction, managerial, and contextual factors influencing the process of innovation, often drawing on organisational and project management studies, such as evaluations of specific 'real world use' of new information technologies (e.g. Mitropoulos and Tatum, 1999; Harty 2008). They perhaps get closest to revealing the practices and outcomes of innovating, and the often unforeseen and serendipitous paths innovations take. However, they are also often oriented to micro-level detail rather than interrogation of the institutional and contextual backdrop that might constrain or enable the broader uptake of innovative solutions.

All of these studies have merit and contribute much to an understanding of innovation in construction. They are also evidence of the extensive innovation consistently and routinely occurring within construction activities. Firms and projects are highly successful at implementing innovation in specific contexts and niches. This categorisation is not meant to be a thorough evaluation of the many innovation-oriented studies in construction, nor a critique of those studies. But it does serve to identify differences in scale and focus. The units of analysis vary from the innovation itself, to

groups of actors, project, firms, supply chains or sectors. As noted above, often the topics follow current government or pan industry recommendations, whether Total Quality Management (TQM), or Lean, or BIM.

### **Innovative Capacity**

The consideration of innovation as a positive project outcome or differentiator of project success is well established - indeed taken for granted - and we do not challenge this here. Together, these four areas point towards a need to consider the innovation itself, the activities and practices of 'doing' specific innovation on projects, and the broader contexts and institutions of construction projects that help or hinder both their performance, and their subsequent spread. Without claiming a new or universal theory of innovation, for the purposes of this paper, we would suggest the term 'innovative capacity', denoting both the willingness and ability of construction actors and organisations to engage in innovation, to capture these various aspects. It can consider the characteristics of the innovation itself, the propensity of actors and teams to engage in innovation, potentially incorporating motivations, incentives and risk mitigation, and organisational and institutional barriers (or enablers). In our case, we intend to use this concept to help understand how the emerging use of IPD could enable innovation to emerge and grow despite the recognised challenges to innovation on projects.

## **RESEARCH METHODOLOGY**

To study the concept of innovative capacity in the context of IPD, a phenomenological approach was pursued using the case study of an institutional owner. The case study serves as an opportune project for two reasons: first, the owner explicitly identified innovation as a qualification in the team selection process, as well as a motivating factor for pursuing IPD. Second, this is the owner's first use of a multi-party contract. The owner is experienced in delivery of capital facilities projects, but new to the use of IPD contracts, offering the unique opportunity to see how the contractual model may enable the development of innovative capacity.

### **Case Study**

The Pennsylvania State University is delivering demolition and reconstruction of the Agricultural and Biological Engineering (ABE) building of approximately 7,000 m<sup>2</sup> (77,000 ft<sup>2</sup>) of new construction, and, renovation of the 1,500 m<sup>2</sup> (16,000 ft<sup>2</sup>) existing structure and historical facade. The project will incorporate new graduate education labs, research labs, offices, classrooms, a fermentation facility, and a maintenance shop. The team will be pursuing LEED certification, currently trending toward Gold, for a total estimated construction cost of €27 million (\$30 million), with a construction start in early September 2016 and completion in winter 2017. The IPD contract engages the owner, designer (architect and engineer), general contractor, mechanical contractor and electrical contractor as the five signatory partners. Penn State selected the general contractor and designer as a team, followed shortly by selection of design-assist specialty contractors.

To develop this case study across the entire design phase, the project was tracked from the beginning of the design process to the early stages of construction; however the emphasis of this analysis is based on data collected at a Lessons Learned workshop hosted by the project team in early October of 2016, as the demolition of the existing building was underway and the team was transitioning between the design and construction phases.

## RESULTS

The Lessons Learned workshop engaged more than a dozen participants from the five signatory partners over a full day, and was facilitated by an IPD expert. The workshop had ten items on the agenda, ranging from the selection process and on-boarding, to the contract and financials, and down to the collaborative methods being used, such as collocation and the cluster organization. For each topic, the individual participants brainstormed topics regarding the process and challenges observed, these were aggregated on a central wall using sticky-notes, and then a discussion of the collective topics was facilitated, with insights from the more than 100 IPD projects the facilitator had experienced.



*Figure 1: IPD team brainstorming discussion items.*

One of the focal and re-emerging topics at the workshop was that the project team was trending over-budget, by approximately \$1 million (£ 750,000). The team was using a Target-Value Design approach to pursue the target cost for reaping the 'shared reward' that enabled the profit and potential incentive pool of funds for the signatory firms. While the discussion did not focus on the innovative solutions pursued or executed, it did emphasize the team's use of new processes, collocation strategies, and new organizational approaches to enable the team to be innovative.

In particular, two processes were discussed to highlight both the opportunities and challenges the team observed. First, the use of the Lean Construction Institute's Last Planner was attempted during the design process. Last Planner has been well defined and has grown in use over the past decade in the context of field construction planning, enabling the foreman for work crews to engage in a heterarchical approach to detailed task scheduling for crews. The translation of the Last Planner approach to the design process is challenging - design is by its nature iterative. It is quite difficult to have an engineer or architect clearly define the time and outcomes of design tasks in the same level of detail and specificity as construction tasks.

In the discussion at the Lessons Learned workshop, the team identified many benefits, and challenges. The coding indicates which of the four areas the noted items relates, regarding the enabling or hindering of innovative capacity based upon the workshop discussion. The discussion and captured feedback were coded based not on the team's perception, but on the indicated barriers or enablers that aligned with the factors noted:

- (I) - Innovative tool or process,
- (T) - Team and Actors' willingness to engage,
- (C) - Context or institutional barriers, such as communication challenges, and,
- (S) - Spread and Management, or dissemination across firms and projects.

*Table 1: Benefits and challenges from implementing the Last Planner in design*

| Benefits (Plus)  | Challenges (Delta)   |
|--|--|
| (I)- drove collaboration   | (C)- not effective in design, hard to get some team members to commit to the process |
| (T)- theory was well explained   | (T)- process was constantly interrupted  |
| (I)- great tool for engaging team members                              | (C)- team had trouble defining clear commitments                                     |
| (I)- one cluster was quite successful internally using the process     | (C)- the 'what' of the handoffs was often unclear                                    |
| (T)- concepts and thinking were very useful                            | (T)- chaos in commitment communication   |
| (T)- allows input from team members that might otherwise be overlooked | (I)- sometimes team got too detailed   |

In the discussion that followed, the team confirmed that the process and use of the Last Planner system was valuable for enabling the team to collaborate, specifically citing some of the outcomes from the electrical system collaborations that resulted. The implementation into design was not as effective as they would have liked, and they identified the designers' preference for a week or two-week cycle to the design, as opposed to a more daily discussion and update that is typically used in construction. The application into the design phase was challenging in that the novel process was new, particularly to the individual designers. The level of detail expected was not something the design team was familiar with providing, and the need to be able to specify the information and detail of what they needed from their colleagues was considered challenging to clearly articulate. Despite these challenges, the attempt and engagement of the entire team in the use of the innovative process was consistently agreed to add value. The implementation was where the team felt there was room for improvement. In addition, there was discussion that the team needed a facilitator for the use of the Last Planner in design that was both familiar with the process of using the Last Planner system, but also experienced and knowledgeable in the design process.

The second approach for creating capacity within the team that highlights the opportunity related to team collocation. The team was geographically distributed, and met face-to-face, typically on a monthly basis for three to four days; which the team referred to as 'Big Room' meetings:

*Table 2: Benefits and challenges noted from the team's use of the 'Big Room'.*

| Benefits (Plus)                           | Challenges (Delta)                         |
|---|--|
| (T) - team-building events were effective | (C) - save time for problem solving        |
| (I) - good collaboration at meetings      | (I) - limited space                        |
| (I) - effective flow of meetings          | (C) - 3 days per month 'not enough'        |
| (I) - frequency (monthly) OK              | (T) - too many attendees, not enough focus |
|   | (C) - agendas for big room were late       |
|   | (C) - too much "we need more time"         |

The discussion that followed the brainstorming focused on the need for more face-to-face interaction, as well as better use the limited time available. The team agreed that having face-to-face time was extremely valuable. It contributed to the sense of team, with the team-building events facilitating close interactions. The team felt that they worked well together when they met in person, and that the meeting structure flowed well, with the frequency being 'acceptable' given the project constraints. There was near universal agreement that more face-to-face interaction was desirable, but given the budget constraints on the project no obvious solutions emerged. Regarding the challenges based on this limited interaction, the space that was available was small given the size of the team. Due to team size, the ability to focus on specific discussions was at times wasteful for the large group and the balance of how they spent the time working in smaller breakout cluster meetings was seen as an area they should have planned more effectively. This would have given the Big Room meetings more of a 'charrette' approach, believed to be more productive by the team.

## DISCUSSION

Innovative capacity considers the abilities and willingness of firms to engage in inter-organizational, collaborative and distributed novel activities. The two processes identified were new to most of the team members. The topics and discussions reflect the team's engagement in collaborating across organizational and disciplinary lines.

The contractual arrangement itself, as the framework that is being considered, is identified based on three original elements cited by Kent and Becerik-Gerber (2010). The agreement brings together the concepts of overcoming the contextual and institutional barriers, but targeted at enabling the team and actors within the signatory partners. By putting all of the decision-making authority, and flexible budget, into their hands, the incentive of the companies in concept aligns with the overall success of the project, however this is a new context for most industry participants. As noted in the two examples, all of the areas in which the innovative tools instigated collaboration amongst the teams was well received. It was often the contextual changes that created the challenges for the team members. The ability to adjust their behaviour, as well as justify decisions and practices to their home firms, were the most challenging elements. The institutional training for disciplines and traditional contractual arrangement create challenging barriers, even when the barriers themselves are no longer in place.

The early involvement of all parties is somewhat vaguely defined. As the facilitator stated it, at times the contract 'mumbles' to allow the team to determine for themselves what is best for the project. For the case study project, the lab requirements encouraged the early engagement of mechanical and electrical trade partners. In this case, the longitudinal fragmentation of the industry is overcome to allow for novel participation at the earliest stages of design. The nature of the contract encourages the team to engage

more parties at this early stage, so they can help validate the program and develop the contract itself, to which they are committing. By enabling this engagement, the design process and system development are more likely to be successful in meeting the team's commitment. While the path innovations take can seem random, having the flexibility amongst the team members to inform that path is of critical importance to repeating successes.

The use of shared risk and reward emerged, specifically in the context of the Big Room meetings. The team was given free rein to decide when and where to meet to support the design process. They chose to spend funds, which could have been shifted toward the shared reward pool, to have face-to-face meetings. They believed these interactions sufficiently valuable to overcome the costs of flying team members at regular intervals. When reviewing their evaluation, the team found the Big Room time valuable. The items they noted as detractors stem from the institutional norms - agendas do not provide enough time for problem solving. And these new, valuable interactions were not frequent enough - possibly due to their lack of experience with how valuable they would be when initially planning the meetings.

The two examples, while not comprehensive in the processes and elements related to their pursuit of innovative outcomes, are indicative of the team's effort to create innovative capacity. The capacity is not targeted solely at innovation, but on the ability to create or enable new interactions amongst the project team members. The use of the IPD contract was targeted because of the potential for the team to pursue design options and solutions that are challenging, if not impossible, to fully explore in a more traditional contract structure. The contractual structure and the reimbursement methods are intended to create a safe space for teams. This enables team members to fail in pursuit of new designs, systems, or innovative processes, with the cushion of the rest of the team to vet the ideas before they advance too far. The contract also structures financial arrangements among the project team to create flexible capacity within the budget. As the facilitator framed it, the reason for the cost guarantee in the IPD contract was to remove the risk of failure as a barrier for designers and contractors to pursue more innovative ideas.

Table 3: Project comparison for unit costs

|  | % New Construction<br>(by area) | Total Area<br>(SF) | Cost / Area<br>(\$/SF) | With all<br>of the |
|--|---------------------------------|--------------------|------------------------|--------------------|
| Agricultural Engineering               | 70%                             | 100,000            | \$450/SF               |                    |
| Chemical and Biomedical<br>Engineering | 100%                            | 193,000            | \$746/SF               |                    |
| Materials Science and<br>Engineering   | 20%                             | 108,000            | \$604 / SF             |                    |

signatory project team members absorbing this risk only against their final profit in the shared risk and reward pool, and with their project specific costs and overhead guaranteed, the financial risks are small, though not insignificant. While the project was not complete when this paper was published, a comparison of the unit cost for several Penn State projects is noted in Table 3. While there is a great deal of construction specific context, the two projects noted are similar in user type - labs and classrooms, within the same 3 year window of construction, and built on the same campus by the same owner. The ability of the Agricultural Engineering team to deliver the project at the same expectation of quality and performance as the sister facilities, for significantly lower

unit cost is a strong testament to the team's challenges and need to pursue innovative processes and design solutions.

In addition, the interest among companies simply to participate in the efforts to employ the new project delivery method and contract structure that may be considered un-tested itself signals a willingness to collaborate and pursue innovative approaches. By choosing to participate, the firms engaging indicate a willingness to pilot new processes or novel mechanisms for collaboration amongst disciplines, as noted. This alone suggests capacity and willingness to pursue innovation. While the interest in participating demonstrates willingness, there are other considerations that have been documented related to integrated design not explicitly considered by the contract. The criteria and process for selecting the signatory partners is still new, and the ability to identify individuals and firms to further project goals is an on-going challenge. The willingness and drive of the individuals needs to meet, if not exceed, that of the firms they represent. Furthermore, how do you evaluate the potential for a designer or contractor to be innovative on a given project? Similarly, the specific challenges of the project scope and the level of complexity offer both challenges, and opportunities for innovative solutions, but often dependent on a sound technical foundation.

## CONCLUSIONS

The pursuit of more effective delivery of capital projects is an on-going challenge in construction. We presented a case study in which an IPD project was undertaken as the delivery method enabling new processes for collaborating across organizational and disciplinary boundaries. Highlighting discussion from an internal team Lessons Learned workshop, two examples that represent the teams efforts to create innovative capacity amongst team members were presented. Innovative capacity was used to understand the manner in which the multi-party contractual model can enable innovative capacity as a broader understanding of the needed advance to allow innovation to more broadly grow and disseminate. The four areas of innovative capacity were defined and used to understand the opportunities and challenges observed by the case study project team.

While the context of the project is intriguing for seeing the pursuit of new and innovative processes, the use of a case study approach limits the ability to recognize the broader implications of the noted phenomenon. A formalized framework for innovative capacity should be developed to provide a basis for analysing the outcomes across projects and firms to better inform the application of these emerging contractual models. The use of IPD contracts is growing in the USA, and similar contract structures are emerging in parallel in different locals throughout the world. As elements begin to standardize, a larger study to recognize the critical elements of IPD that consistently enable project teams could be studied, but require a new lens to understand how they could grow innovation in new and broader ways across construction.

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# DESIGN

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# EXPLORING THE DYNAMIC SOCIAL INTERACTIONS THAT UNDERPIN WORK HEALTH AND SAFETY RELATED DESIGN DECISION-MAKING

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The proactive practice of anticipating and ‘designing out’ work health and safety (WHS) risks at early project stages, known as Safety in Design, is well-recognised. Previous research also suggests that the effective interaction between design and construction participants is vital to make construction process knowledge accessible to design decision-makers. Nevertheless, effective communication still seems to be a problem in practice. A PhD study is underway to explore the impact of interactions between design and construction decision-makers on the quality of design decisions and WHS outcomes. Social network analysis (SNA) is recommended as a useful tool to explore the patterns of interaction between project participants. Previous applications of SNA in construction have largely been cross-sectional and single-level in their focus, implicitly assuming a degree of stability in the project context. The reality is, however, that the construction project context is unpredictable. Decisions unfold and trade-offs are made at different organisational levels as participants negotiate solutions to emergent problems. The identity, role and influence of project participants also change over time. Thus, the longitudinal and multilevel applications of SNA may be better suited to investigate the complex and dynamic patterns of interaction that underpin design decisions. In this paper, the research rationale is explained and a methodological discussion is put forward.

Keywords: social network analysis, dynamic interaction, decision-making, H&S

## INTRODUCTION

The prevalence of accidents and injuries in the construction industry is problematic due to the financial, psychological and productivity burdens created for individuals, organisations and the whole industry. Traditionally, construction firms have been solely held responsible for on-site work health and safety (WHS). However, during the past two decades, there has been a growing recognition that the root causes of WHS incidents on construction sites can be traced back to problems inherent in systems of work conceived in the early lifecycle of construction projects (e.g. planning and design stages). Consequently, the proactive practice of anticipating and ‘designing out’ WHS risks at early project stages, referred to as Safety in Design (SiD), has gained recognition and has become a key feature of WHS legislation and policies in some countries, for example Construction Design and Management Regulations 2015 in the UK and the current model WHS regulations which has become a requirement in most of the states in Australia. In

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addition, a growing number of construction companies have included SiD processes as part of their safety management and risk management procedures.

In line with these initiatives, research has been conducted in relation to the effective implementation of SiD. In particular, the organisational and contractual separation of the design and construction functions in construction projects has been identified as a problem because free and effective flow of communication between constructors and designers is not always possible. Recent research (Lingard *et al.*, 2014a) has provided evidence that positive WHS outcomes are facilitated through the integration of construction process knowledge into design decision-making about the permanent features of a building or facility.

Furthermore, research has concluded that the timing of making WHS related decisions is also important in construction projects and that early consideration of WHS in project decision-making can lead to the implementation of more effective methods of risk control during construction (Lingard *et al.*, 2015). Despite the growing momentum surrounding safety in design (SiD), research has provided evidence that in many cases designing for WHS has achieved suboptimal results in the construction industry (Gambatese *et al.*, 2005). In fact, in many cases, the implementation of SiD has been limited to deliver modest reductions in WHS risks rather than eliminating inherently dangerous activities (Atkinson and Westall, 2010). Studies have proposed a number of factors contributing to successful implementation of SiD including designers' knowledge and attitude towards the concept (Gambatese *et al.*, 2005), clients' motivation and commitment and involvement of contractor (Goh and Chua, 2016). Nevertheless, an important underlying issue, which remains unresolved, is that the efforts to improve WHS at design stage in construction have failed to acknowledge and cope with the special characteristics of the design process (Lingard *et al.*, 2014b).

## **DESIGN DECISION MAKING IN CONSTRUCTION PROJECTS**

Construction design is a complex process. Lingard *et al.*, (2012) classify the complexity inherent in the design process into two categories: organisational complexity and technological complexity. The organisational complexity stems from a significant division of tasks, involvement of multiple specializations and many interdependencies between organisational elements at different hierarchical levels (Lingard *et al.*, 2012). In fact, design teams are referred to as 'temporary, multidisciplinary and network-based organisations' (den Otter and Emmitt, 2008). The technological complexity of the design process, on the other hand, arises from the involvement of a network of tasks, requiring contributions from multiple specialists, and a high level of interdependency between technologies, tasks or inputs (Lingard *et al.*, 2012). In fact, design outcomes emerge from a network of inter-related decisions made through repeated interactions between multiple stakeholders. These interactions, in turn, form a complex structure of information exchanges supporting the design decision-making process.

Design is a multi-disciplinary process. As a result of the high complexity in modern construction methods and techniques, the design and construction processes have progressively become more specialised. This specialisation has increased the number of participant organisations and individuals with design responsibility (Austin *et al.*, 2007). Often, the required knowledge to make design decisions resides in more than one design participant (Pektaş *et al.*, 2006). Consequently, the timely and effective exchange of information between participants is critical for completion of design tasks and to ensure that components are compatible (Gray *et al.*, 1994). Design process is dynamic and collaborative. Tryggestad *et al.*, (2010) view construction design work as a collective

activity characterized by social negotiations among coalitions of parties and distributed knowledge production. As they have also revealed, design involves a continuous process of (re)design activities to accommodate transforming interests of participants. Design goals are not invariant inputs established at the outset of a project which remain unchanged. Rather, design goals evolve through a flexible process of revisiting ambitions and engaging in ‘trade-offs’ to find practicable solutions to emergent problems (Tryggestad *et al.*, 2010).

Iteration is a typical characteristic of the construction design process. Iteration implies refinement and is usually required for two reasons: 1) an unexpected failure to meet design requirements, 2) a response to the late availability of new information (Pektaş *et al.*, 2006). Minimising unexpected iterations is desired in design management. One way of achieving this is to improve information quality and reduce uncertainty in decision-making through timely supply of information and involvement of appropriate participants in the design process. In addition, faster iterations (fewer amount of rework) are achievable by improved coordination of design activities (Pektaş *et al.*, 2006).

The interdependency inherent in construction design is indicated in research by Austin *et al.*, (2000) who report that a typical building design process can comprise between seven and 12 iterative loops. Each of these iterative loops consists of between five and 30 interrelated tasks. They also examined the design process of a hospital project and identified around 800 tasks and 10,000 information dependencies. Looking at specific phases in design, Austin *et al.*, (2001) found high interdependency within and across activities in the conceptual design of a single building element. They also identified ‘the process of social interaction’ (i.e. the transfer of information, opinion and ideas) between design team members as a critical component of conceptual design activity.

Research has also revealed the roles that different groups of participants play in shaping design decisions. Particularly, suppliers and specialist subcontractors have been recognised for demonstrating innovative and independent decision-making in the design and manufacture of specialized building components (Lingard *et al.*, 2012). Indeed, there is a growing recognition that modern building design is a collective and interactive process which involves complex and dynamic interdependencies between activities and among participants, and is thus best undertaken collaboratively.

## **INTEGRATING DESIGN AND CONSTRUCTION DECISIONS**

Research in construction has identified considerable benefits in the integration of construction expertise and knowledge into early project decision-making. (See e.g Song *et al.*, 2009). Improved constructability and WHS have been mentioned frequently as one of these benefits (Gambatese, 2000; Lingard *et al.*, 2014a). Consequently, it has been proposed that improvements in WHS require more integrated approaches to WHS decision-making which are supported by early-stage collaboration and effective interaction within and between two groups of project participants:

- those involved in early planning and designing the final product (i.e. building, structure, and facility), and
- those involved in making decisions about the construction process.

The collaborative design development is the basis for building sustaining relationships that accommodate complexity and reduce uncertainty (Austin *et al.*, 2007). Through collaboration, knowledge and information can be shared between project participants and there would be less reliance on inaccurate assumptions. This is particularly important in relation to SiD, which involves knowledge from two main areas, the design of the final

product and the design of construction process. A main issue identified by researchers is that design professionals in the construction industry mostly possess limited knowledge of construction and maintenance processes (Gambatese *et al.*, 2005). This is partly because design professionals have traditionally focussed on the requirements of end users of a facility or building rather than those who undertake the construction and maintenance works (Hecker and Gambatese, 2003). As Lingard *et al.*, (2014b) suggest, the problems can be overcome by ensuring that:

- a genuine lifecycle approach to safety is adopted in design; and
- design decisions are informed by construction [and WHS] knowledge [through collaboration].

Effective interaction between project participants involved in the design and construction stages of construction projects has great potential to facilitate collaboration and address the knowledge gaps mentioned above; however, in practice, the organisational and contractual separation of the design and construction functions acts as an impediment to freely and effectively flowing communication (Lingard *et al.*, 2014b; Atkinson and Westall, 2010) and can negatively influence desired outcomes including those related to WHS (Baiden and Price, 2011). Despite this acknowledgement, few empirical studies have explored how to achieve improved WHS outcomes by addressing the segregation and communication problems in construction projects. Hare *et al.*, (2006) cite several mechanisms that substantially assist with integrating WHS into project planning and design decision making:

- two-way communication between designers and constructors;
- the early involvement of the constructor;
- participation in health and safety workshops; and
- collaborative brainstorming.

Franz *et al.*, (2013) have presented case study data suggesting that in comparable projects, better WHS outcomes are achieved when specialist contractors are involved early. Improved constructability is often claimed to result from collaborative or integrated approaches to project delivery and that, by implication, WHS is also enhanced (Kent and Becerik-Gerber, 2010). However, some researchers caution that the implied link is not straightforward:

- Ankrah *et al.*, (2009) observe that the procurement method will not generate, as a matter of course, a positive cultural orientation to WHS;
- Atkinson and Westall (2010) point out that Integrated Project Delivery does not guarantee improved safety outcomes.

To sum up, an existing challenge in relation to the implementation of SiD in the construction industry is that, in most cases, there is not enough collaboration and effective communication to support the effective integration of design and construction decision-making. Even in cases that systems and processes have been put in place to facilitate collaboration and communication, they have failed to cope with the complex and dynamic nature of the design process. Therefore, it is suggested that to better exploit the WHS improvements intended by SiD, there is a need to understand and find ways to enhance communication and collaboration in the complex and dynamic context of construction projects. This understanding and enhancement effort should be based on the acknowledgement and acceptance of the special characteristics of the construction design process, i.e. the complex, dynamic and collective nature of design decision-making.

## UNDERSTANDING SOCIAL INTERACTIONS IN PROJECTS

Construction projects involve social activities. Project participants normally come together from different firms. They possess diverse knowledge and expertise and interact to make decisions about various aspects of the project and deliver a set of tasks that contribute to the achievement of the overall project goals. The patterns of interactions and relationships between project participants are important in terms of understanding how project organisations function (Pryke, 2012). The project interactions can be conceptualised as social networks. According to Pryke and Smyth (2006), through these networks, individuals who are engaged in different project functions (e.g. planning, design, construction) communicate in relation to their project roles and responsibilities and establish a sense of ‘mutual understanding’ about terminology, values and priorities.

Social networks exist at multiple levels of project organisation. They create the substructure that supports different project functions at various levels. Pryke (2012) observes that project participants are embedded in multi-layered transitory networks of relationships that relate to project functions. At the lowest level, individuals with project-related responsibilities exchange information with other individuals both from the same firm and from external firms. The networks constantly change. Due to the diverse set of circumstances and different knowledge combinations and expertise required to perform various tasks, the interaction networks continually reconfigure, enabling the project participants to deal with the multitude of complex activities involved in executing a project (Pryke and Smyth, 2006).

The networks of interactions are particularly important in relation to design decision-making. Austin *et al.*, (2007) suggest that collaborative design needs an easy flow of information between all parties outside the rigid structures forced by contractual arrangements. To reduce the unexpected impacts, assumptions in relation to early design aspects need to be more accurate and/or enough tolerances should be considered to accommodate future changes. This, in turn, requires collaboration and effective communication to make the right information available to the right participants at the right time (Pektaş *et al.*, 2006).

According to Chinowsky *et al.*, (2011), an effective level of exchange between parties involve the exchange of both explicit and tacit knowledge to resolve inter-task issues as they arise; however, the unstable context of construction projects and insufficient past working interactions between parties create challenges for effective collaboration. This has mostly directed project team efforts to build [reactive] communication networks that are efficient in meeting particular project needs, but may lack the characteristics of an effective network (Chinowsky *et al.*, 2011). Pirzadeh and Lingard (2017) suggest that project leadership teams can benefit from continuously mapping interaction networks and understanding how they change and play out to produce project outcomes. This understanding can assist project teams to proactively design, encourage and maintain networks that are more likely to support effective decision making and performance.

Social-network analysis (SNA) is proposed as a practical method to map and analyse relationships and interactions. SNA is an analytical tool to visualise and study the patterns of relationships and the exchange of resources (e.g. knowledge, information) among participants in a network. In the construction context, SNA has been applied in the analysis of relationships, information exchanges and communication patterns between project participants (both at individuals and organisational levels). SNA has been recommended as a useful method for understanding the roles and quantifying the interactions of participants in construction project coalitions. Social network

characteristics have been used to conceptualise construction project coalitions and to compare project procurement and governance systems (Pryke, 2012), to explain poor performance in team-based design tasks (Chinowsky *et al.*, 2008), and to identify barriers to collaboration that arise as a result of functional or geographic segregation in construction organisations (Chinowsky *et al.*, 2010). The technique has been used, in combination with task dependency analysis, to identify potential communication disconnections between project participants (Chinowsky *et al.*, 2011). Park *et al.*, (2010) used SNA to study inter-firm collaboration in the construction industry and its effect on organisational performance. SNA has also been used to analyse knowledge flows among construction project participants during the design variation process (Ruan *et al.*, 2012). In addition, Lingard *et al.*, (2014a) used SNA to map and analyse the pattern and nature of communication between participants in WHS related design decision-making in construction projects and found a link between social network measures and WHS performance.

So far, the applications of social network analysis in construction projects have been mostly one-off and cross-sectional, implicitly assuming a static and lasting pattern of interactions between project participants. In a classic fashion, the technique has mostly been used to analyse ‘static’ or ‘aggregated’ networks (Tang *et al.*, 2009) by taking a snapshot of the social interactions at a particular point in time or to aggregate the social interactions over a period of time, e.g. over the whole project duration, to create an overall view of the social network. As such, this approach assumes some level of stability in a project social network over time. This assumption might be valid for short periods of time; however, its validity is questionable over long time spans due to the dynamic context of construction projects. The reality is that while the formal structure of a project organisation might remain stable throughout the project for contractual reasons, the configuration of participant’s changes as they assume different roles for dealing with different activities at various organisational levels (Pryke and Smyth, 2006).

## **THE NEED FOR A LONGITUDINAL AND MULTI-LEVEL NETWORK APPROACH**

In the context of SiD, although collaboration and effective communication have been emphasised as a requirement for the effective implementation of SiD, few studies have actually delved into the nature of communication and collaboration in relation to SiD decision-making as it happens in the real complex and dynamic context of the construction design process. Firstly, despite recognizing the networked nature of relationships and interactions in construction projects, there are few studies that have taken a network perspective to observe collective interactions and negotiations in live projects as design decisions unfold and participants’ roles and interests change (examples of using network perspective are Tryggstad *et al.*, 2010; Lingard *et al.*, 2012).

In the context of construction WHS, the application of SNA has shown that effective interaction between those involved in the design of the structure (building or facility) and the construction process is linked to improved WHS outcomes (Lingard *et al.*, 2014a). Nevertheless, these applications have mostly been cross-sectional, and as such, have not taken into account that networks are dynamic and evolve over time. By taking a snapshot of the social network or by aggregating the social interactions over periods of time (e.g. normally over the whole project) these studies have assumed a static and lasting pattern of interactions between project participants. Using this approach, the social network data has often been collected retrospectively, by asking participants their recollections about project interactions and communication patterns during the project. This approach

assumes a level of stability in social network over time, thus does not appreciate the complexity and dynamism of the construction project context. In fact, recent applications of SNA to study the properties of human interactions have identified that the time dimension of interactions is usually a 'neglected' or 'understated' factor (Tang *et al.*, 2009). Consequently, there is a requirement for longitudinal studies of relationship and interaction networks (in relation to construction WHS) that take into account the dynamism of project context.

Secondly, where network-based methods have been used to observe relationships and interactions in relation to project outcomes, the link between network measures and project outcomes is not clearly explored and established. Most of these studies refer to the coexistence (correlation) of particular network patterns/measures and specific outcomes and consider this coexistence as the evidence for a link between those patterns and outcomes. For example, a high number of direct links between network members, indicated by a high network density, has been linked to better knowledge sharing and higher performance in project teams (see for example Chinowsky *et al.*, 2008). This approach is limited in that it does not reveal the nature of this link and does not explain the relation between the two variables. It is argued that there is a need to explore the mechanisms through which network characteristics affect project outcomes (in this case, WHS outcomes), and vice versa. Put differently, a framework is required that establishes strong relations between dynamic social processes and project outcomes, such as WHS performance. Only with this level of understanding, solutions can be identified to effectively implement SiD. As highlighted by Lingard *et al.*, (2012), in the collective, reflexive, and uncertain context of design, it is imperative that any study investigating the development [and implementation] of SiD processes should take into consideration the reflexive [and interactive] nature of design work and explain the way in which processes and/or tools 'fit' within design work.

Thirdly, decision making about WHS is a complex process which involves interaction between participants with different risk perceptions. Thus, understanding project participants' attributes (such as roles, behaviours and viewpoints) as they make decisions is an important step in explaining how and why social intra-project interactions take place and affect WHS related technical outcomes. Collecting qualitative data about the participants' attributes, the quality of their relations and the content of their interactions can help to understand how networks change and why certain outcomes emerge in projects. According to Loosemore (1998:315), "both quantitative and qualitative methods have a role to play in understanding the complexity of people's changing social roles, positions and behaviours within construction organisation". In a recent longitudinal study, Pirzadeh and Lingard (2017) combined SNA and in-depth interviews to account for the dynamism and temporal nature of the design process and its underpinning interactions. As the study revealed, each decision-making scenario involved specific knowledge sources and interactions. Consequently, the participants in making each decision and the pattern of interaction between them were specific to that scenario and changes were observed during the decision-making.

Fourthly, it is important to consider different levels of relationship and interactions in construction projects. At the macro level, construction projects are conceptualised as networks of firms administered by sets of contracts (Pryke, 2012). Winch (1989) refers to construction projects as 'temporary coalitions of firms' bound together by flows of information and material. These formal relationships are fairly stable, at least over each project stage, and would not change greatly unless the project goes through a major structural change. They provide the context for interactions between individuals or

groups at lower organisational levels or may be regarded as the aggregation of lower level relationships. At micro level, construction projects can be viewed as networks of participants from different firms who engage in social interactions and perform project tasks. The uncertainty inherent in undertaking project activities makes it difficult to apply a centralized approach to decision-making and calls for decentralization of authority and strong reliance on localized decision-making (Dubois and Gadde, 2002). Thus, interactions at this level are often informal, and can be highly transient and ad hoc to rapidly suit and support local decision-making requirements. However, project participants also work in the context of their firms and consequently affect and get affected by the relationships that their firms are involved in. Therefore, the macro and micro levels of relationships may display important interdependencies, and relationships at each level might be best explained in conjunction with relationships at the other level. In fact, since organisations [including project temporary organisations] are multilevel systems, a network approach to study and explain organisations should also be multilevel in scope, considering how networks at one level influence network at higher or lower levels (Moliterno and Mahony, 2011).

## CONCLUSIONS

Effective implementation of SiD in construction requires collaboration and effective interaction between design and construction decision-makers. Particularly, the project interaction networks need to support the integration of construction knowledge to the design process. However, design process is collective and complex. In addition, the socio-technical context of construction projects is dynamic and unpredictable. These characteristics create challenges for creating and maintaining effective interaction networks that underpin informed design decisions which are safe and constructible. It is proposed that project teams benefit from continuous mapping and understanding project communication patterns. This can particularly be helpful to implementation of SiD. Understanding interaction patterns can highlight opportunities for involving participants with construction knowledge in the decision process as well as encouraging free flowing information between participants to produce better decision outcomes. This, in turn, requires approaches that acknowledge the complex, dynamic and multilevel nature of the project interactions.

It is argued that there is a need for longitudinal studies that take a multilevel network approach and combine quantitative and qualitative data to capture and analyse interaction patterns prospectively as they happen in the dynamic context of construction projects. In line with this argument, a PhD study is currently underway. The aim of the study is to explore the way in which interactions between design and construction participants underpin collective decision-making and impacts upon construction WHS. To appreciate the complex context of construction projects, qualitative and quantitative data are integrated and a multilevel network approach is adopted. In addition, the dynamism in interaction pattern is captured by mapping communication patterns at each decision-point along the design decision-making process. The research outcomes are expected to contribute to more effective implementation of SiD in the construction industry as a proactive way of achieving better WHS outcomes.

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# REDUCTION OR REVALUING IN COST CONSTRAINED DESIGN? -REVERSE INNOVATION CONCEPTUALIZED

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Construction is ripe with examples of cost overrun. Practice is rich on systematic reductions in functionality and ways to avoid scope and cost creep. But research on such systematic reductions are rare. An emerging research literature on reverse innovation propose ways to understand this. Emerging third world markets triggered a geographically oriented notion of reverse innovation. However, second generation conceptualizations include reverse innovation reducing functionality, cost and pricing, and adding new values addressing clients in a new way. Most reverse innovation examples are simple consumer products, but in building, with its complex products, to conceptualize processes and practices of reverse innovation is promising access to new markets. The aim is to explore a conceptualization of reverse innovation of complex built products and gather insights of reverse innovation processes from cases. They exhibit different features and processes, reduction strategies with departure at an (imagined) high end product, appear to be recurrent in construction. Once faced with a potential, estimated cost overrun some designers would follow an ad hoc strategy of reduction in functionality until the cost target is reached. However proactive strategies, such as innovative substitution, offshoring of design work, shift of suppliers, and global sourcing are possible.

Keywords: costs, value management, innovation, reductions

## INTRODUCTION

There are many, also contemporary, examples of project budget and time overruns. In the 2016 UK construction excellence report, 32% of the reported projects experiences cost overrun and 49% time overrun (Construction Excellence 2016). In some cases, such overruns are accompanied by commonly accepted scope creep, presented as improved functionality and consented to, or even celebrated, by stakeholders. In other cases, overruns lead to repercussions, legal, financials or reputational. However, in some “third type” cases it is clear, even early on, that overrun just cannot be tolerated. Budgetary frames in such cases cannot be moved. They might be regulated by law, as in social housing in Denmark, or their politically negotiated character in some cases cannot be “unfrozen”. In such “third type” projects, stakeholders possibly adopt different paths of developing briefing, design and producing buildings. The paths of various types of reductions.

The research interest of this paper is what characterize such brief, design and production reductions? If systematic reduction is carried out - for example by going through each

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design area; architecture, structure, HVAC etc., to find functional and cost reductions, then when is such systematic reductions innovation, do they lead to new value or revaluing?

The theoretical framing is reverse innovation (Von Zedtwitz *et al*, 2015, Winter and Govindarajan 2015) and reverse engineering (Messler 2014, Lee *et al*, 2016). Reverse innovation is defined as reducing function, cost and price, but also adding new value for the customer. Departing from mass produced consumer goods and moving into complex product-service as notion for building projects.

The paper discusses two empirical cases, selected for their content of reverse innovation. The projects are a public school and a non-profit social housing student's accommodation, for short a school and a dormitory. The cases are developed through revisiting published case studies of the two projects. The dormitory project encompasses 66 new student accommodations. It was designed according to German norms for passive houses. It was built at 7.35 million euros within the maximum cost of 2,485 euros/m<sup>2</sup> set by Danish Government allowed cost for social housing construction. Which is a strict frame in the context of Danish building costs. The school project was a renovation of a relatively old urban public school. The primary and secondary school and its municipality participated in a national architecture competition and was renovated in selected areas such as the hall, the primary school premises, and the library at 3.75 million Euro. The constraints of this project originated from the municipality budget priorities.

The contribution of this paper is to identify reverse innovation of complex products as a research gap and commence conceptualising how reverse innovation can be understood and used on buildings as epitomic cases of complex product services.

The structure of the argument is as follows. As the method outlines the spine of the knowledge production carried out here it is presented first. Then follows the framework of understanding accommodated to answer to the objectives of the research. The two selected cases are first described and then discussed in the light of the objectives and the theoretical concepts. This allows the argument to draw a set of conclusions and implications.

## **METHOD**

The research questions invite the adoption of an overall paradigmatic placing in interpretive sociology. To commence conceptualising reverse innovation in a building sector context, the paper draw on innovation concepts, reverse engineering and reverse innovation. As many concepts of reverse innovation focus of geographical relocation, the conceptualisation turn to the few looking at complex product services. This conceptual endeavour is still early explorative in character. Illustrative cases from the building industry in Denmark was searched for, that encompassed reduction in functionality to meet low resource customers. The two cases selected come from a small group of contemporary and previously researched cases. These include large greenfield hospital projects (2), public school projects (3), sustainable buildings (2), and infrastructure projects (1). One school and one sustainable building, the dormitory, was chosen because the briefing, design and production processes were best documented, i.e. quite pragmatic reasons in correspondence with the exploratory stance of the paper. The other cases are used as backdrop for the discussion.

The dormitory project encompasses 66 new student accommodations built from 2006 to 2009 (author reference). It was designed according to German norms for passive houses

and built within the square-meter frames of Danish social housing. The project also included testing of a renewable energy technology. It is the main building that is in focus. The process was followed from start to one year after commissioning, i.e. from 2006 to 2010. The activities in the design and planning process from November 2006 to August 2008 is of special interest here. Process mappings from records of 31 different meetings was carried out in this period. These mappings focus on innovation, process and product topics. A year after finalising the dormitory, an occupants' questionnaire was sent out, and 18 occupants responded out of about 66 possible. The questionnaire covers perceived value of the clients.

The school study is a longitudinal study of the processes from the initiating architectural competition (1995) until the second renovation has been carried out (2005). Qualitative interviews have been carried out in three rounds; in the start, in the middle and in the end of the processes. Some 16 interviews with stakeholders have been done, each of 1, 5-2 hours length. Most was interviewed in the start. In the middle and end, only active stakeholders were interviewed. Also, document analysis was used. The early phase was a joint process where a ministry and three schools participated.

To reanalyse these two cases the author reread case descriptions and analysis done previously (references to be inserted). Moreover, the author could draw on more detailed knowledge of the cases from previous collaboration with authors and others in the two cases.

## **FRAMEWORK OF UNDERSTANDING**

The framework combines approaches to construction innovation, reverse innovation and reverse engineering.

### **Construction Innovation**

The concept of innovation originates in economic theories about growth. However, a host of studies and approaches have proposed to add to or reconceptualise this understanding (Orstavik *et al*, 2015). Most famous is probably the center for the sociology of innovation in Paris, with profiled contributors like Callon and Latour proposing actor network theory as understanding. A position emphasising the process of innovation. Here we more modestly follow Orstavik *et al*, (2015: 4) proposal of understanding innovation as “humanly created changes in established ways of creating value”. Innovation are often exercises in a tension between value and cost and value propositions by stakeholders tend to get mediated through cost calculations (Van de Ven *et al*, 1999). Also innovation is “measured” or identified through a contextual argument (Tidd and Bessant 2009), underlining that innovation can improve competitiveness in one context, even if well known in another, something which is in turn exploited in the geographical version of reverse innovation.

### **Reverse and Value Engineering**

Reverse engineering and value engineering are quite mature concepts, which both occasionally have been assigned quite cynical features. Reverse engineering being a tool for industrial espionage and value engineering for a strong focus on cost reduction. Messler (2014:1) understands reverse engineering as

...a powerful technique, process, method, and means for creating a design.... It is, quite simply, mechanical dissection or "teardown" of mechanical, electrical, electromechanical or mechatronic, and, occasionally, biological entities.

Teardown and dissection are central concepts and Messler mostly take point of departure is a physically realised product that can be disassembled to learn about its design. Reverse engineering make use of CAD models of the product (Durupt *et al*, 2014, Lee *et al*, 2016). Reverse engineering is linked to and overlapping value engineering and value management. All pointing to the "plastic" shaping of the value of objects along with their physical shaping (Messler 2014). However for Messler it is the technical "read off" of the physical product which is important less than the costs. And functional reductions does not enter his conceptualisation. Value engineering is in turn, according to CIOB (2017) used to solve problems and identify and eliminate unwanted costs, while improving function and quality, thereby integrating technical functionality, value and cost. The aim is to increase the value of products, satisfying the product's performance requirements at the lowest possible cost. The central methodology is to analyse the component parts of a product in terms of its function, searching for ways of providing the (same) functions at a lower cost; and then to verify the economic and technical feasibility before putting it on production. In construction this involves considering the availability of materials, construction methods, transportation issues, site limitations or restrictions, planning and organisation, costs, profits and so on, according to CIOB (2017).

### **Reverse innovation**

The definition of the reversal of innovation initially denoted a product or service developed in a developing country that was then at a later point in time or immediately, introduced in an advanced country (Zedtwitz *et al*, 2015). This approach involves quite some focus on marketing in the advanced country (Hussler and Burger-Helmschen 2016, Tournois 2016). The first definitions of reverse innovation thus simply focused on geographically reverse movements from emergent to advanced markets. Zedtwitz *et al*, (2015) extended this and defined reverse innovation as "any type of global innovation that, at some stage during the innovation process, is characterized by a reversal of the flow of innovation from a developing country to an advanced country, and that is eventually introduced to an advanced country's market". However going beyond the geographical conceptualisation second generation definitions include reverse innovation with new values of the product or service addressing potential clients in a new way (Hussler and Burger-Helmschen 2016, Winter and Govindarajan 2015). The potential for reverse innovation is twofold. First it lies in the rise of developing countries as emerging markets, where medium and low cost products can find new customers (Zedtwitz *et al*, 2012). Second it relates to disrupting western and other developed markets by adopting reverse innovation approaches. Failure from Western companies to grasp the economic, social, and technical contexts of emerging markets can potentially threaten incumbent companies in the west. Winter and Govindarajan (2015) claim that experience has shown the following five failures are prevalent: Trying to match market segments to existing products, trying to reduce the price by eliminating features, forgetting to think through all the technical requirements of emerging markets, neglecting stakeholders, refusing to believe that products designed for emerging markets could have global appeal.

#### *Examples of reverse innovation of complex products*

Most examples of realized reverse innovation are consumer goods such as mobile phones. Reverse innovation of complex products is thus a research gap. But products of medium complex range also surface such as passenger cars; the Fiat 147 (Zedtwitz *et al*, 2015), the Renault Logan (Winter and Govindarajan 2015) and the Tata Nano (Winter and Govindarajan 2015). The Logan for example, is a car that Renault designed specifically for Eastern European customers, assumed to be price-sensitive yet demanding value. The Logan cost only \$6,500, but offered greater size and trunk space, higher ground

clearance, and more reliability than rival products. To obtain a low price, Renault used fewer parts than usual, and manufactured it at low labor costs in Romania. This reverse innovation combines geographical and value reversal. A number of projects have followed Govindarajan and Sarkar (Govindarajan 2010)'s idea of a \$300 house for low resource groups in developing countries (Gross 2010). Thus, the picture is that the upper market of complex products is less covered by reverse innovation efforts. Here the potential would relate to systematically reducing functionality to address needs in a lower resource market.

The process of reduction might be carried out in direct collaboration with customers as value creation is with complex products. Xu and Xu (2016:62) provide three examples in reverse innovation processes of complex products i.e. “pure low temperature waste heat power generation technology”, “large coke oven technology“, and “horizontal well drilling technology”. These complex products were gradually developed by Chinese companies, relying on reverse innovation from advanced markets technologies. However the complex product-services are delivered in an emerging market context and not to advanced markets. And Xu and Xu (2016) tells little of the processes of realizing these reversed product services. Complex product-services, or at least the value of complex product- services are coproduced with the costumer (Løwendahl 2000). The producer-customer relation thus has a networked character in complex product-service context in contrast to marketing for mass markets, which is often highlighted in reverse innovation (Hussler and Burger-Helmschen 2016), Tournois 2016).

Apart from Xu and Xu (2016) the literature on reverse innovation in complex product-services is scarce. From writings on buildings as complex product service it is well known however, how multi-aspect design can be complex and emergent (Gann and Salter 2000) and lead to over engineering (Winch 2002) and cost and time overrun (author reference). Along with Zedtwitz it is suggested here, that reverse innovation can occur in any of the complex product-service realization steps, or as Zedtwitz (2012:12) specify it, four characteristic phases: concept ideation, product development, primary target market introduction, and subsequent secondary market introduction. As noted by Subramaniam at al., (2015), Zedtwitz *et al.*, (2015)'s conceptualization reveals that a number of possible reverse innovation flows are still uncharted.

His 16-type model mostly cover mixes of advanced economy (A) and developing economy (D) interactions, but also involves an AAAA version where all four phases are placed in advanced countries. This is however portrayed as old-fashioned. In this present framework however it is proposed to focus innovation activity and value creation, meaning that in principle reverse innovation can occur in the AAAA model as well. And that this is instrumental, given the closeness to the customer in complex product-service design such as building design. Given the growing use of engineering offshoring in building (author reference) it is not unlikely that reverse innovation of buildings also might involve geographically displaced elements, probably during design, meaning following an ADAA model.

#### *Framework*

Reverse innovation in complex product-services departs from a reverse engineering understanding of technical “read off” of functional product features and systematic reductions. Complex product-services, or at least the value of complex product- services are coproduced with the costumer. While the geographical location of any step of the realization of a complex product service is in no way de-appreciated here, the definition is however that reverse innovation can create change and value in all steps in this realization

also independently of geographical de-location. Reverse innovation activities in principle encompasses co-design with users, reconceptualising, reduction of functions, refinancing, changed marketing. One might talk about weak and strong reverse innovation. Weak covers those humanly created changes that do systematically reduce function and cost, which therefore can be understood as innovation in a concrete context. Strong reverse innovation is when the exercise of reduction leads to improvements of the value/cost balance by departing from pure reduction and introducing new creative, innovative solutions to meet the cost regime.

### *The Dormitory Case*

The project was initiated by the non-profit social housing association Fruehøjgaard. This association had participated in innovative projects before, and it wanted to contribute in 2006 to the development of sustainable buildings still maintaining cost efficiency. This client had a number of visions and ideas for the project, encompassing use of passive house design, prefabrication, realizing a good indoor climate and a collaborative process of partnering and lean. The architect was selected through a competition amongst five competitors. This led to the selection of an architect and consulting engineer. Shortly after the brief design commenced. As the project was carried out within the public governance of social housing a strict budgetary control of design and production cost was implemented. Also, a confirmation of the allowed frame was sought through a meeting with the responsible ministry.

However, in the subsequent period the budget control failed and there were numerous dialogues over the contracts. This led to a budget status made in May 2007, which showed a deficit of 675 000 Euro or roughly 10% of the budget. This budget was scrutinized entry by entry and an action plan was elaborated. 135000 Euros in cost reductions was found, yet in September another status revealed that the deficit had reached 21%. This predominantly occurred due to the primary building component of the structural elements, the bath cabins and the building envelope which compared to the ministry benchmark figures cost the double. This links into another central aim for obtaining a compliance with government demands was through using prefabricated elements. A supplier of bath cabins was contracted early in 2007. Another Danish manufacturer of prefabricated modular building envelope elements participated in the early phase in 2007. The manufacturer developed a prototype of a room module, but the calculated cost was too high and the project was forced to shift supplier. In autumn 2007 the project had allocated costs to these prefab elements that were a serious burden for the budget.

A shift was made to using façade elements for a passive house building envelope, using a German prefab manufacturer, a collaboration that commenced in November 2007. This created a saving on structural elements of some 350 000 euro. Also, a German windows supplier was chosen. This can also be seen against the background of the status of the Danish market for building components at the time. In 2007-2008 it was understood that no Danish component manufacturer could live up to the passive house standard. By December 2007 a deficit of 55000 Euro was reached and preliminary accepted. The designing demand of living up to passive house standards triggered three iterative rounds of energy calculations. The early process of involved calculations by the engineering consultant using Danish energy calculation software. However, in early 2007, calculations still showed a net heating demand of 21 kWh per m<sup>2</sup> per year higher than the standard 15 kWh. By July 2007, the design work was able to meet the certification demands. Third, as the clients' demand was a certificated passive house, it was decided to ask for consultancy from the Darmstadt experts. This third round of calculations showed

that the third demand of total specific primary energy 120 kWh per m<sup>2</sup> per year could not be met, primarily due to differences in definitions. But the project met its cost goal. In the project's calculated final balance, the total cost was set at 7.35 million euros. This equals a cost per square meter at 2,300 euros, or 92.4% of the maximum amount of 2,485 euros/m<sup>2</sup> set by the government. This was made possible by the mentioned budget reduction exercise and by several of the participating companies that saw the project as innovative and were willing to put aside part of their costs in terms of hours spent, as they viewed it as an investment in future knowledge and products. Prefabrication was another goal that was met. The degree of prefabrication is some 59%. The passive house certification was obtained a year after occupation.

### *The School Case*

The school participated in a national architect competition on "the public school of the future". The three participants in the competition was chosen by the ministry of education with the aim to find schools representative of schools in general in Denmark. The school chosen here is a relatively old school placed in an urban area with limited possibilities of enlarging its estate. The school aimed at a considerable renovation. It has been granted a smaller budget as part of the municipality school plan, but aspired to use the architect competition as lever for enlarging the budget for renovation. To participate in the competition the municipality signed a contract with the ministry, which committed the municipality to invest funding in the project. The conditions for the competition were published and involved amongst other things an obligatory participation in the competition teams of a didactical expert. The competition was initiated and finalized over a period of five month.

The ministry and the municipality had five meetings to prepare a text program for the school. This was a tough process as the school representatives and the municipality started from scratch and had to deliver quickly. Subsequently the architects' proposal was developed over 1-2 months. The competition follow standard rules for Denmark and involved architecture experts, an independent surveyor contracted to evaluate the cost of the projects and other stakeholders including representatives of the municipal board (politicians). It there quickly surfaced that there was a mismatch in expectations and agreements. Most projects presented cost up to 8 times more than the municipality had allocated.

The competition was framed by the ministry and led by the architects' experts however and price did not enter as criteria, to allow for creativity to blossom. The project was subsequently split in two to accommodate the cost frames of the municipality. The rebuilding of the gymnastics hall was realized as designed, yet was a small project. Whereas the other part was reconceptualised. The process of this project became long and even halted over several years. When funding for the second part arrived the architect and schoolmaster selected elements from the competition project. They choose to focus on the hall, a central meeting point yet a passive area. Here a service counter, a café and the school library was incorporated into the hall. A theatre hall was created and cellar facilities equipped for receiving the youngest pupils. The theatre is a new element compared to the competition project.

## **DISCUSSION**

The dormitory process features a client with many ambitions and visions, but still having to act within a detailed public governance. This framework triggers an active and conscious search for innovation that can aid in combining the contradictory framing. The cost frame was accepted as a thoroughgoing condition for the project. The client in this

manner decided not to circumvent it by financial innovation that could have orchestrated more funding (Åkerström and Pors 2017). There are actually examples of combining social housing projects in Denmark with for example commercial buildings to do such innovations, combining two clients. The process that emerged has a more or less constant focus on reducing costs. The choice of foreign suppliers is a direct consequence of the combination of a strict cost level and a high demand for value through quality functionality.

Thus, windows and façade modules was purchased in Germany. Such reverse innovation does not reduce functionality. The project did comply with many if its goals. It reached its cost goals, yet only after a rigorous reduction exercise. It received a passive house certification thereby living up to a central product demand and realizing a central goal of innovation. However, the perceived value by tenants was more problematic as the indoor climate did not live up to expectations. And the consulting engineers participating restricted their hours billing to the project to maintain its feasibility. In the public school project the reverse innovation involves first splitting the project in two to accommodate the cost frames of the municipality. And in the second round picking and choosing from the larger competition project. In the first part the gymnastics hall was realized as designed, yet was a small project. Whereas the other part was reconceptualised.

In the second part, a few elements from the competition project was selected and a theatre hall added. This approach was possible because the original project did not involve deep structural changes of the school building, neither was the project a strongly integrated unity. It thus echoes proposals of using modular design in reverse innovation. The process of this project became long and even halted over several years. The school master being the only thoroughgoing person. This also enabled the pick and choose approach. And can -if strongly interpreted- be viewed as a reorientation of the target group for the product, the school master more or less monopolised the project in the end. This can be compared to the repositioning of market and marketing in reverse innovation. In terms of value creation for the customer, the interest groups in the customer constellation is split in their evaluation of the result. The central actors are on the other hand disappointed over the lack of realization of the designed project Other stakeholders, accept the result and further stakeholders such as the teachers are not satisfied. The case shows that it is not given that reverse innovation will occur in the design phase. Here a post design phase is entered where central actors “pick and choose” from the design.

### **Systematic reduction?**

The two cases are common in their lack of direct systematic reduction (no use of reverse or value engineering) beyond practices resembling bookkeeping where the actors go through entry by entry their budget to find possibilities of reduction, which was used in the dormitory case and the functional split of major parts of the product used in school case, supplemented with the pick and choose approach made possible by the renovation project of the school. In this manner, the two projects represent each their extreme in the rule of thumb strategic dilemma of “cut on the surface evenly across functional areas or cut in depths, one functional area out”. These two strategies are common knowledge and common sense, the first even having a popular nick name “the forage harvester method”. Sehested (2008) is told by her interviewee architects, that these reduction situations are recurrent, a similar finding to that of the author’s hospital project, where one interviewee even claimed that reduction approaches must be accommodated to the single project special characteristics.

## **Innovation?**

The use of reductions in the two projects lead to innovation. In the dormitory, the use of another supplier of the building modules is at a time a considerable saving and a process/product innovation. Also, several elements of the school project add new innovative elements to the school's way of operating (i.e. the design of the primary school area, the detailed design of the hall). The analysis of the cases first show that “non-geographical” reverse innovation occurs. However once established that the cases predominantly operate in a single context of high resources it can be noted that the dormitory case do utilize the differences in price and experiences Denmark- Germany in terms of supply of building components for passive houses. Moreover, other cases not discussed here, feature cost reduction through offshoring of design work, insourcing of migrant workers and other socio-geographically based practices.

## **CONCLUSION**

This paper set out to explore how reverse innovation might be relevant for a complex product- service such as building projects. This was done asking what characterize brief, design and production reductions. If and when systematic reduction is carried out, then when can such systematic reductions be understood as innovation? Innovation was defined as change that create value and reverse innovation defined as reducing function, cost and price, but also adding new value for the customer. The paper then analysed illustrative exemplars of reductions in brief, design and production of building where a budgetary and/or political framing meant that scope or budget expansion was not possible, also asking whether systematic reduction was carried out through scrutinizing each design area of the building to find functional and cost reductions, then is such systematic reductions innovation, does it lead to new value or revaluing? The theoretical framing used drew on reverse innovation literature, arguing that reverse innovation can add value to customers without having to use geographical “transplantation” from high resource to low resource areas/continents of the world. But using reverse engineering approaches complex product-services can be realized.

The paper presented and analysed two illustrative empirical cases, selected for their content of reverse innovation. The projects were a public school and a non-profit social housing student’s dormitory. The analysis of the cases first show that “non-geographical” reverse innovation occurs. This type of innovation has occurred in Danish context of lower resource clients in need of as much value adding functionality of the product service offer they could get at an affordable price. In the dormitory case the budget frame triggered innovation and acted as a thoroughgoing frame, and led to reverse innovations, but also to sustainable innovation and process innovation. The school case exhibit a far more ad hoc approach in circumventing and addressing limited resources. The cases share a lack of direct systematic reduction beyond bookkeeping approached scrutinizing entry by entry used in the dormitory case and the functional split of major parts of the product used in school case. The implication of a possible future role of reverse innovation is to commence a learning and search process for approaches and procedures that can accommodate strict budgetary frame. In a global perspective, the use of reverse innovation have major impact on possibilities of realizing welfare. But also in the western hemisphere, resource differences prevail, that justify that building professionals should be able to realize projects for low income groups. In the present context of Scandinavia a strong paradox of an overheating building sector, rising material prices and large low resource groups in society pose threats to social stability.

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# **DISASTER AND RESILIENCE**

# DISASTER RISK REDUCTION CONCEPTUAL FRAMEWORK: OPEN DATA FOR BUILDING RESILIENCE IN CRITICAL INFRASTRUCTURE

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Disaster Risk Management (DRM) and Disaster Risk Reduction (DRR) emerged as systematic approaches to reduce the impact of climate change on the built environment. However, post 2015 United Nations (UN) disaster emergency frameworks failed to capture the dynamics of hazards, exposure and vulnerability, due to the lack of accountability and accuracy of disaster data loss. This paper aims to explore the nature and impact of the utilisation of Open Data in DRR to build resilience in critical infrastructure. A historical review of DRM and DRR policies emergence pre-and post the year 2015 is applied. Based on evidence from empirical research and UN global reports, a correlational study between the 2015-2030 Sendai Framework for Disaster Risk Reduction (SFDRR) and Sustainable Development Goals (SDGs) is applied. Using the indicators of (SFDRR) Target D, and (SDGs) Goal 11, terminological analysis is applied for disaster damage, critical infrastructure and disruption of basic services. This paper offers a conceptual framework for building resilience in critical infrastructure across disaster preparedness three-stage process of recovery, rehabilitation and reconstruction. This framework rests on firm theoretical foundations concerning the Open Data for resilience initiative principles, and use case for building resilience in the Kathmandu Valley's, Nepal critical infrastructure.

Keywords: disaster risk management, disaster risk reduction, open data, urban resilience

## INTRODUCTION

The disastrous impact of climate change on urban livelihoods and natural biodiversity systems has long been observed worldwide. Shaped by the type of hazard and degree of exposure, extensive disaster risk derived by urbanisation, environmental degradation, socio-economic inequality, and poor urban governance is witnessed to accumulate larger losses in mortality, economic and physical damage (Shaw *et al.*, 2010:198).

Over the past ten years, approximately 700 thousand people have lost their lives, over 1.4 million have been injured and 23 million have been made homeless because of disasters. At the same time, the Hyogo Framework for Action (HFA) 2005-2015: building the resilience of Nations and communities to disasters was adopted by the World Conference on Disaster Reduction, but the layer of extensive risks was 'not captured by global risk modelling, nor are the losses reported internationally' (UNISDR 2015:90).

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‘Climate change may not be responsible for the recent skyrocketing cost of natural disasters, but it is very likely that it will impact future catastrophes’ (NASA 2016). The variations of risk drivers between the countries globally reflect the uneven social, economic and governance construction of hazards, risk and vulnerability.

There have been various attempts in the year 2015 to address challenges related to development, climate change and disaster risk losses. The Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030 was endorsed by the United Nations (UN) General Assembly, and adopted by 187 countries as a 15-year, voluntary, non-binding agreement with four priorities and global seven targets, which aim at the reduction of disaster risk and losses in lives, livelihoods and health. This was followed with the adoption of the 2030 Agenda for Sustainable Development Goals (SDGs). With 17 Goals and 169 targets, both the SFDRR and SDGs aim to reduce disaster damage to critical infrastructure and disruption of basic services.

On first sight, it might seem plausible to argue that effective monitoring of disaster data loss can help achieve progress in reporting to the SFDRR and the SDGs global targets and associated indicators. However, on closer inspection, Cutter and Gall (2015) indicate that ‘existing loss accounting systems vastly underestimate the true burden of disasters, both nationally and globally’ (Cutter and Gall 2015). The 2017 Sendai Framework Data Readiness Review - Global Summary Report, gave scope to gaps in loss-data availability, accessibility, quality, applicability and the ‘need to be sufficiently consistent and comparable to allow meaningful measurement of progress and impact’ (UNISDR, 2017).

Moreover, calls for local solutions (Manyena, 2016:41), and understanding the challenges of DRR multi-level governance (Triyanti and Chu, 2016:1) in developing countries requires addressing data collection approaches at the local level, to help develop and validate reporting for global frameworks at the national and regional levels. In this respect, this study is needed to empirically investigate the use of Open Data in disaster preparedness for building resilience in policy and practice.

Defined as ‘the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions’ (UNISDR, 2016). The term ‘resilience’ have been explored broadly across different research disciplines, yet all agreed on the role of local communities’ social dynamics in understanding the scale of risk and level of vulnerability, to strengthen urban resilience.

Hence, the key question is: How can open data fill the gaps in capturing, sharing and using disaster data losses from underlying risks, and recognising the challenges for achieving the global targets? Based on empirical evidence from UN global reports, literature review of DRM and DRR theories in the context of urban resilience and this paper addresses the gap in disaster data loss, and discusses the implications of building coherence between the 2015-2030 Sustainable Development Goals (SDGs) and the Sendai Framework for Disaster Risk Reduction (SFDRR).

## **METHODS**

This paper is part of an ongoing PhD that aims to develop an Urban Resilience toolkit to support the implementation of SFDRR in the Middle East and North Africa (MENA) Region. To prepare and validated the elements of the toolkit with a robust methodology, the key objective of this paper is to develop and demonstrate a Disaster Risk Reduction Conceptual Framework, based on the use of open data for building resilience in critical

infrastructure. In an attempt to unravel the objectivist ontology of DRR in the contexts of the 2015-2030 SFDRR and SDGs, the literature review includes data from secondary resources, refereed journals and UN policy reports, to undertake an inductive theoretical perspective towards filling the gap in disaster loss databases, and achieve the global targets.

Starting with the historical review of DRM and DRM ideologies emergence in UN frameworks pre-and-post the year 2015, the paper prioritizes investigating a correlational study between SFDRR and SDGs, against the three main constructs of Target D for the SFDRR, and SDG Goal 11- Target 11.5.2 (disaster damage, critical infrastructure and disruption of basic services). In particular, this study analyses the characteristics and constructs of the indicators terminologies, to understand how data losses are collected across disaster risk timeframe, scale, and assessment process.

Using strategic DRR and DRM theory, a conceptual framework is developed to understand how the shared principles of preparedness process of recovery, rehabilitation and reconstruction take place, jointly with the Global Facility for Disaster Risk Reduction (GFDRR) Open Data for resilience initiative principles. It prioritizes understanding the paradigm of risk-resilience in using, sharing and collecting consistent data on extensive hazards, exposure and vulnerability of critical infrastructure.

The paper will then showcase the use of Open Data in mapping critical infrastructure in the case study of Kathmandu, Nepal, building seismic resilience in the Kathmandu Valley's education and health infrastructure. The paper concludes with learning lessons, identifying gaps and future challenges for the interpretation of disaster risk assessments, and hazard impact model in reporting for the 2015- 2030 global indicators.

## **HISTORICAL REVIEW**

### **Disaster Risk Management and Disaster Risk Reduction**

The United Nations Office for Disaster Risk Reduction (UNISDR) states that, the term disaster management encompasses several activities of organization, planning and application that address measures for preparing, responding to and recovering from disasters (UNISDR 2016: 14). Prominently, disaster management focuses on implementing strategies that may not lead to eliminating the risk of disasters.

This topic was debated as early as 1961 by Duncan, as cited by Kroll-Smith and Couch, identifying the physical factors of disaster. On the contrary, Quarantelli (1985, 1987) suggested the social norms of disasters in relation to the demand of action and capability of response beyond geophysical terms. (Kroll-Smith and Couch 1991). The UNISDR define disaster as 'a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts'. Notwithstanding, disasters social and physical scopes are recognized in the differentiation between emergency response and recovery actions (UNISDR 2016:13).

Emergency management was first initiated during the First World War in 1935, following the bombing of civilian areas, and the establishment of the Civil Defence Service by the Home Office of the United Kingdom. Brought about protecting the population against nuclear destruction, a shift towards protection against natural hazards such as floods and earthquakes arose by the end of the Cold War 1991.

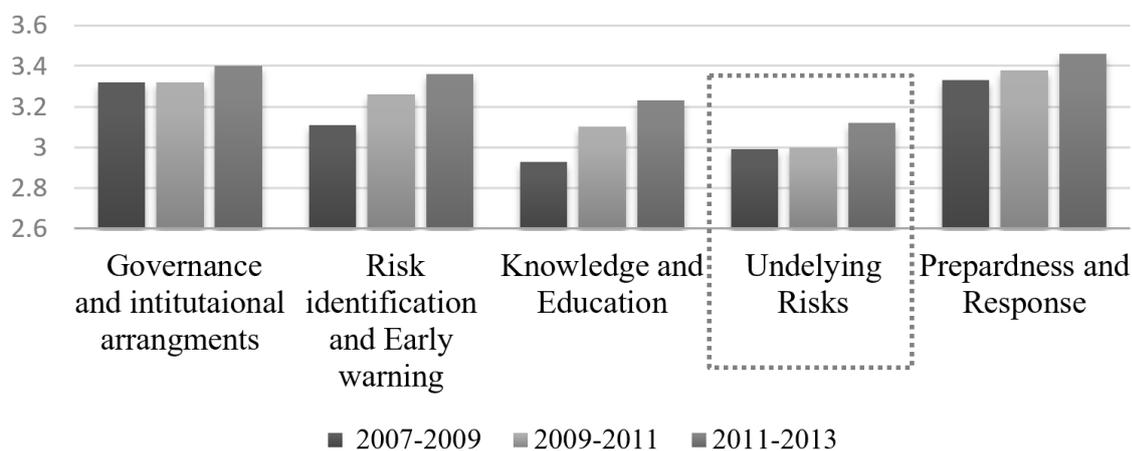
In the early 1960s, The United Nations General Assembly (GA) started adopting measures regarding severe disasters, to inform the Secretary-General of the type of emergency they are in the position to offer. This came into effect when the Buyin-Zara earthquake struck Iran and killed more than 12,000 people. This is followed by the creation of the United Nations Disaster Relief Office (UNDRO), to promote the study, prevention, control and prediction of natural disasters, and assist in providing advice to governments on pre-disaster planning.

Recognised as ‘the International Decade for Natural Disaster Reduction’, the period 1990-1999 witnessed the GA supremacy of reducing the impact of natural disasters for all people, with focus on developing countries. This was endorsed by Yokohama Strategy and Plan of Action at the World Conference on Disaster Reduction, which was held at Yokohama, Japan from 23 to 27 May 1994 (UNISDR 2017).

The 3rd Millennium witnessed the international community movement towards early warning, to take timely actions in advance of hazardous events. This was triggered with El Niño phenomenon’s acute impact and climatic changes affecting the equatorial Pacific region and beyond, aimed to review the Yokohama Strategy, identify gaps and mitigate challenges. The early warning system movement was consolidated with the establishment of the International Strategy for Disaster Reduction (ISDR) and emphasis on shift from Disaster Risk Management (DRM), to Disaster Risk Reduction (DRR).

The ISDR endorsed the Hyogo Framework for Action (HFA) 2005-2015: building the resilience of Nations and communities to disasters, adopted by the World Conference on Disaster Reduction (Kobe, Hyogo- Japan), to facilitate disaster reduction strategy into national plans. Focusing on the reduction of disaster losses, Priority for Action 4 of the HFA calls to ‘Reduce the underlying risk factors’ (UNISDR 2015).

Figure 1: Progress in implementing the HFA 2007-2013 (Source: Adapted from the UNISDR 2015 Global Assessment Report on Disaster Risk Reduction), (Part II-p.114)



Since 2007, 146 governments have participated in at least one cycle of the HFA review using the online HFA Monitor. In 2011-2013, 136 countries submitted reports, and governments have reported growing levels of HFA implementation over time (Figure 1). Nevertheless, HFA monitoring mechanism focused on reporting data losses from large scale intensive disaster (e.g. earthquakes and cyclones), and overlooked the underlying risks of mortality, physical damage and economic losses from small scale extensive disasters (e.g. floods, landslides) derived by poor urban governance and planning. These notions have been elaborated by Dodman *et al.*, (2009), in the light of scale, frequency

and impact, divided into biological, chemical, and physical hazards (Dodman, D., Hardoy, J and Satterthwaite 2009).

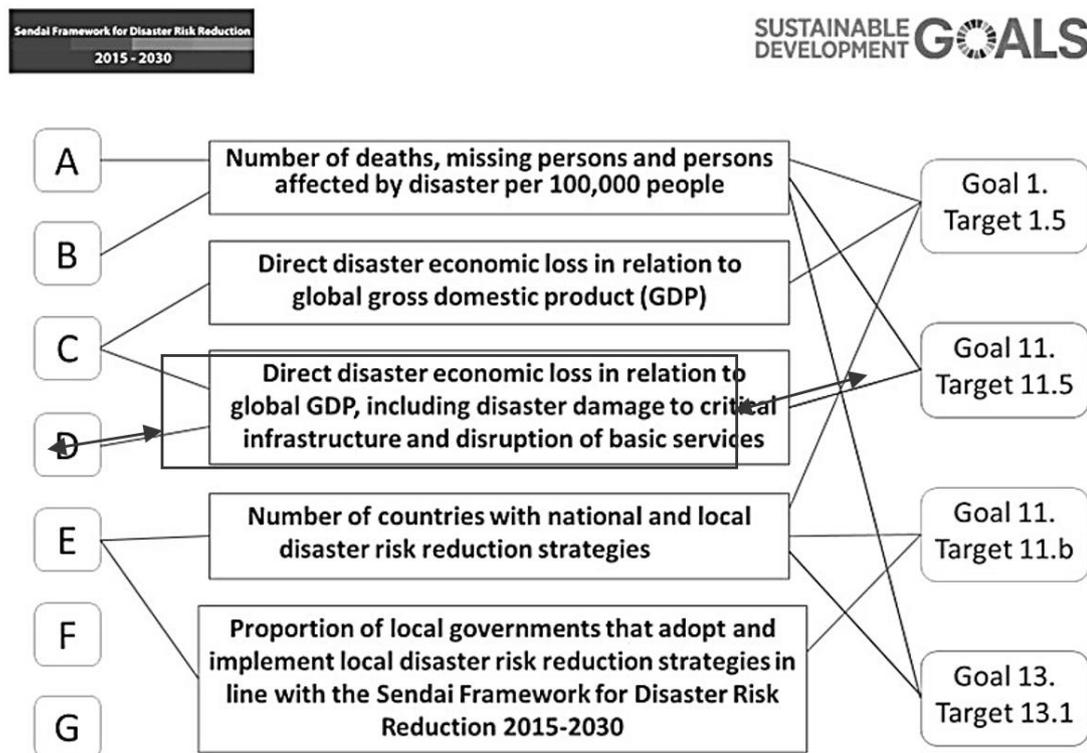
It is often argued by UN reports and policy documents that an evolution from managing disasters to managing risks was affiliated with the launch of the Sendai Framework for disaster risk reduction (SFDRR) 2015-2030. However, evidence from the 2015 Global Assessment Report on Disaster Risk Reduction recognise that ‘most resources continue to be invested in strengthening capacities for disaster management, and there has been limited success in applying policies, norms, standards and regulations to manage and reduce risk across development sectors’ (UNISDR 2015:118). Hence, there is growing consensus to differentiation between DRR and DRM tools and mechanisms to address the underlying risk drivers, and best utilise Open Data in disaster risk preparedness, beyond tendencies to mitigate challenges in post-disaster recovery only.

## CORRELATIONAL STUDY

### Critical Infrastructure in SFDRR and SDGs

Peters *et al.*, (2016) stated that ‘delivering this global vision by 2030 in a sustainable and inclusive way, requires that we act upon all the major frameworks negotiated and agreed throughout 2015 and 2016’. (ODI, 2016:10). Based on the 2017 Integrated Research on Disaster Risk and International Council for Science policy document, Figure 2 highlight the correlation between SFDRR and SDGs global targets through common indicators (UNISDR, 2017).

Figure 2: Correlation between SFDRR and SDGs global targets through common indicator (UNISDR, 2017)



As noted by Luijijf *et al.*, (2008), gaps in data losses caused by cascading effects due to infrastructure interdependencies are identified as a key challenge for critical infrastructure protection (Luijijf *et al.*, 2008:303). More to the point is the fact that ‘data are typically more available on physical damage and human impact, and less available on economic

losses, losses of specific assets and infrastructure’ as noted by the Sendai Framework Data Readiness Review (UNISDR, 2017).

Considering that the terms ‘damage’, ‘critical infrastructure’, ‘disruption’ and ‘basic services’ are addressed coherently across the SFDRR, SDGs, as presented in Table 1, to understand how data losses are collected across disaster risk timeframe, scale, and assessment process. This will help identify the level of interruptions or damages per sector in critical infrastructure and basic service, on extensive and intensive risks for all hazards.

Table 1: Data disaggregation and statistical processing - SFDRR and SDG indicators

| <b>Target D for the SFDRR Target (d)</b> ‘Substantially reduce disaster <b>damage</b> to <b>critical infrastructure</b> and <b>disruption</b> of <b>basic services</b> , among them health and educational facilities, including through developing their resilience by 2030’ |  |  |   |
|---|--|--|---|
| <b>SDG Goal 11, Target 11.5.2</b> ‘Direct disaster economic loss in relation to global GDP, including disaster <b>damage</b> to <b>critical infrastructure</b> and <b>disruption</b> of <b>basic services</b> ’   |  |  |   |
| Terminologies   | Duration   | Assessment Process   | Scale   |
| Damage  | Physical harm, not structural or architectural, which may continue to be habitable, although they may require some repair or cleaning that happen during the event or within the first few hours after the event   | Assessed soon after the event to estimate recovery cost and claim insurance payments.  | These are tangible and relatively easy to measure.  |
| Critical infrastructure   | The physical structures, facilities, networks and other assets that support services that are socially, economically or operationally essential to the functioning of a society or community.  | Number of times interruption or damage occurs per population and sector  | By country, event, hazard type, sub-national administrative unit, asset   |
| Disruption  | Disturbance and interruption of services, activities, or process that may affect different segments of the population with differing degrees of severity, including cases in which service delivery continues.   | Disruptions of services can be measured in smaller units of time, for example hours or even minutes or seconds<br><br>Duration of service disruption and the number of people who did not receive basic services | Disruption of services may occur at irregular periods of time (or) can also be due to lower levels of quality                                 |
| Basic services  | Services that are needed for all of society to function effectively. This include water supply, sanitation, health care, education, housing, and food supply. They also include services provided by critical infrastructure such as electricity, telecommunications, transport, finance or waste management that are needed for all of society to function. |  | By destroyed/damaged, transportation mode, service sector (duration: short, medium and long; an affected scale in terms of household numbers) |

## CONCEPTUAL FRAMEWORK

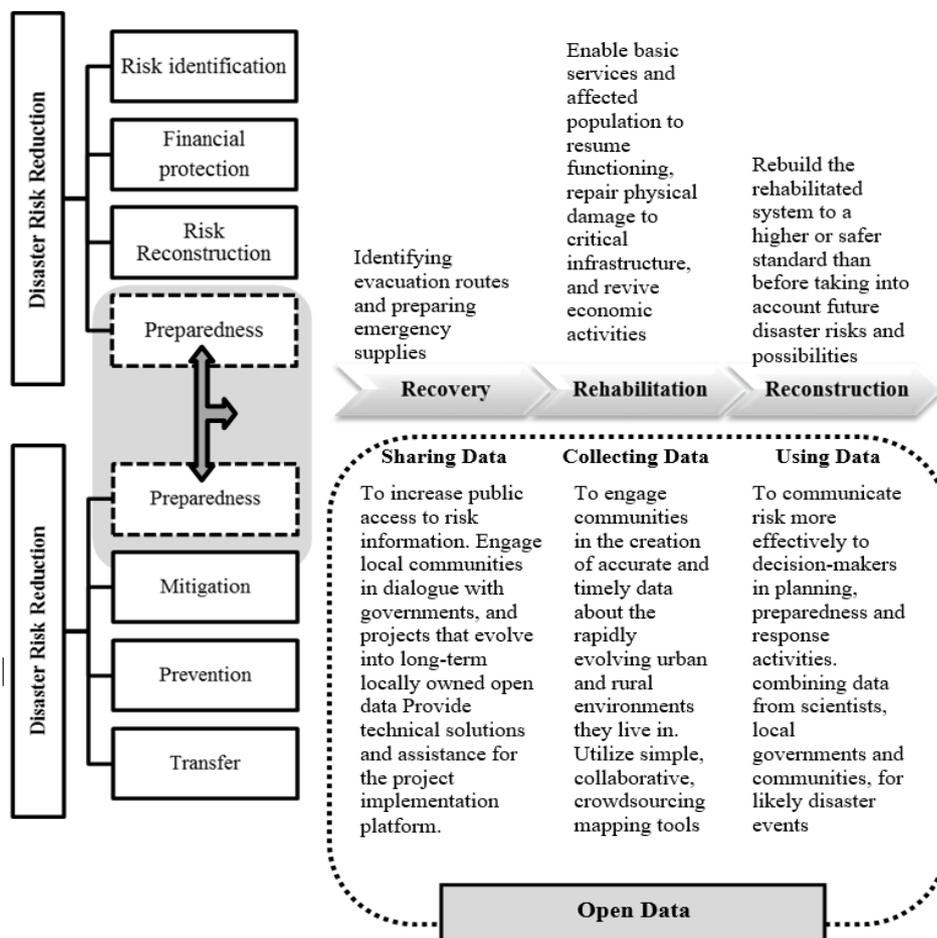
### Use of Open Data for Critical Infrastructure Preparedness in DRM and DRR

It has been argued by Kirschenbaum (2002), that preparedness elements are driven by social factors that vary according to disaster management agencies, and community based collective behaviours, reflecting the components of ‘provisions’, ‘planning’ and

‘protection’ (Kirschenbaum 2002:14). Notwithstanding, the component of data sharing, using and collecting is missing. This study points towards a more integrated eco-system to use Open Data for preparedness and effective response to “Build Back Better” in recovery, rehabilitation and reconstruction’ (UNISDR 2015).

Defined as ‘data that is open to anyone free to use, re-use or redistribute’, Open Data must be legally open to be placed in the public domain with minimal restrictions, and technically open in formats that are machine readable and usable. In the context of disaster preparedness, Open Data for disaster loss should maintain the standards for relevance, accuracy, reliability, timeliness, punctuality, accessibility and clarity. This allows for developing comparable and coherent data sets that can be ‘sufficiently consistent and comparable to allow meaningful measurement of progress and impact’ (UNISDR, 2017).

Figure 3: The interrelationship between DRR and DRM (Preparedness and Open Data)



Adopting the 2011, Global Facility for Disaster Reduction and Recovery (GFDRR) model (Figure 3), links between DRM and DRR highlights the contrast elements of preparedness, and identify core tools to improve risk information, communication and mitigation.

The indicators addressed here to measure the global progress for the SFDRR and SDGs provide guidelines on how and why the indicators are constructed, but do not identify a cohesive global approach to be adopted for data collection. Within the boundaries of disaster timeframe and level of damage, the terminologies listed under (Direct), (Basic) and (Critical) for basic services and infrastructures cannot be identified in the context of

small scale and slow-onset disasters. These disaster-related data gaps overlook the underlying risks associated with socio-economic dimensions at the recovery and rehabilitation phase.

Accordingly, the use case below showcases the use of Open Data through participatory hazard mapping methods for critical infrastructure (schools- hospitals) in Kathmandu, Nepal. This model provides a guide on using Open Data tools to fill the data-loss gap and accommodate the dynamics of all hazards in measuring resilience for the SDGs and SFDRR indicators.

Table 2: Case study: Kathmandu, Nepal: Open Data for Critical Infrastructure (2012)

|   |  |
|---|--|
| <b>Country:</b> Nepal   |  |
| <b>City Profile:</b> Kathmandu, capital city, is situated in central Nepal bowl-shaped valley between four major mountains, at high elevation (approximately 4600ft or 1400m)   |  |
| <b>Population:</b> Exceeding one million  |  |
| <b>Risk profile:</b> Earthquakes and landslides   |  |
| <b>Objectives:</b> To build seismic resilience in the Kathmandu Valley’s education and health infrastructure  | <b>Expected Outcomes:</b> The model will be used to prioritize plans for retrofits of schools and health facilities to improve structural integrity in the face of earthquake. |
| <b>Project:</b> Critical Health and Educational Sector Infrastructures  | <b>Partnership:</b> Government of Nepal, the World Bank and GFDRR Open Cities Project  |
| <b>Stakeholders:</b> Universities, technical communities, community groups, local government, Kathmandu Living Labs (local NGO)   |  |
| <b>Method:</b>  |  |
| <ul style="list-style-type: none"> <li>• Collect structural data (asset and exposure) for 2,256 schools and 350 health facilities in the Kathmandu Valley urban areas</li> <li>• Engage all stakeholders in order to create a robust asset inventory and expand the OSM (Over 2,300 individuals participated in OSM trainings or presentations during the first year of the project)</li> <li>• Create a disaster risk model to determine the relative vulnerability of the relevant buildings.</li> <li>• Create a comprehensive base map of the valley by digitizing over 100,000 building footprints, mapping the road network, and collecting information on other major points of interest.</li> </ul> |  |
| <b>Results:</b> Kathmandu has to date mapped over 100,000 buildings and collected exposure data for 2256 educational and 350 health facilities within Kathmandu Valley.   |  |
| <b>Sustainability Plan:</b> Kathmandu Living Labs to follow-up OpenStreetMap trainings and mapping.   |  |

## CONCLUSIONS

Disasters result from a combination of hazard, with their respective to exposure and vulnerability exacerbated with climate change extreme weather events, evidence from previous literature indicate that the severity and frequency of disasters impact are most to be affecting the ‘grassroots-level community’ (Shaw, Pulhin *et al.*, 2010:116). The subjectivist review of building resilience in DRM and DRR pre-and-post 2015 UN frameworks is challenged in this paper, to identify the gap in disaster data losses database from underlying risks, and aim to explore the nature and impact of the utilisation of Open Data for building urban resilience in DRR.

Due to the lack of multi-level disaster management governance system at the local, national and regional levels, Open Data is indemnified as an ecosystem-based disaster risk management tool responding to Triyanti and Chu recommendations, by developing a conceptual framework the use of Open Data for Preparedness in DRM and DRR shared

variables of ‘recovery’, ‘rehabilitation’ and ‘reconstruction’, in conjunction with the Open Data for Resilience initiative three stage process of sharing, collecting and using data for DRR. (Triyanti and Chu, 2016)

With the focus on building resilience, the SFDRR and the SDGs 2015-2030 agendas have the potential to integrate the paradigm of risk-resilience, taking into account the issue of inconsistency in monitoring reliable data of disaster damage to critical infrastructure and disruption of basic services. The correlation study in this paper and analytical outline of the SDG 11.5.2 and SFDRR Target D terminologies, duration, assessment process and scale, engender that the indicators addressed to measure global progress in the implementation of the global targets provide guidelines to the Metadata (describing how and why is the indicators constructed) and Methodology (the Summation of data from National statistics offices) but does not provide mechanism of data collection and tools for analysis to monitor progress and develop DRR resilience plans at the local level. Accordingly, this paper showcases the Kathmandu, Nepal model of using Open Data for mapping critical health and educational infrastructure, and create a disaster risk model to determine the relative hazard, exposure and vulnerability.

In the context of building urban resilience, national and local governments would require identifying local techniques to mitigate climate change impact by reporting on small-scale onset, and frequent hazardous events that are not registered in international disaster loss databases. Lack of transparency, weaknesses of urban governance and limitations in financial and human capacities may cause socio-economic assessment biases, and will remain as challenges for the application of Open Data findings into extensive hazards. It is important to improve human and technical capacities with the use of Open Data tools to obtain a consistent report on data losses for all hazards and underlying risks. This will have be compared to the Hyogo framework of last decade (2005-2015), to develop evidence based record on the implementation of SFDRR and achievement of 2030 SDGs global targets.

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# CREATING AN OPPORTUNITY TO INNOVATE DURING DISASTER RECOVERY

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Innovating in construction can be a complex task. Innovating in construction whilst recovering from a disaster adds an extra level of complexity. This paper examines a unique innovation process adopted by an alliancing organisation (SCIRT) during the Canterbury earthquake recovery. SCIRT was an organisation formed to reconstruct the damaged horizontal infrastructure (water, waste water, roads and highways). The innovation process developed by SCIRT for capturing and measuring innovations was novel as it came from a desire to recover well from the earthquakes and to seek opportunities to construct better and more efficiently. A process was set up to specifically encourage, capture and measure innovations. This process is described in the paper, but was centred on an innovation KPI. Over 600 innovations captured were reported and analysed for this research, giving a rich picture of where innovations originate, what types of innovations occur more frequently, and where in a construction life cycle different innovation types can best be developed. The paper shows that, despite innovations being created in a time of change and uncertainty, the innovations created can have lasting long term benefits for the wider construction industry.

Keywords: innovation, reconstruction, disaster, SCIRT, New Zealand

## INTRODUCTION

The construction industry is critical to the functioning of a domestic economy. In New Zealand, the construction industry is one of the largest sectors of the economy, accounting for 8% of total employment in the country (Statistics NZ, 2016). However, in spite of its importance to the national economy in terms of size, it seems to be lagging behind other sectors in terms of innovation. In 2010, the construction industry in New Zealand established the Building and Construction Sector Productivity Partnership to actively address the problem of low productivity in the sector (Wilkinson *et al.*, 2012). Although the early focus was on identifying and quantifying the problems that led to low productivity, over recent years the focus has shifted to problem solving and addressing the cultural and mechanistic change that is needed to resolve the well-documented problems (Wilkinson *et al.*, 2012).

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One of the areas that the partnership identified as critical for achieving significant improvements in the sector's productivity is innovation. The ultimate goal was for 20% productivity improvement by 2020, but this required a shift in methodology. The Construction Sector Productivity Partnership advocated for new, innovative, approaches as required in order to significantly improve performance at the same cost or maintain the same level of performance at a much lower cost. Unfortunately the construction industry is one of the least innovative sectors compared to other industries such as manufacturing and traditional services, (Reichstein, Salter, and Gann, 2005). The R&D report produced by Statistics New Zealand indicates that R&D expenditure in the construction industry accounts for a low 5% of the total expenditure in the sector (Statistics NZ, 2012).

Indeed, this problem is not limited to New Zealand as, internationally, the construction industry is seen as a traditional or low-technology sector with low levels of expenditure on activities associated with innovation (Seaden *et al*, 2003). Although there is much research on innovation in the construction industry, most of this research tends to consider innovation in relatively stable environments. There are few studies which show how innovation can be encouraged in crisis situations. This paper examines innovation development in a highly stressed environment. A large-scale alliancing organisation (SCIRT) developed innovation practices during the Canterbury earthquake recovery. The innovation process developed for capturing and measuring innovations was novel as it came from a desire to recover well from the earthquake and to seek opportunities to construct better and more efficiently.

### **INNOVATION IN CONSTRUCTION**

There is a large body of knowledge about the innovation in manufacturing and service industries and innovation research in construction industry is becoming a more mature field, although still lags other industries (Barrett and Sexton 2006, Loosemore, 2015a, 2015b, 2015c). Various different definitions have been developed for innovation in order to make innovation more understandable. These provide a broad definition of innovation as "...doing things differently or better across products, processes or procedures for added value and/or performance" (Brown, 1994) or as the "intentional introduction and application within a role, group or organisation of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, the organisation or the wider society" (West and Altink, 1996).

Ozorhon, B (2013) showed that innovations occur at different phases of construction and have multiple benefits, drivers and enablers. Taylor (2005) stated that, "much of the innovation that occurs in sectors, such as construction, is invisible to the innovation metrics traditionally used to rank industries in many countries, and it is for this reason that they appear to underperform in comparison with other industries". This invisibility was also identified by Loosemore (2015c) as in that the majority of construction innovations appear in the form of problem-solving that is developed daily in order to address project difficulties. Loosemore (2015c) observed that although many researchers indicate that construction industry is not very innovative, construction companies do engage in day-to-day problem solving activities. Loosemore refers to these as "Hidden Innovation" (Loosemore 2015c) which are often opportunistic and unplanned in response to situations that arise when dealing with limitation of resources, changing working conditions and facing unplanned challenges and events during the construction phase of the project. Due to the hidden innovation, large scale innovation capture, management and dissemination is unusual in the construction industry, and in order to do this, a systematic process for classifying and managing innovations is required. Seaden *et al.*,

2003 agreed, believing that strategic decisions around innovation creation could enhance innovation uptake and that creating innovative thinking business environments and an innovation business strategy increase innovation development. The most commonly accepted innovation classifications have been developed by analysing innovation within the manufacturing and services context (Noktehdan *et al.*, 2015). Three key defining elements of innovation can be identified from manufacturing: types of innovation, novelty of innovation and the benefits the innovation creates.

### **Innovations in Times of Crisis - The New Zealand Experience**

The repair and reconstruction of infrastructure in the Canterbury region was one of the largest and most complex civil engineering projects in New Zealand's history. A large number of resources were needed to cope with infrastructure repair and rebuild demands (CERA, 2012). The policy response to the task of horizontal infrastructure reconstruction was the creation of the Stronger Christchurch Infrastructure Rebuild Team (SCIRT), with a mandate until the end of 2016. SCIRT adopted an alliance-like project management model to deliver the recovery of horizontal infrastructure projects. Following the February 2011 earthquake, the New Zealand government recognized the need for a different approach to deliver the horizontal infrastructure reconstruction. The Government chose an alliancing-based project delivery model based on country expertise and experience and the need to enable optimal delivery with the speed required post-earthquake, in comparison with other possible models (Office of the Auditor-General, 2013).

The SCIRT alliance was set up in September 2011, and made up of eight partner organizations, consisting of three owner participants and five non-owner participants. The three owner participants are the Christchurch City Council (CCC), CERA (Canterbury Earthquake Recovery Authority, established as a government department to lead and coordinate the Government's response and recovery efforts following the earthquakes), and NZTA (New Zealand Transport Agency), each of which played a different role: CCC and NZTA as asset owners and funders while CERA as Crown funder and mandated to coordinate the overall rebuild activity on behalf of the central government. Five private construction companies were chosen as non-owner participants within the alliance and as the delivery team - City Care, Downer Construction, Fletcher Construction, Fulton Hogan and McConnell Dowell.

As illustrated in Figure 1, there was an Alliance Leadership Team (ALT) for governance, under which an Alliance Management Team (AMT) was set up to manage the operations undertaken by an Integrated Alliance Team (IAT). The IAT acted in a project facilitator's role to deliver the planning, design and management functions to enable the delivery teams to do the work. Together with their subcontractors and suppliers, the delivery teams were responsible for undertaking the repair and reconstruction works on the ground. The alliance model was built via a 'gain-share, pain-share' mechanism among five main contracting teams. Construction work for each team was allocated based on performance. Integrating professional and construction services into the alliance model meant that SCIRT could serve as a 'one-stop shop', offering flexibility in the way the infrastructure rebuild stakeholders were coordinated (SCIRT, 2013)

### **Innovation in SCIRT**

Innovation was one of the key performance indicators (KPI) at SCIRT. An innovation strategic plan supported creative ideas through the project lifecycle. An innovation strategic plan in SCIRT initiated a culture through the project teams and individuals for

developing innovation as one of the project's first priorities. Innovations were captured in the value register, and reviewed and approved by management to count towards performance assessment (Auditor, 2013). Innovation in SCIRT was defined as "a feature of system, operation or built work that gives better performance at the same cost of the same performance at less cost" (SCIRT, 2011). The innovation score was calculated by the SCIRT measurement system based on these structures:

- MCOS (minimum condition of satisfaction) - 2 innovations a month
- Stretch - 3 innovations a month
- Outstanding - 5 innovations a month

The number of the registered innovation per month by each of the SCIRT project teams used was the only criterion for categorizing innovations in one of the above groups. The KPI for innovation caused project teams to develop more innovations through the project lifecycle. More than 600 construction innovations were developed through the SCIRT project lifecycle

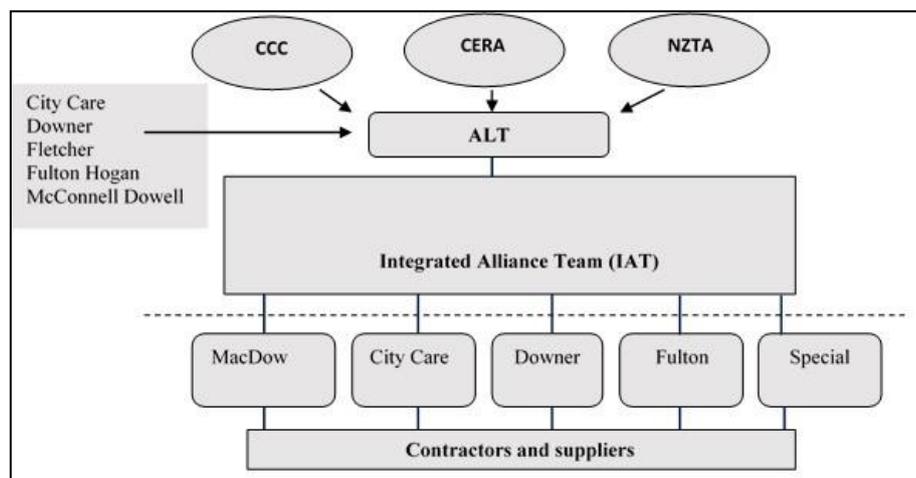


Figure 1: SCIRT temporary organisation

## RESEARCH METHOD

The SCIRT learning legacy project was launched in 2014 in order to share the knowledge and experiences of SCIRT. Full access by the researchers to the SCIRT learning project was given through a contract between the University of Auckland and The SCIRT learning legacy project.

A multiple method of data collection was used in this research. The following were the key sources: SCIRT innovation database, SCIRT technical documentation, project reports and SCIRT delivery system guidelines. The researchers were given open access to the SCIRT innovation database. This database had over 600 innovations captured as evidence of the innovation KPIs created by the construction and design companies working in SCIRT. All the reported innovation were registered through SCIRT. The types of information reported for each of the +600 innovations included data codes, innovation name and innovation originator, technical and managerial information for each of the SCIRT innovations was made available to the researchers through discussions with SCIRT employees. Project monthly reports and technical reports were used to supplement the database information, of particular use were those innovations being adopted and trialled on site. The research analysed the SCIRT innovations using innovation models developed for the research. The analysis of the data allowed for the researchers to develop a comprehensive innovation model.

## THE INNOVATION RESULTS

The innovation model adopted to understand and categorise the innovations was developed using previous literature. This included the innovation novelty, benefit and type. Analysis of the literature showed that innovation “Type”, “Novelty” and “Benefit” are three main ways of defining innovation. The research developed an innovation classification model in order to address a lack of shared understanding about innovation among different parties in the construction industry. A multidimensional innovation classification model developed different types of construction innovation, with levels of novelty, and varying benefits. Typically the innovation literature distinguishes between incremental and radical innovations.

### Innovations by Novelty

Slaughter's (1998 and 2000) research provided the more detailed categorisation of novelty used for this classification model. These categories are Incremental, Modular, Architectural, System and Critical, where:

- Incremental innovation is a small change. It is often the result of continuous improvement initiatives and on-the-job problem solving, based upon current knowledge and experience.
- Modular innovation entails a significant level of novelty in one area of a system, but without impacting the other components of the system. Modular innovations may be developed within an organization and implemented without much impact on other components.
- Architectural innovation involves a small change within a component of a system, which results in major changes in the links to other components and systems. The distinction between modular and architectural innovations is the degree of interaction with other components of the system.
- System innovations are identified through their integration of multiple independent innovations that work together to perform new functions or improve the facility performance as a whole.
- Critical innovation is a breakthrough in science or technology that often changes the character and nature of an industry. While incremental innovations occur constantly, critical innovations are rare and unpredictable in their appearance and in their impacts.

Analysis of the data shown in Figure 3 represents the spread of innovation categories in the novelty dimension of the classification system. Most innovations in the SCIRT database were made up of architectural or modular innovations. There were no critical innovations. The implications for the construction industry of this finding is to show that it is relatively straightforward to create modular innovations which are contained in one area, and do not impact other areas. For SCIRT, an example would be in redesigning the information technology databases for designers to make it easier for designers to use. Architectural innovations were also high, where an impact crosses usual organisational boundaries, for instance a design change impacting construction. In the case of SCIRT there were redesigns of pipe connections which had consequential impacts on construction. Of interest was the lower numbers of incremental innovations (small changes, every-day changes and problem solving (as referred to by Loosemore (2015c) as hidden innovations)). Despite a process and incentive for capturing innovations, incremental innovations lagged the other innovation novelty classifications. One reason

for this might be that the companies were focussing on wider innovation generation and were generally able to record more substantial innovations to meet KPI targets.

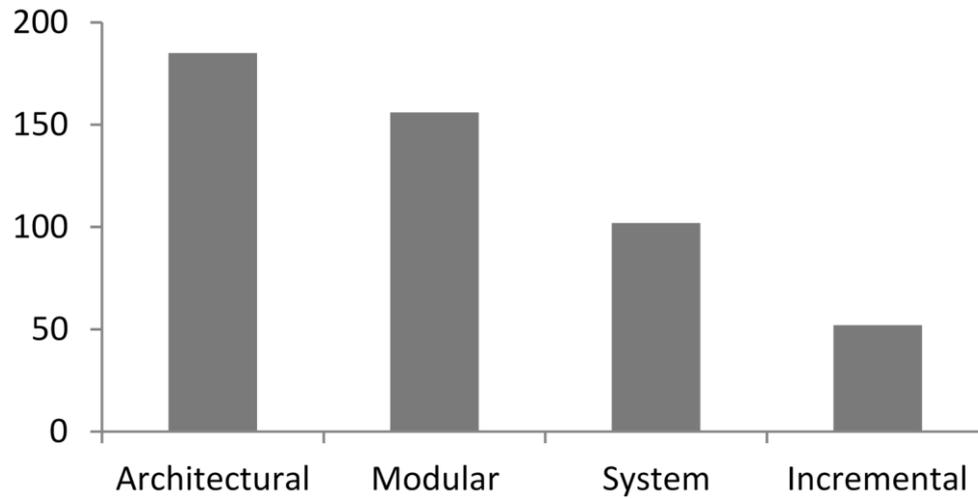


Figure 2: Innovation classification based on Novelty

### Innovations by Type

The definitions of the different aspects of type of innovation were developed from the literature (Zhang *et al.* 2003), whereby, the following were chosen as definitions:

*Tool:* The Tool Innovation involves the development or implementation of novel construction machinery, equipment or tool into the construction project.

*Function:* The Functional innovation refers to new tasks developed or introduced in the construction project or associated management processes.

*Product* Innovation involves all new construction materials and products developed in the project or introduced to the project and used within the construction process.

*Design* Innovation is related to new and innovative plans, designs, sketches or concepts for the building or infrastructure being developed in the project.

*Technology* (Design + Product): The new technology refers to the new design that is coupled with a new material or product.

*Method* (Tool + Function): The Method innovation is the combination of the Tool and Function innovation that involve both a new tool or equipment and new tasks that are usually related to the new tool.

Figure 3 represents the spread of innovation categories in the "Type" dimension of the classification system. Most innovations in the SCIRT database were made up of tools or functions in terms of innovation type. What is clear is that SCIRT created opportunities to produce new tools, equipment and machinery to deal with the earthquake damaged infrastructure. Many of these innovations stemmed from the need to rebuild in liquefied areas, necessitating new ways of constructing, and using different trenching and tunnelling techniques.

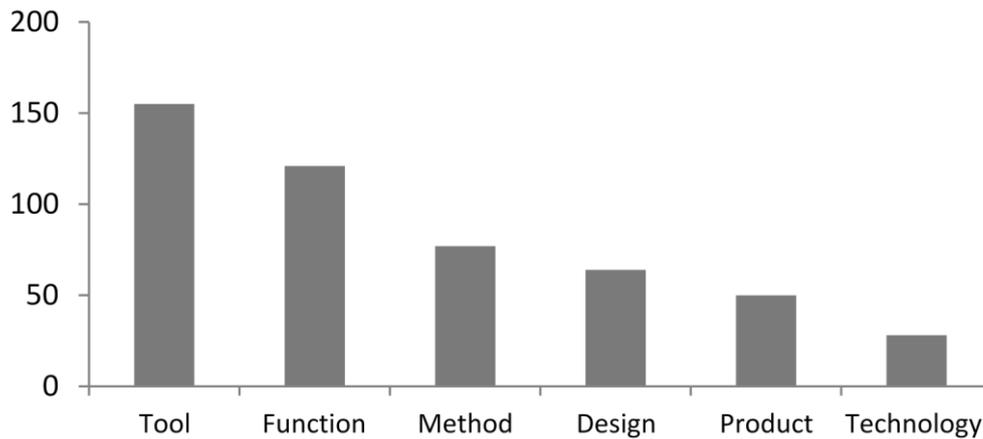


Figure 3: Innovation classification based on Type

Figures 4 and 5 demonstrate the changing trends of innovation through the lifecycle of the projects where Phase 1 “Starting the project”: Project definition, Project allocation and Concept design and Phase 2 “Organising and preparing”: detail design, TOC, Construction allocation and Phase 3 “Carrying out the work”: Construction and Handover.

The data shows (Figure 4) that innovation types of tools and functions had a similar trend with significant increase in the construction phase of the project (phase 3). Product, design and method innovations showed a marked increase from the start of the project to the organizing and planning phase of the project, with a decline in the construction phase of the project. The technology type of innovations showed a descending trend as project moved to the planning and construction phases.

From a novelty perspective (Figure 5), the results show two types of trends. The more novel types of innovation (System and Architectural) showed a dipping trend, with the number of reported innovations increasing significantly in the organizing and planning phase of the project and dropping off as the project moves in the construction phase. Modular and Incremental innovations had an increasing trend throughout the project lifecycle, with the peak occurring in the construction phase.

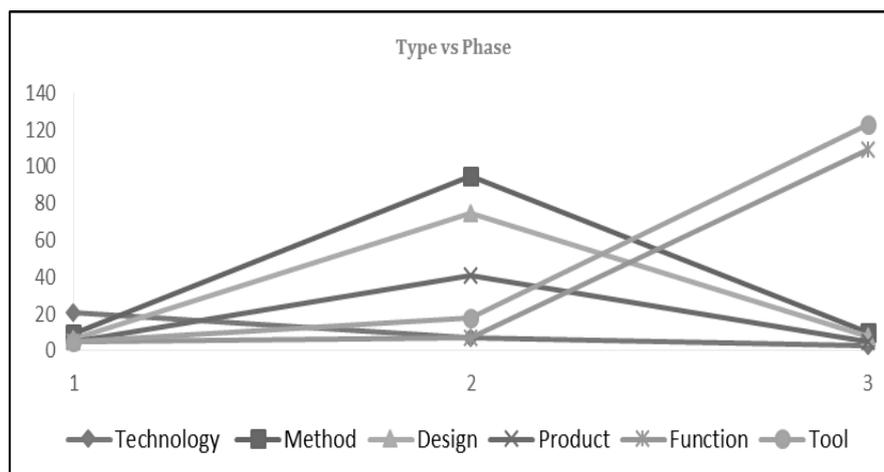


Figure 4: Changing trend of the number of reported innovations categorized by Type

## DISCUSSION

The research reported in this paper shows the development of a greater understanding of type and novelty of innovations as created by SCIRT. The research strengthens the view

that the industry is by nature innovative. Innovations in this case tended to be modular and architectural in nature. There was evidence of innovations found at SCIRT akin to the "hidden innovations" referred to by Loosemore (2015c), these were the incremental innovation classification.

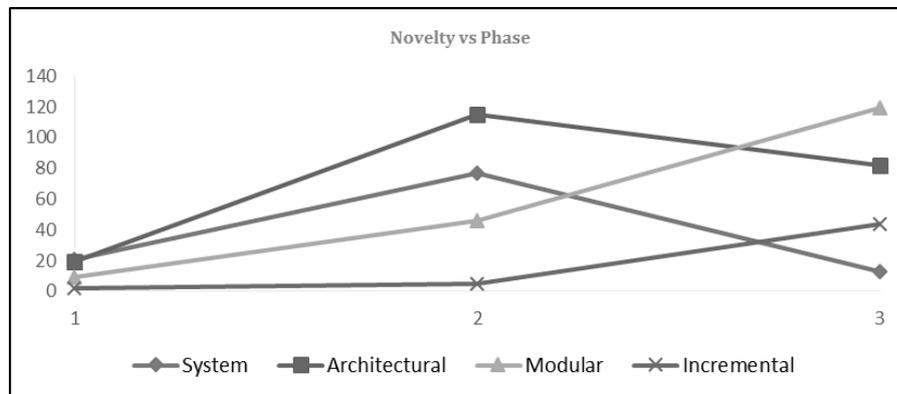


Figure 5: Changing trend of the number of reported innovations categorized by Novelty

The results demonstrably agree with Ozorhon (2013) that developing a culture of innovation at the starting phase of a project increases project innovation creation throughout the project life cycle. The research shows that at the starting phase of the project there is the likelihood of innovations driven by involvement of an influential team of stakeholders, with opportunities to drive innovation creation throughout the whole project life cycle. In the case of SCIRT, attitudes towards risk and uncertainty were favourable, and the encouragement of alternative methods was high. The starting phase provided an enhanced opportunity for development and implementation of systemic technology and method innovations.

Phase two of the project, concerned with organising and preparing details of the construction work. At SCIRT this involved a substantial increase in collaborative activities among the different companies with expertise required for detailed design, planning and tender process preparation, and selection of contractors and allocation of construction work. SCIRT demonstrated that by creating a climate which encourages communication, collaboration and innovation, this can lead to a large increase in innovative behaviour. This supports the view of Seaden *et al.*, (2003) who believed that creating innovative business environments increase innovation development. The research in this paper extends this work by showing different phases and innovation types. The development of innovative designs as well as the introduction of novel construction products and methods were found to be the most prevalent types of innovation at phase 2.

Furthermore, in phase 2, the tendency is to focus on more system and architectural levels of novelty, as critical decisions are being made with regards to the details of the construction work. The third phase of the project is characterised by significant increase in the size of the project organisation, increasing costs of change and incremental reduction of risk and uncertainty. This creates an environment where it becomes much more difficult to introduce systemic and large impact change and instead the focus is shifted towards localised problem solving (hidden innovations). However, in the case of SCIRT, where all innovation capture were incentivised through the SCIRT innovation KPI, hidden innovations were revealed, and shows that at phase 3, which is predominantly construction, there is a large shift towards tool and function types of

innovation. As the emphasis in this phase is on-time and on-budget delivery of the project, the reported innovations had lower levels of novelty.

## CONCLUSIONS

This paper has shown how a new and complex organisation (SCIRT), working under difficult circumstances (rebuilding an earthquake affected region), can generate a system of innovation development over the organisations lifespan. The level of innovation potential of infrastructure projects is high, but the mechanisms for encouraging innovations needs to be in place. The innovation development capability of SCIRT was assessed based on novelty and type views of innovation and showed how different innovation types and innovation novelty occur at different project life cycle phases. introduction of a innovation KPI and driving an innovation culture throughout the construction life cycle have been shown, through this research, to reveal the hidden innovations, which are often seen as mere problem solving, but can have transformative impact when viewed as a whole. Although this research was conducted with a dynamic organisation created to provide solutions at a time of crisis, the research shows that it is possible to create the environment where innovation thrives. Specifically, the research recommends incentivising innovation to maximise innovation creation throughout a construction project lifecycle.

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# **EDUCATION AND KNOWLEDGE**

# **SOUTH AFRICAN FEMALE CONSTRUCTION STUDENTS' PERCEPTIONS OF GENDER AND SEXISM AND PREPARATION BY THEIR UNIVERSITY**

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As part of providing appropriate education and support to female students of Construction, Economics and Management (CEM) at the University of Cape Town, their current responses to hegemonic patriarchy in the industry were explored. Working collaboratively, the researchers infused concepts of gender; masculinity; sexism and discrimination within the engineering curriculum in 2016 and 2017 and ran semi structured focus groups with 17 CEM female students from these years. The intention was to establish their experiences of sexism (hegemonic patriarchy) in their professional environment and to identify their responses. The findings demonstrate that female students question the authenticity of their inclusion in the workplace. The data shows an internalised patriarchy by the female students, who rationalise the sexist behaviour and/or over perform to be seen as equal to male colleagues within the work place. The research concludes that there are sexist practices that affect females' ability to develop as professionals within the construction workplace. Recommendations focus on appropriate curriculum responses and professional development skills and suggest upskilling students to invoke change within their future workplace. This gender research is important to South Africa where increased employment of women in construction is legislated.

Keywords: gender, women, construction industry, socialisation, health

## **INTRODUCTION AND OBJECTIVES**

Recent research has shown that gender diverse management has a positive impact on a workplace. Generally, companies with more gender-balanced management teams have better financial results than those without such teams (McKinsey Global Institute 2013). However, globally, women are still less represented in the workplace than men (40%) and of those women working, 57% do so part-time (ILO 2016). In South Africa, there are incentives for women to enter the construction industry. The conundrum is, however, that the good intention behind the drive for female empowerment could have a negative outcome if students involved are not appropriately educated and prepared to manage potential problems related to gender and sexism. Students need curricula and co-curricular spaces to discuss issues of masculinity, patriarchy, discrimination, gender based violence and HIV/Aids - all of which may exist in the construction industry (Wood, 2014). The programme described here has focused on the female students in the construction and property course as they have potential to move into management

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positions so their attitudes and knowledge, and perceptions in relation to sexism are essential.

Thus the over-arching aim of this study is to identify the perceptions and experiences of gender discrimination and related sexism in industry by the female student body from Construction, Economics and Management (CEM) at the University Of Cape Town (UCT). The objectives were to first, understand their experiences and the impact these experiences have on them and their coping mechanisms. Secondly, the study was to consider how the CEM, UCT curriculum prepares the female student to respond to these challenges once they are in the workplace. The study builds on work and relationships explored in a previous study on inclusion of health and safety knowledge (from HAICU) in the formal syllabus within Professional Communication Studies (PCS) taken by the CEM students (English and Alves 2016).

## **BACKGROUND**

The studies on women gaining and retaining employment in the construction industry circulate similar challenges: namely, gender norms, lack of appropriate education and training, work-life issues and the glass ceiling (Haupt and Fester 2012, English and Le Jeune 2012, Mathur-Helm 2011, Floro and Komatsu 2011).

In a study of 1,435 industry practitioners, 141 first and final year construction students and 17 women working in the industry, it was found that discrimination applied to women plus their being regarded as not having the same gravitas as men were negative factors (Madikizela and Haupt 2010). A reinforcing factor - both a contributing one and an outcome was that there are so few role models for women in the industry - is confirmed by this study as well (English and Le Jeune 2012).

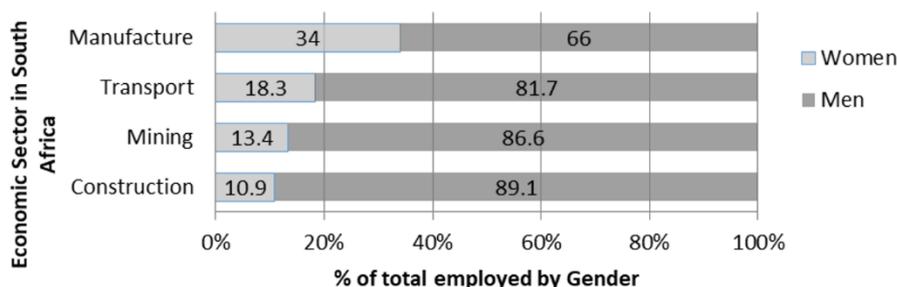
In terms of the macro environment, it is interesting to place South Africa in comparison with the other countries. South Africa is viewed as a third world country yet has been progressive in some areas since the paradigm shift brought by democracy in 1994. By 2013 more women than men were registered as voters and women make up nearly half of the parliament (Johnston 2014). The same equitable results are not seen in industry even though, over 10 years ago, the Construction Industry Development Board (CIDB), South Africa set minimum levels for female employment in the construction industry (CIDB 2006). Numerous other legislative initiatives on domestic rights, children and marriage have been instituted. In 2014 the African National Council (ANC) produced a manifesto which included facilitating women's access to work, business and enterprise. This reflects that, since 1994, the greater political drive has been to meet issues of poverty, race and economy with gender equality being a secondary concern. While this is understandable, gender equality is the cornerstone enabling women's rights to be met.

The current World Economic Forum ratings of the gender gap are an indicator that the rating is not only about numbers. In 2016 the issue of the wage gap became a basis for a study across countries. South Africa came through well overall in 15th position out of 72 countries (World Economic Forum 2016:10). The improved reading for "Namibia and South Africa, is due to progress in closing their gender gaps in women's labour force participation and estimated earned income" (World Economic Forum 2016: 23). The global indices looked at economic participation; opportunity; education; health and survival; and political empowerment. South Africa scored only 63/72 for economic participation and opportunity.

At the macro-level, public policies need a legal framework to support women in the marketplace, and with land and property rights. In Lesotho, Namibia and South Africa,

laws recognising husbands as the heads of households have been abolished. This has enabled women to register property in their name (Hallward-Driemeier 2011). A mechanism to assist women enter positions of influence and independence is affirmative action - particularly intended to redress in practice the effects of past or continuing discrimination between men and women (ILO 2007). An example of this was the 2012 gender policy developed by the Congress of South African Trade Unions (COSATU) advising unions to ensure leadership positions for women and now one third of its leadership is female (Munakamwe 2014). However, the percentage of women in construction compared with other industries, remains low (see Table 1) and the reasons for this continue to relate to a hostile environment, negative attitudes of employers and lack of motivation for women (English and Hay 2015).

Table 1: Percentages of women and men employed in construction and related industries



(Source: adapted from Statistics South Africa's Quarterly Labour Force Survey (QLFS))

## THEORY AND METHODOLOGY

The constructivist worldview was applied, namely critical theory, to inform the research methodology. The critical theory lens was particularly useful to analyse the perceptions of the female students because critical theory takes into account intersectional relations of race, class, gender, sexuality and education, among others (Gramsci 1971, Denzin 1978, Neuman 2013). In the application of critical theory within this study, the intention was to seek out the relationship between societal structures and the female students' perceptions and their decision-making in relation to gender and 'being' female in the construction industry. Using the qualitative method of semi structured focus groups, three focus group discussions were held (May 2016, July 2016 and March 2017). Female students who were part of the construction course were invited to attend (Table 2).

Table 2: Number of students per focus group

| Year       | Number of students from CEM |
|------------|-----------------------------|
| 2016 May   | 7                           |
| 2016 July  | 5                           |
| 2017 March | 5                           |

## DATA COLLECTION METHODS

Under the critical theory approach, the power relation is equalised between the researcher and the participant, who are considered collaborative partners in the research process. The focus group was deemed fit for purpose as it invited a dialogical process between participants and the participant and researcher. The following questions facilitated the focus group discussion.

## FINDINGS

From the data analysis, the following nine themes emerged: protectionism; inherent agency; authentic inclusion; over-performance; assertion of patriarchal assumptions; navigating sexism; career development in a male dominated profession; and scope of influence or leadership. In the paragraphs that follow, each theme is discussed in relation to the findings that emerged in the focus groups. The students were able to give this information on the base of their having vacation work which gave them opportunity to experience habitual behaviours in the industry (CTEq, 2015).

*Table 2: Focus group questions and probes*

| Six Focus Group Question   | Probe / Prompts   |
|--|---|
| What do you think are some of the challenges that you think you may experience in industry because of your gender? | Harassment? Deemed unable to participate?<br>Compelled to prove oneself?                          |
| Are these challenges specific to female engineers industry?  | Whether response is positive or negative, give examples?  |
| Are these challenges specific to South Africa or developing countries?   | Perceptions of developed versus developing countries?   |
| How has the engineering curriculum prepared you to respond to the challenges you've mentioned previously?          | Formal curricula content?   |
| Has the university prepared you to respond to some of the challenges?  | Informal discussion e.g. societies. Activities such as building on site e.g. Habitat for Humanity |

### Protectionism

The first finding was that of protectionism which is described as the actions of some men who take it upon themselves to protect, support and assist females in the workplace. The female students shared their experiences of protectionism which ranged from warding off advances of young men to educating the female students about how to navigate and therefore succeed in the workplace “to earn respect” (F1).

In instances where younger men would make inappropriate advances, it was found that the older men would reprimand the younger men’s behavior by stating “leave her alone, leave her to work, she’s not here for you guys... I’ve never heard you ask me how my weekend was” (F1). Similarly, GW described her frustration of being protected by men onsite and stated “the moment a woman walks onto a construction site men are like are you okay? Like, I can walk on dirt, like my feet can handle it. We can handle the things that men can handle, but they don't think we can” (GW).

Whilst there appears to be an altruistic motive by male colleagues to support the female student(s), protectionism is recognized by some authors as benevolent sexism (Glick, Fiske *et al.*, 2000) which is defined as the full support by men for female equality yet the male colleague(s) will continue to provide support and assistance to the female without specifically being asked to do so. The limitations of protectionism are wide reaching, and can in its most extreme form, limit the female student(s) learning, career development, and professional identity within the workplace. There is therefore a need for educators in higher education, to consider the function of the curricula and/or supporting co-curricular work that can better prepare and equip female students in their navigation of sexism, patriarchy and other forms of gender based violence in the workplace.

### **Inherent Agency**

The inherent agency in 'being' female in a male dominated industry is the power held by the female body and presence which invites attention. Some students considered that there is an inherent advantage in 'being' female in a male dominated industry. One participant indicates, "Like the minute a female walks in, you immediately get attention. ... and then you... voice what you have to say" (F1). Conversely, GL indicates that because the female is receiving this special attention, it is not always possible to know whether the males in the company are genuinely listening and including female colleagues.

### **Authentic Inclusion**

Authentic inclusion as opposed to performed inclusion is related to the earlier theme of inherent agency - where females experience different treatment because of their gender. However, whether this 'treatment' is genuinely aimed at including females is contentious, because individuals in companies may believe it is advantageous to appear to be including and supporting females in the industry due to the high "demand" for females in property (RM); yet on the other, females are unsure whether their inclusion in the workplace is tokenistic. The latter resulting in females being uncertain of whether their professional contributions are being viewed for their true quality and worth. As a result, females feel compelled to "match" and/or out perform their male colleagues to be valued and respected in the workplace.

In the last decade, the inclusion of women in the workplace as formalised practice has seen beneficial results (ILO, 2016) and the cohort recognised this as an advantage - but could identify the difference between authentic inclusion within the workplace setting as opposed to performed inclusion for points as GL's comment confirmed, "So a company ... is earning some points from having some females".

### **Over-Performance**

An outcome of being uncertain of the authenticity of inclusion by male colleagues in the workplace, is the female students drive to prove that the points are spurious; they are achievers in their own right. Furthermore, the female students also feel they must over-perform to be regarded as equal to their male counterparts - "I will show you I can be here" (F1). This is compounded where there is a racial divide as depicted in the this statement by one female participant, "When I'm talking to a professional, especially a white male in the industry, I feel a lot of pressure to prove myself and I don't think it's solely because I'm a student wanting to impress a professional. I think it has very much to do with being an Indian female" (GL).

### **Assertion of Patriarchal Assumptions**

The female participants in this study shared common experiences where they were not allowed to perform functions on site, which were deemed too difficult for the female student. For example, one participant describes how her supervisor specifically prevented her from using a jack hammer (despite having used it before elsewhere) claiming that "it's heavy" (F1) and granted permission for the male student to use the tool. Similarly, F13 describes being told to not "worry, just sit there" rather than being involved with heavy lifting on site.

In both instances, there is an assumption made about the female body and its ability to participate in heavy labour. For both students, the sense of frustration is exacerbated by the need to prove to colleagues that they are more than capable. Furthermore, the

patriarchal assumptions directly impact on the students' ability to fully engage with the scope of the work involved in the property and/or construction industry, with the result that female students end up "mainly doing administrative work, but there's so much more to learn; but they [the supervisor] haven't asked if you would like to [get involved in the heavy labour] or if you are capable of doing it [heavy labour]" (F13).

Once again, educators are challenged with preparing females for careers in property and construction, through a curriculum that is seemingly distanced from the realities facing female students in industry. Left unchallenged, it is likely that educators may be underpreparing female students with the skills needed to succeed and assert themselves in male dominated industries.

### **Navigating Sexism**

There is a defeatism, an acceptance of being patronised, in that many felt it easier to work around the status quo which ranges from dismissive attitudes through to sexual harassment, than to confront it "... girls just, they have to because if you're not the top intelligent student, I mean, once you've graduated, a male is more likely to get a job if you're not on the top" (F2).

In addition to the patriarchal assumptions, there were also many instances of sexism that affected female students within the workplace but which they learn how to navigate. Sexism that was experienced included receiving "like 24 marriage proposals a day (FI), whilst another student was told "your job is so easy, why don't you go and do real work and work in a kitchen?" (LI). Similarly, GL was reprimanded for going on site without "safety so they [male colleagues] were like it's a bit dangerous you know, don't come here with your high heels" (GL). These experiences disadvantage the female students who may be an excellent graduate but unable to overcome the discrimination found within the male dominated industries.

Young female students and graduates who, in addition to developing their careers, are having to work within a possibly inhospitable organisational culture. What then can females do when faced with hegemonic patriarchy in the workplace? One student's response was to ignore it [sexual harassment], and then somehow, I just wouldn't feed the fire...and just try to showcase how I actually know what I am doing and prove to them, I am on par with you" (AN). Another student who had experienced persistent advances from a male colleague brushed the sexism off with a sense of despair "because you are going to see these people over and over and I don't want it to be an awkward experience" (LI).

Both responses to sexism by the students depicts a desperation on the part of the female students to "not feed the fire" (AN) yet the students fail to realize that they are rationalizing sexism on behalf of male colleagues who in any setting (including higher education) would be dismissed for sexual harassment. It is also interesting to note that the students do not refer to the male behaviours in a condescending way but rather dismiss sexism in order to protect the working relationship.

### **Career Development in a Male Dominated Profession**

Two issues for women in non-traditional work are lack of role models and social acceptance, both by themselves and by their environment (Madikizela and Haupt, 2010, English and Hay 2015). Perceptions held by family towards the construction industry reflect assumptions about the type of career path that it is usual for a female to pursue as the comment by F13 illustrates "It's just frustrating, because it limits how much you can

learn, because obviously you go on site to participate in the more hands on work but you end up doing mainly administrative work."

Societal norms are that women in construction can only be administrative support, be it in the site office or as an estate agent, a largely feminized career. This has been perpetuated by the lack of role models ("because I honestly don't know someone who has done this [construction and property] course before" FS5) and of knowledge ("Property still has a stigma, so everyone assumes that because you say I'm in the property industry, they're all thinking brick and mortar" RM).

The perpetuation of these attitudes has been through the lack of role models. Female students with no female archetypes to aspire to follow have lacked confidence in their outlook. The reflection was that there was a negative viewpoint which was not being challenged. "In our industry there are very few of us already and then if you want to take six months [for maternity leave] it's going to be like oh, let's not employ so many of them because they just disappear for six months in the end" (FS). The resulting lack of confidence is inherent in attitudes to curricula that does not ensure that female students are accessing the same knowledge as male, as verbalised by this debate "Isn't there a project where you're going to have to do everything yourself?" (FS3) and "That's why I'm so scared, because I'm not going to be able to" (FS2).

### **Scope of Influence or Leadership**

Women were described earlier as having good communication skills and thus adding to the dynamics of leadership (McKinsey and Company 2013; ILO 2016) and this has been well documented in research specific to construction (Fielden *et al.*, 2000, Dainty *et al.*, 2004). Leadership for the students was seen as a future role but not in conventional terms of power but of respect, development and outreach. As female students they emphasised communicative practices "...think about the social impact of the development, as opposed to just developing this. If you are developing in the UK, most of it is more just you are developing so that there is space for people to live. In South Africa you've got to think much more broadly. Is it inclusive? Is it going to help future generations?"(FS). Though having no role models themselves, they saw themselves taking on this role "I actually went to my high school to tell them about what I am doing, which they obviously were not aware of...we should] make them aware that there is property, because so many people don't know" (F5).

## **CONCLUSIONS AND RECOMMENDATIONS**

The researchers consider that a focus on the relationship between graduate competency, the curriculum *and* the places of employment is lacking. We question how universities and industries are preparing themselves for our graduates and what quality assessments are being conducted to ensure that our graduates are being received into inclusive, equal, and diverse workplace environments that reflect the ethos of inclusion that is being attempted and in some areas successfully inculcated in our own institutions of higher education. What this research therefore emphasises is the potential disconnect between the taught curriculum and the expected competencies of graduates. Of concern is the underprepared state of companies to receive graduates that are expecting industry to be inclusive, equal and diverse.

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# **MAKING AN IMPACT: TEAM BUILDING AS AN ALTERNATIVE EDUCATION TO ENABLE CONSTRUCTION MANAGEMENT HONOURS STUDENTS TO DELIVER**

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Experience and anecdotal evidence indicate that Honours students experience challenges in terms of completing the academic year. Furthermore, the ten core competencies as well as the fifteen attributes / states of emotional intelligence (EI), impact on students' performance as well as their performance in the work environment post-graduation. The purpose of the study reported on is to determine the impact of a one-day team building event directed at developing the core competencies of students, and enhancing attributes / states relative to the EI of students. A self-administered questionnaire survey of students' perceptions of an event post-intervention provide insight relative to their understanding and appreciation of the intervention, as well as the impact thereof. The salient findings include - the team building activities contributed to: an enhancement of seventeen skills, and an improvement in understanding and appreciation of ten core competencies as well the development thereof; and an enhancement of fifteen attributes / states relative to EI. Based upon the findings it can be concluded that the one-day team building event had the desired impact in terms of the skills desired to be needed to complete the year, thus enhancing the competency of students to perform following graduation.

Keywords: core competencies, emotional intelligence, honours students, team

## **INTRODUCTION**

The Construction Management Honours Programme at Nelson Mandela Metropolitan University (NMMU), South Africa, has since amending its programme to a 1yr post-graduate Honours degree, grappled with students finding it a challenge to complete the academic year. Part of the restructuring of the programme included the removal of an industry year and has resulted in both staff and industry identifying particular issues including:

- An over reliance on technology as the only source of information coupled with an inability to engage with research and discuss the findings of the research conducted;
- An inability to stay the course and complete a set task as instructed;
- A lack of understanding on how to integrate chapters or package information from various sources to form a holistic viewpoint;

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- Students have an inability to articulate their thoughts, communicate amongst themselves or with their lecturers / employers;
- They lack site experience and participation in team based activities.

Given the aforementioned, it was decided that a practical intervention needed to be introduced into the Honours programme that could address shortcomings and provide an alternative learning environment within which students were challenged to resolve situations using the combined skill sets and cognitive abilities of their team (class) mates. The mechanism chosen was based on a pre-existing ‘Amazing Race’ type team building intervention located in close proximity to the university campus, with the expressed intent being to enhance student's competencies thereby improving their ability to complete the year at the first attempt. A study was conducted to determine whether the activities involved in the event contributed to an improvement in participants’ understanding and appreciation of ten core competencies; enhanced seventeen skills; developed the ten core competencies, and enhanced fifteen states / attributes relative to emotional intelligence.

## THE LITERATURE

### Competency and Emotional Intelligence

In Techonomics (2007), H Lee Martin makes reference to the cycle of learning (Figure 1) which is broad concept aligned with acquiring a new skill. Before students attend university they are ignorant with respect to what construction management entails only becoming aware through immersive interventions during their academic years. They are hungry for knowledge but due to a number of structural failures in the current undergraduate programme, they are not sufficiently exposed to the management of resources within defined parameters, along with the requisite technical expertise (Smallwood, 2007) and therefore do not completely master the skill sets required to enter post-graduate study. This leaves them ill equipped when starting the process afresh in the honours year, incompetent with respect to the more onerous requirements of a research treatise and the complexities of balancing the continuous workload associated with it alongside there more traditional theoretical classes.

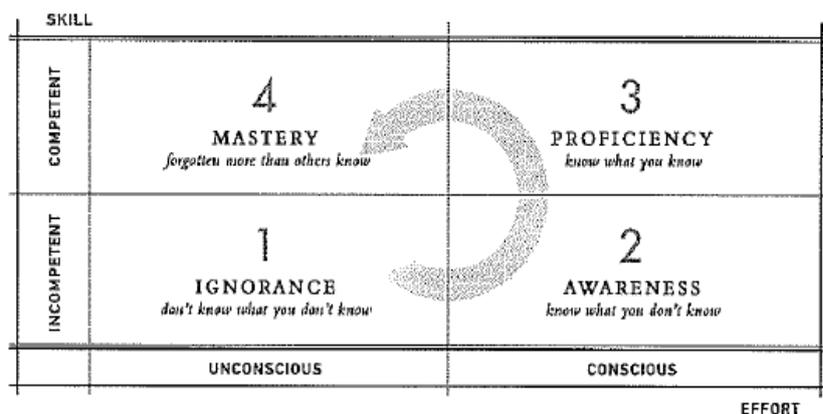


Figure 1: The cycle of learning (Techonomics, 2007)

Competency embodies the capacity to transfer skills and abilities from one area to another ‘as competencies are the characteristics of managers that lead to the demonstration of skills and abilities’ (Smallwood and Emuze, 2011). An inability to sufficiently master these competencies whilst within the higher education domain through vacation work or practical skills learning leaves the student ill prepared when they do finally graduate. As

Jackson (2015) notes, 'it is important to be refining, developing and practicing your skills, not simply starting to learn them'. This has been borne out by feedback received through industry liaison bodies, such as the Master Builders Association, whose members have highlighted that students do not come with the competency required of a construction manager and that many lack any affinity to a project environment when commencing employment.

Farrow (2016) also addressed this and highlighted that students are not having "significant learning experiences" because their needs do not match the typical authoritarian, fact-based environment of the traditional college classroom. Furthermore, traditional approaches to management education fail to consider "that practitioners deal with ill-defined, unique, emotive and complex issues" (Cunliffe, 1999) that require a different set of skills to that taught.

Songer and Walker (2004) describe Emotional Intelligence (EI) as an "individual's ability to identify emotions in oneself and others and to exhibit appropriate responses to environmental stimuli". Complex projects place additional emphasis on PMs' needs for EI, because of the unique characteristics such as 'complexity of personnel, multiplicity of goals, strong uncertainty of activities and difficulty in coordinating stakeholders' (Fan, 2013) mean there is a 'strong positive correlation between PM's EI and project performance' (Fan, 2013). As the role of the CM within project teams has an even greater influence on the delivery of the project to achieve a positive outcome, these 'attributes / states of emotional intelligence' all contribute to optimizing (best possible) performance.' (Smallwood *et al.*, 2013)

Sunindijo and Hadikusumo (2005) have also identified that "Project Managers with a higher score of EI tend to use more open communication, a key factor in organizational success' as 'emotional self-awareness, self-control, empathy, organizational awareness, cultural understanding and communication' open the possibility of getting the best out of people. This therefore further emphasises the need 'to be placed on developing the emotional intelligence of construction managers, commencing during tertiary education'. (Smallwood *et al.*, 2013)

Furthermore, as Smallwood *et al.*, noted in Emotional Quotient and Managing Construction Projects (2013), the ten core competencies that fall within the categories of self-concept, traits, and motives, as well as the fifteen attributes / states of emotional intelligence (EI), impact on students' performance as well as their performance in the work environment post-graduation. Chinowsky and Brown (2004) also pointed out that students with inadequately developed EI will lack problem solving capabilities as well as other professional attributes such as leadership, communication skills, creativity and an understanding of the external variables impacting upon their business.

Smallwood (2007) 'indicates that supervision, communication, motivation and leadership are the top ranked skills required for practicing construction management'. Competent graduates are in high demand due to an increasing need to deliver services and upgrade infrastructure within the Republic as well as on the rest of the African continent. Therefore, tertiary construction management education programs and training must develop such core competencies (Smallwood and Emuze, 2011) as the employers expect students to hit the ground running when they enter the jobs market.

In addition, the 2008 Confederation of British Industry (CBI) report revealed that board executives (86%) overwhelmingly rank positive attitude and employability skills at the top of their demands. The employability skills include: Self-management - a readiness to

accept responsibility and improve performance, flexibility, and time management; Team working - respecting others, co-operating, persuading, and contributing to discussions, and; Problem solving - analysing facts, issues, and applying creative thinking to develop appropriate solutions.

### **Alternatives to Traditional Learning Competency**

Mo *et al.*, (2007) emphasise that skills include an ability to think across disciplines; team working; and social and environmental awareness. The traditional education model is not providing students with these core skills and learning this in the traditional class room environment is challenging due in part to the gates placed within the structure of university's by administrators so that cross disciplinary, practice based learning only happens infrequently and is mostly coerced. The use of practical workshops is challenged by class size and the limitations of the transport infrastructure, detrimentally impacting the majority of students. "93% of all construction management students surveyed indicated their preference for visual learning while 72% preferred active learning" (Farrow, 2016)

Team based discovery learning is seen as one of the most effective ways in promoting students' learning. (Arifani, 2016) The problem-based learning (PBL) approach involves the learner, reflecting on their experiences, and engaging in self-directed inquiry". (Hmelo-Silver *et al.*, 2007) PBL can thus provide a platform within which "students learn content, strategies, and self-directed learning skills through collaboratively solving problems". As project managers usually face problems on projects that 'require them to react to unexpected events and cope with "uncertainty" scenarios' (Zwikael and Gonen, 2007), problem solving, stress tolerance and the ability to forge strong interpersonal relationships to resolve those uncertainty's as quickly as possible become key attributes companies will look for in graduates. These are the very aspects that are lacking in many of the honours cohort and thus teaching 'critical reflexive analysis or the ability to problemize assumptions and generate different perspectives' (Cunliffe, 1999) become core competencies that are observed in a 'field' rather than classroom environment.

This is further supported by the notion that "learning the concepts and theories of a discipline is best situated in the context of the practices of that discipline" and is 'supported by current theories of learning' (Hmelo-Silver *et al.*, 2007). Games may contribute to project management training in organizations and the academy, as they give some practical experience to the participants. (Zwikael and Gonen, 2007) In the context of Higher Education, students have the ability to "transition from visualising and listening and actually attempt to 'do' what they are being taught" (Jackson, 2015) whilst 'team-based discovery learning' is 'very effective' in improving students' ability to 'formulate research topics, develop a draft research proposal, and write a comprehensive research proposal.' (Arifani, 2016)

## **RESEARCH**

The 'Amazing Race' event entailed the completion of six activities, an introductory hoop raising exercise followed by the need for teams to complete a high wire zip line course, negotiate an obstacle course, assemble a puzzle without a reference image, target shooting, and ejecting a plastic ball from a tube filled with water. Each of the activities was led by the resorts' events' team leaders and entailed one or more of the following: strategising; planning; evolving of tactics, and taking of action. Furthermore, completion of the activities required certain skills, whilst core competencies play a role in the completion of such activities, so too the fifteen attributes / states of emotional

intelligence. 19 Students attended the team building event, and were requested to complete a self-administered questionnaire within a few days of the event, with a 100% return experienced, in itself a result based on prior submissions experience. The questionnaire consisted of thirteen questions, twelve of which were closed ended, and either a five-point or six-point Likert scale type question. This papers focus is on the findings relative to four of the questions. A measure of central tendency in the form of a mean score (MS) between 1.00 and 5.00 (five-point), and 0.00 and 5.00 (six-point) was computed based upon the percentage responses to the points on the respective scales to enable interpretation of the responses and to rank variables where necessary.

Table 1 indicates the extent to which the team building activities enhanced seventeen skills in terms of percentage responses to a scale of 1 (minor) to 5 (major), an additional point did not, and MSs.

*Table 1: Extent to which the team building activities enhanced participants' skills*

| Skill                  | U   | Response (%) |     |      |      |      | MS   | Rank |    |
|------------------------|-----|--------------|-----|------|------|------|------|------|----|
|                        |     | Did not      | 1   | 2    | 3    | 4    |      |      | 5  |
| Team building          | 0.0 | 0.0          | 0.0 | 0.0  | 0.0  | 10.5 | 89.5 | 4.89 | 1  |
| Communicating - oral   | 0.0 | 0.0          | 0.0 | 5.3  | 0.0  | 31.6 | 63.2 | 4.53 | 2  |
| Decision making        | 0.0 | 0.0          | 0.0 | 0.0  | 10.5 | 31.6 | 57.9 | 4.47 | 3  |
| Leadership             | 0.0 | 0.0          | 0.0 | 0.0  | 0.0  | 52.6 | 47.4 | 4.47 | 4  |
| Planning               | 0.0 | 0.0          | 0.0 | 5.3  | 5.3  | 26.3 | 63.2 | 4.47 | 5  |
| Motivating             | 0.0 | 0.0          | 0.0 | 5.3  | 10.5 | 21.1 | 63.2 | 4.42 | 6  |
| Coordinating           | 0.0 | 0.0          | 0.0 | 0.0  | 5.3  | 47.4 | 47.4 | 4.42 | 7  |
| Leading                | 0.0 | 0.0          | 0.0 | 5.3  | 5.3  | 36.8 | 52.6 | 4.37 | 8  |
| Organising             | 0.0 | 0.0          | 0.0 | 5.3  | 5.3  | 42.1 | 47.4 | 4.32 | 9  |
| Controlling            | 0.0 | 0.0          | 0.0 | 0.0  | 15.8 | 36.8 | 47.4 | 4.32 | 10 |
| Interpersonal          | 0.0 | 0.0          | 0.0 | 0.0  | 10.5 | 52.6 | 36.8 | 4.26 | 11 |
| Supervisory            | 0.0 | 0.0          | 0.0 | 5.3  | 10.5 | 52.6 | 31.6 | 4.11 | 12 |
| Negotiating            | 0.0 | 0.0          | 0.0 | 10.5 | 31.6 | 15.8 | 42.1 | 3.89 | 13 |
| Initiating             | 5.3 | 0.0          | 0.0 | 10.5 | 15.8 | 26.3 | 42.1 | 3.84 | 14 |
| Procedures development | 5.3 | 0.0          | 0.0 | 15.8 | 5.3  | 36.8 | 36.8 | 3.79 | 15 |
| Technical              | 0.0 | 0.0          | 0.0 | 5.6  | 27.8 | 50.0 | 16.7 | 3.78 | 16 |
| Persuading             | 5.3 | 0.0          | 5.3 | 10.5 | 5.3  | 52.6 | 21.1 | 3.58 | 17 |

Given that there are effectively six points on the scale, the MSs are between 0.00 and 5.00, the midpoint being 2.50. It is notable that all the MSs are > 2.50, which indicates that in general the team building activities contributed more of a major than a minor extent to an enhancement in participants' skills.

11 / 15 (64.7%) MSs > 4.17 ≤ 5.00, indicates the extent to which the team building activities enhanced the related skills between a near major extent to a major extent / major extent. Team building, the primary objective of the event, predominates and is ranked first. Communicating orally, the number one operational level construction management skill and major challenge identified amongst the cohort, ranked second, followed by decision making, leadership and planning. It is notable that the five functions of

management work, namely planning, organising, leading, controlling, and coordinating are in the upper range. Table 2 indicates the extent to which the team building activities contributed to an improvement in participants’ understanding and appreciation of ten core competencies.

*Table 2: Extent to which the team building activities contributed to an improvement in participants’ understanding and appreciation of ten core competencies*

| Core competency                    | U   | Response (%) |     |      |      |      | MS   | Rank | within Rank | Rank overall |
|------------------------------------|-----|--------------|-----|------|------|------|------|------|-------------|--------------|
|                                    |     | Did not      | 1   | 2    | 3    | 4    |      |      |             |              |
| Self-concept:                      |     |              |     |      |      |      | 3.76 |      |             |              |
| Attitude                           | 0.0 | 5.3          | 0.0 | 0.0  | 26.3 | 21.1 | 47.4 | 4.00 | 1           | 6            |
| Values                             | 0.0 | 0.0          | 5.3 | 0.0  | 26.3 | 47.4 | 21.1 | 3.79 | 2           | 7            |
| Self-image                         | 0.0 | 0.0          | 0.0 | 15.8 | 26.3 | 21.1 | 36.8 | 3.79 | 3           | 9            |
| Aptitude                           | 5.3 | 0.0          | 0.0 | 5.3  | 31.6 | 47.4 | 10.5 | 3.47 | 4           | 10           |
| Traits:                            |     |              |     |      |      |      | 4.19 |      |             |              |
| Team player                        | 0.0 | 0.0          | 0.0 | 0.0  | 5.3  | 31.6 | 63.2 | 4.58 | 1           | 2            |
| Self-confidence                    | 0.0 | 0.0          | 0.0 | 5.3  | 10.5 | 42.1 | 42.1 | 4.21 | 2           | 4            |
| Handle ambiguity                   | 5.3 | 0.0          | 0.0 | 10.5 | 5.3  | 52.6 | 26.3 | 3.79 | 3           | 8            |
| Motives:                           |     |              |     |      |      |      | 4.42 |      |             |              |
| Preservation of team integrity     | 0.0 | 0.0          | 0.0 | 0.0  | 5.3  | 26.3 | 68.4 | 4.63 | 1           | 1            |
| Focus on success                   | 0.0 | 0.0          | 0.0 | 0.0  | 5.3  | 42.1 | 52.6 | 4.47 | 2           | 3            |
| Preservation of personal integrity | 0.0 | 0.0          | 0.0 | 5.3  | 10.5 | 47.4 | 36.8 | 4.16 | 3           | 5            |

Mean MSs based upon the MSs of the three sub-categories of core competencies are also presented. Given that there are effectively six points on the scale, the MSs are between 0.00 and 5.00, the midpoint being 2.50. It is notable that all the MSs are > 2.50, which indicates that in general the team building activities contributed more of a major than a minor extent to an improvement in participants’ understanding and appreciation of the ten core competencies. However, a review of the MSs in terms of ranges provides a more detailed perspective.

Two traits, namely team player, and self-confidence, and two motives, namely preservation of team integrity, and focus on success fell within the range of  $4.17 \leq MS \leq 5.00$ . Preservation of personal integrity (MS = 4.16) is just below the lower end of the range. The other 6 / 10 (60%) MSs are  $3.34 \leq MS \leq 4.17$ , which indicates the contribution can be deemed to be to a near major contribution / near major contribution: one motive, namely preservation of personal integrity, one trait, namely handle ambiguity, and four self-concept, namely attitude, values, self-image, and aptitude. In terms of categories of core competencies, motives (MS = 4.42) is ranked first followed by traits (MS = 4.19), and self-concept (3.76).

Table 3 indicates the extent to which the team building activities contributed to the development of participants’ core competencies in terms of percentage responses to a scale of 1 (minor) to 5 (major), an additional point ‘did not’, and MSs. Mean MSs based upon the MSs of the three sub-categories of core competencies are also presented. It is notable that all the MSs are > 2.50, which indicates that in general the team building activities contributed more of a major than a minor extent to the development of participants’ core competencies.

*Table 3: Extent to which the team building activities contributed to the development of participants' core competencies*

| Core competency                    | U   | Response (%) |       |       |       |      | MS   | Rank | Rank within | Rank overall |
|------------------------------------|-----|--------------|-------|-------|-------|------|------|------|-------------|--------------|
|                                    |     | Did not      | Minor | ..... | Major |      |      |      |             |              |
|                                    |     |              | 1     | 2     | 3     | 4    | 5    |      |             |              |
| Self-concept:                      |     |              |       |       |       |      |      | 3.92 |             |              |
| Attitude                           | 0.0 | 0.0          | 5.3   | 0.0   | 10.5  | 31.6 | 52.6 | 4.26 | 1           | 5            |
| Aptitude                           | 0.0 | 5.3          | 0.0   | 0.0   | 21.1  | 36.8 | 36.8 | 3.95 | 2           | 8            |
| Values                             | 5.3 | 5.3          | 0.0   | 0.0   | 15.8  | 42.1 | 31.6 | 3.74 | 3           | 9            |
| Self-image                         | 5.3 | 5.3          | 0.0   | 0.0   | 26.3  | 21.1 | 42.1 | 3.74 | 4           | 10           |
| Traits:                            |     |              |       |       |       |      |      | 4.19 |             |              |
| Team player                        | 0.0 | 0.0          | 0.0   | 0.0   | 5.3   | 42.1 | 52.6 | 4.47 | 1           | 2            |
| Self-confidence                    | 0.0 | 0.0          | 5.3   | 0.0   | 10.5  | 42.1 | 42.1 | 4.16 | 2           | 6            |
| Handle ambiguity                   | 5.3 | 0.0          | 0.0   | 5.3   | 10.5  | 42.1 | 36.8 | 3.95 | 3           | 7            |
| Motives:                           |     |              |       |       |       |      |      | 4.45 |             |              |
| Preservation of team integrity     | 0.0 | 0.0          | 0.0   | 0.0   | 0.0   | 36.8 | 63.2 | 4.63 | 1           | 1            |
| Focus on success                   | 0.0 | 0.0          | 0.0   | 5.3   | 5.3   | 26.3 | 63.2 | 4.47 | 2           | 3            |
| Preservation of personal integrity | 0.0 | 0.0          | 0.0   | 0.0   | 10.5  | 52.6 | 36.8 | 4.26 | 3           | 4            |

6 / 10 (60%) MSs  $> 4.17 \leq 5.00$ , which indicates that the contribution can be deemed to be between a near major extent to a major extent / major extent: one self-concept, namely aptitude; two traits, namely team player, and self-confidence, and all three motives, namely preservation of team integrity, focus on success, and preservation of personal integrity.

The other 4 / 10 (40%) MSs are  $> 3.34 \leq 4.17$ , which indicates the contribution can be deemed to be between a contribution to a near major contribution / near major contribution: three self-concept, namely aptitude, values, and self-image, and one trait, namely handle ambiguity.

In terms of categories of core competencies, motives (MS = 4.45) is ranked first followed by traits (MS = 4.19), and self-concept (3.92). This ranking follows the ranking relative to the extent to which the team building activities contributed to an improvement in participants' understanding and appreciation of the ten core competencies.

Table 4 indicates the extent to which the team building activities enhanced the participants' attributes / states which collectively constitute emotional intelligence in terms of percentage responses to a scale of 1 (minor) to 5 (major), and MSs. It is notable that all the MSs are  $> 3.00$ , which indicates that in general the team building activities contributed more of a major than a minor extent to the enhancement of the participants' attributes / states. A review of the MSs provides a more detailed perspective.

4 / 15 (26.7%) MSs  $> 4.20 \leq 5.00$ , indicate that the extent of enhancement is between a near major extent to a major extent / major extent relative to problem solving, happiness, interpersonal relationship, and optimism.

9 / 15 (60%) MSs are  $> 3.40 \leq 4.20$ , indicating that the extent of enhancement is between some extent to a near major extent / near major extent. The attributes / states include: assertiveness; flexibility; social responsibility; impulse control; emotional self-awareness; stress tolerance; reality testing, and independence.

Table 4: Extent to which the team building activities enhanced the participants' attributes / states

| Attribute / State          | U    | Response (%) |      |       |      |      | MS   | Rank |
|----------------------------|------|--------------|------|-------|------|------|------|------|
|                            |      | Minor.....   |      | Major |      |      |      |      |
|                            |      | 1            | 2    | 3     | 4    | 5    |      |      |
| Problem solving            | 0.0  | 0.0          | 5.3  | 0.0   | 31.6 | 63.2 | 4.53 | 1    |
| Happiness                  | 0.0  | 0.0          | 0.0  | 10.5  | 26.3 | 63.2 | 4.53 | 2    |
| Interpersonal relationship | 0.0  | 0.0          | 0.0  | 0.0   | 52.6 | 47.4 | 4.47 | 3    |
| Optimism                   | 5.3  | 0.0          | 0.0  | 10.5  | 26.3 | 57.9 | 4.26 | 4    |
| Assertiveness              | 0.0  | 0.0          | 0.0  | 21.1  | 42.1 | 36.8 | 4.16 | 5    |
| Flexibility                | 5.3  | 0.0          | 0.0  | 15.8  | 26.3 | 52.6 | 4.16 | 6    |
| Social responsibility      | 5.3  | 0.0          | 0.0  | 21.1  | 36.8 | 36.8 | 3.95 | 7    |
| Impulse control            | 5.3  | 0.0          | 0.0  | 26.3  | 31.6 | 36.8 | 3.89 | 8    |
| Emotional self-awareness   | 0.0  | 5.3          | 5.3  | 21.1  | 42.1 | 26.3 | 3.79 | 9    |
| Stress tolerance           | 10.5 | 5.3          | 0.0  | 21.1  | 15.8 | 47.4 | 3.68 | 10   |
| Reality testing            | 10.5 | 5.3          | 0.0  | 21.1  | 31.6 | 31.6 | 3.53 | 11   |
| Independence               | 0.0  | 10.5         | 5.3  | 26.3  | 36.8 | 21.1 | 3.53 | 12   |
| Self-regard                | 5.6  | 5.6          | 0.0  | 33.3  | 38.9 | 16.7 | 3.44 | 13   |
| Empathy                    | 5.3  | 15.8         | 5.3  | 10.5  | 47.4 | 15.8 | 3.26 | 14   |
| Self-actualisation         | 15.8 | 0.0          | 10.5 | 15.8  | 42.1 | 15.8 | 3.16 | 15   |

## DISCUSSION

The findings indicate that the team building activities contributed to an improvement in participants' understanding and appreciation of ten core competencies, and enhanced seventeen skills, developed the ten core competencies, and fifteen states / attributes relative to emotional intelligence.

It is notable that relative to the seventeen skills the enhancement was between a near major to major extent / major extent in the case of eleven (64.7%), which included the key skills in the form of team building, oral communicating, decision making, leadership, planning, motivating, coordinating, leading, organising, controlling, and interpersonal. This was an objective of the team building event.

Given that the performance of practitioners and students is affected by the extent to which core competencies manifest themselves, and differentiate between average and above average performance, it is notable that the contribution of the team building event to participants' understanding and appreciation of four (40%) core competencies can be deemed to be between a near major extent to a major extent / major extent, namely team player, and self-confidence, preservation of team integrity, and focus on success. Furthermore, the contribution relative to the remaining six (60%) was between a contribution to a near major contribution / near major contribution. This was an objective of the team building event, especially team player, self-confidence, and focus on success. In terms of the honours year of study the latter two are extremely important.

In terms of the extent to which the team building activities contributed to the development of participants' core competencies, in the case of six the contribution can be deemed to be between a near major extent to a major extent / major extent, namely aptitude, team player, self-confidence, preservation of team integrity, focus on success, and preservation of

personal integrity. This is in alignment with the findings in the literature, especially that of Hmelo-Silver *et al.*, and the PBL approach.

In terms of the extent to which the team building activities enhanced the participants' attributes / states, which collectively constitute emotional intelligence, the extent of enhancement in the case of four (26.7%) is between a near major extent to a major extent / major extent relative to problem solving, happiness, interpersonal relationship, and optimism. Then, in the case of nine (60%) it is between some extent to a near major extent / near major extent relative to assertiveness, flexibility, social responsibility, impulse control, emotional self-awareness, stress tolerance, reality testing, and independence.

## CONCLUSIONS AND RECOMMENDATIONS

Decision making is an important activity of the leading function. Leadership is important, and complements management. Interpersonal skills are invaluable due to the working with people across all levels in the construction industry. Non-traditional interventions such as the team building event reported on, do impact on honours' students' skills, understanding and appreciation of the core competencies, and their actual core competencies, and attributes / states relative to emotional intelligence, which in turn should have contributed to their ability to successfully complete the honours year of study.

Furthermore, the impact should have contributed to their ability to respond during employment interviews, effectively integrate into the construction industry upon employment, and to fulfil a form of management function in the industry. Given the aim of the team building event, namely to enhance skills, core competencies, and emotional intelligence with a view to contribute to honours students' ability to successfully complete the honours year of study, the team building event can be deemed a success. It has thus been recommended that the team building event be undertaken on an annual basis, and that further potential events directed at enhancing skills, core competencies, and emotional intelligence be investigated.

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# MODE OF STUDY INFLUENCES BUILT ENVIRONMENT STUDENTS' PERCEPTION OF THEIR PROFESSIONAL DEVELOPMENT

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Accredited undergraduate courses in construction disciplines are designed to help students develop knowledge and skills to prepare them for professional practice. However, it is recognised that undergraduates are not always as prepared for professional practice as might be desired. The aim of this paper is to examine undergraduates' perceptions regarding how effectively their course prepares them for industry. Students tend, in their academic studies, to focus on assessment, and feedback on assessment has been recognised as an important learning support. Built environment undergraduates at a post-1992 university complete a short paper-based questionnaire at the mid-point of each semester regarding their academic progress and support they may value. This Likert-scaled questionnaire contains 12 statements, plus two free-text questions. Analysis of completed questionnaires reveals mode of study - part-time or full-time - influences student perceptions of their learning experience and its appropriateness to support development of professional practice skills and knowledge. This suggests there may be an opportunity to fine-tune pedagogic practice in order to more effectively support development of undergraduates' professional knowledge and skills.

Keywords: learning, part-time, professionalism, undergraduates, education

## INTRODUCTION

One important function of Higher Education (HE) is to provide skilled graduates who effectively meet the needs of industry and thus contribute to a healthy economy (Leitch 2006). Employers value academic qualifications, and express a desire for undergraduate curricula to reflect their professional practice needs (Hoxley and Wilkinson 2006). However, academic qualifications are not necessarily a guide to professional competence. The Confederation of British Industry finds employers make 80% of any recruitment decision on the basis of perceived soft skills (CBI 2007). Therefore, given an important function of HE is preparing graduates for industry, Higher Education Institutions (HEIs) should consider how they help students develop their soft or employability skills (Bates and Kaye 2014).

One of the authors of this paper is currently undertaking a doctoral study that focuses on the professional skill development of built environment undergraduates. This paper reports part of that study, a doctoral 'work in progress'.

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Students express concern for how their course will prepare them for their professional life (Voss, Gruber and Szmigin 2007). In particular, their concern is with employment opportunities (Kandiko and Mawer 2013). To this end, students value practice-based longitudinal assessment (Bates, *et al.*, 2013). The learning goals of undergraduates and of employers converge around academic knowledge and development of professional practice skills. Yet it appears there is some divergence between desire and practice, as 65% of employers want HEIs to be better at developing undergraduates' employability skills (CBI 2012). This highlights the value of developing students professional practice skills as well as their academic knowledge. But delivering this presents some dilemmas and challenges for HEIs.

The aim of this paper is to examine undergraduates' perceptions at the mid-point of a semester regarding how effectively their course is preparing them for professional practice, and whether assessment and feedback effectively support their learning. The objectives of this paper are first to explore key issues through a literature review, and second to analyse student evaluations of their learning experience.

This study was undertaken at a post-1992 university. In the case of built environment courses, more than half of students study part-time. They attend university one day per week, spending the remaining four days per week employed in professional practice, whereas full-time students' classes are distributed across the week and many of these students have limited or no industrial experience. All but one of these courses are professionally accredited, and students on the non-accredited course often ultimately seek to progress to an accredited one.

## **THEORETICAL PERSPECTIVES**

### **Accountability in Higher Education**

In order to promote public accountability of HEIs and help prospective students make informed choices (HEFCE 2016), final year undergraduates evaluate various aspects of their learning experience through the National Student Survey (NSS), results of which are publically available. From this data, some weaknesses in built environment students' experience are apparent. More than other undergraduates, built environment undergraduates evaluate feedback to help clarify things they did not understand as the weakest part of their academic experience. Across all courses overall satisfaction is approximately 64% for feedback, whereas for construction management courses this figure is 53% (Lamond, Proverbs and Wood 2013). Built environment undergraduates also express concern regarding personal development, acquiring confidence and being intellectually challenged in their course (Lamond, Proverbs and Wood 2013). This is reflected in a concern some built environment employers express - graduates often lack employability skills (Rawlins and Marasini 2011). Thus, it appears that built environment undergraduates and employers have concerns that are not well addressed.

Built environment courses are designed to provide "skills and knowledge for a career in the global construction industry" (The Chartered Institute of Building 2016). However, a clear problem exists, to develop students' knowledge and skills as effectively as desired. This is all the more surprising, given that the curricula are designed taking into account the needs of industry and are approved by professional bodies. Understanding how best to meet undergraduates' learning needs may potentially be enhanced by the reflective practice of tutors, taking into account the changing needs of different groups of students and the mutable professional environment (Schön 1991).

## **Part-Time Study in Higher Education**

Studying in HE on a part-time basis has been recognised as valuable. It offers opportunities to those who might otherwise find it difficult to engage in formal education (Department for Business, Innovation and Skills 2011). Part-time HE contributes to social mobility and offers access to professions which for some groups might otherwise be difficult to obtain (HEFCW 2014). In 2015/16 there were 540,285 part-time students in the UK (Universities UK 2016), which represents almost one quarter of HE students. This is particularly interesting, given that HE offers the opportunity of enhanced earnings and also non-pecuniary advantages such as status (Blanden, *et al.*, 2010). Further, part-time HE offers learners the opportunity to develop knowledge and skills that are valuable in their employment (Bertram, Mthiyane and Mukeredzi 2013; Callender and Little 2015). Students studying on a part-time basis and employed in practice have experience of benefits and challenges of the workplace, which offers additional opportunities for learning. Indeed, such employment provides students that are pragmatist or activist learners an opportunity to learn in a style of their preference (Honey and Mumford 1992), and provides a context for learning (Shaw and Ogilvie 2010).

Part-time students bring professional experience to their formal learning, whilst full-time students do not possess this experience. Built environment students tend to prefer learning by doing (Crabtree 2014). For part-time students this may represent an advantage in so far as they are learning at work. But it also raises questions as to how this learning may be developed to enhance students' knowledge and skills. However, the undergraduate curriculum is similar for all students. Little regard is given to the professional practice experience that part-time students bring to their formal learning; nor is thought given to how this experience may be developed (Bertram, Mthiyane and Mukeredzi 2013). Indeed, part-time learners sometimes experience a tension between their employment and their course (Gibbs, Jones and Oosthuizen 2013). Reflective practice offers students opportunity to improve (Argyris and Schön 1996) and may be one route to enhance learning.

## **Supporting Learners**

There exist difficulties for learners both with and without experience of professional practice (Hasson, McKenna and Keeney 2013). It is important to offer a learning experience that meets the needs of all learners in HE, regardless of their professional experience. Given that students focus in particular on assessment, providing assessment that is authentic to professional practice is valuable as a means to develop their professional knowledge and skills. However, real world conditions can be difficult to recreate (Ashford-Rowe, Herrington and Brown 2014). This illustrates some of the challenges facing built environment tutors as they seek to provide all undergraduates with an effective learning experience.

To develop students' learning, assessment feedback is also recognised as valuable (Hyatt, 2005) and should be integral to teaching (Hattie and Timperley 2007). The Quality Assurance Agency for Higher Education (QAA 2012) identify assessment feedback as playing an essential part in enhancing learning. Indeed, Eraut (2004) argues feedback is the most important contributor to learning, although it needs to be of a high quality to be effective (Sadler 1998). This paper contends that feedback tailored to mode of study could help students' academic learning and develop their professional practice skills.

## METHOD

Data were gathered during March 2017, which is the mid-point of the semester, at a post-1992 university. Within built environment, 569 undergraduates study part-time (59%) and 391 full-time at this university. This is in contrast to both the University and Faculty within which the Department sits, each of which have approximately 17% part-time students.

Built environment students are invited to complete a paper-based questionnaire at the mid-point of each semester regarding their academic progress on the modules they study. Although the questionnaire was not designed specifically for research, it is standardised across all modules offered by the Department and provides an opportunity to collect consistent responses from students. Because participants had to opt-in to the use of their responses for this study, there may have been some self-selection in the sampling, but this could not be quantified and is unlikely to have resulted in significant bias for the comparisons made here. This questionnaire contains 12 statements using a four-point Likert scale for responses - definitely agree, agree, disagree and definitely disagree. Likert scales have the advantage of being practical (Harland, Dawkin and Martin 2015), and such questionnaires can be relatively quick and easy to implement and analyse. There are also two free-text questions at the end of the questionnaire, and these are to identify what students most like about a module and what tutors can do to help them with any areas of concern. The questionnaire also inquired whether students are attending university on a part-time or full-time basis.

For the Department, the purpose of this questionnaire is two-fold. First, it allows tutors to identify any problems at an early enough stage so as to be able to undertake remedial action should it be required and to see whether students have any specific issues that could be resolved. Second, it is intended to encourage students to reflect on the progress of their learning, and identify any support that would benefit them. Tutors read the completed forms and respond if there are issues that need addressing, noting also those things that students value. The questionnaire is regarded as a helpful tool in providing information which is then used to ensure that students' learning needs are effectively met. This student questionnaire is deemed informal and is not part of the formal university mechanism to gauge student perceptions of their learning experience, although the value of such questionnaires has been recognised (Vohmann, *et al.*, 2015).

Ethical approval to undertake the research had already been secured using the University protocols. In addition, to protect participants, the questionnaire is anonymous and participants were asked to tick a box at the top of the questionnaire to confirm they were happy for their return to be included in anonymized research data. Tutors voluntarily provided their students' completed questionnaires for inclusion in this research. All returns were anonymous, the researcher had no information regarding which students or tutors had participated.

Of 266 questionnaires returned to the researcher, 87 had not 'opted-in' to the research, and so these were excluded from the data analysis. Not all respondents answered the question regarding their mode of study, and so these were also excluded from the analysis. It was considered that, as asking whether the student was studying on a part-time or full-time basis was new, the form could benefit from modification to add clarity here. This left a total of 101 returns that were included in the study. This paper uses student responses to three of the 12 statements, plus the two free-text questions. Questionnaires were analysed quantitatively, counting responses for each statement. The Mann-Whitney U-test was used to test for significance of difference in response between the full-time and part-time

students, and Cronbach's alpha coefficient of internal consistency was calculated for the same data. Both analyses were undertaken using SPSS (Gray 2014). The free text comments were analysed using thematic analysis which is considered flexible (Braun and Clarke 2006) and appropriate for analysis of such data.

## FINDINGS AND DISCUSSION

### Findings

It must first be noted that the overwhelming majority of students evaluated their learning experience positively. That the courses under study provide an effective learning experience is well established, for example in external examiner reports and continued professional body recognition. This work is concerned to examine students' perception of part of that experience in order to inform and develop pedagogic practice.

Checking for consistency, Cronbach's alpha coefficient of reliability was calculated as 0.985. This is considered within the acceptable limit of reliability (Gozum and Hacıhasanoglu 2009).

In response to the statement 'I understand how this module links with employment as a professional in the built environment' there was a difference in strength of feeling of response between full-time and part-time students (Table 1).

*Table 1: Proportional responses to the statement "I understand how this module links with employment as a professional in the built environment" from full-time and part-time students, with the Mann-Whitney U-test for significance of difference between the two groups*

|                               | Definitely agree | Agree | Disagree | Definitely disagree |
|-------------------------------|------------------|-------|----------|---------------------|
| Full-time student<br>(n=34) * | 74%              | 26%   | 0%       | 0%                  |
| Part-time student<br>(n=67)   | 40%              | 58%   | 2%       | 0%                  |

\* n = number of responses for this group

Part-time students were more likely to evaluate this as agree rather than definitely agree. Full-time students were more to evaluate this as definitely agree that their learning experience linked with employment as a professional in the built environment. Very few students disagreed and none definitely disagreed with the statement, indicating that almost all students could recognise links between their academic study and professional practice. There was a statistically significant difference in strength of feeling in responses between the two modes of study (Table 1).

In response to the statement 'The assessment develops my knowledge / skills', part-time students were again more likely to evaluate this as agree rather than definitely agree (Table 2). Full-time students were more likely to 'definitely agree' with the statement. No full-time students disagreed or definitely disagreed. The difference in responses between the two groups were again significant (Table 2).

Table 2: Proportional responses to the statement "The assessment develops my professional knowledge / skills" from full-time and part-time students, with the Mann-Whitney U-test for significance of difference between the two groups

|                          | Definitely agree | Agree | Disagree | Definitely disagree |
|--------------------------|------------------|-------|----------|---------------------|
| Full-time student (n=33) | 55%              | 45%   | 0%       | 0%                  |
| Part-time student (n=67) | 27%              | 63%   | 10%      | 0%                  |

*Mann-Whitney U = 814 p < 0.01*

It is possible that the difference may have arisen because full-time students had little or no professional experience from which to draw, and so their expectations were different from those of part-time students. The full-time students may have had a more acute awareness of their professional knowledge and skills development. In other words they were learning about new things which they had not previously encountered.

Not all students responded to the statement 'feedback has helped clarify things I did not understand', instead leaving this part of the questionnaire blank. Of those students who did respond, a number of students disagreed or definitely disagreed with the statement (Table 3). No other statement received such strong negative responses, and again part-time students were less inclined to agree overall (Table 3).

Table 3: Proportional responses to the statement "Feedback has helped clarify things I did not understand" from full-time and part-time students, with the Mann-Whitney U-test for significance of difference between the two groups

|                          | Definitely agree | Agree | Disagree | Definitely disagree |
|--------------------------|------------------|-------|----------|---------------------|
| Full-time student (n=33) | 43%              | 33%   | 21%      | 3%                  |
| Part-time student (n=63) | 11%              | 48%   | 36%      | 5%                  |

*Mann-Whitney U = 748 p < 0.01*

In response to the free-text question 'what do you most like about the module?' part-time students frequently commented on the extent to which their academic learning related to their work, in particular regarding those things they found valuable. For full-time students there was little such recognition. They wrote about pedagogic and timetabling aspects of their module; for example, 'breaks up the lectures' was apparently considered a positive feature.

Few students answered the question 'How can module staff help you with any areas of concern or improve the module?' Of those that did, there was some reference to receiving more professional practice guidance or information, and this was more frequently made by part-time students, which is perhaps counter-intuitive. Students from both modes of study expressed concern regarding particular aspects of their learning experience - clarity regarding the detail of assessment requirements, understanding coursework criteria, and receiving feedback.

**Discussion**

Findings above suggest that, interestingly, mode of study was an important factor in students' perceptions of their development of professional knowledge and skills. This

was statistically significant. Mode of study may have consequences for students' perceptions of what is valuable to support their learning and what is less effective. In turn, this should inform pedagogic practice. Such perceptions of what is appropriate may be shaped by students' own professional experience. It is possible that part-time students, with their professional experience, are more demanding in respect of development of professional knowledge and skills in their formal learning. However, their own professional experience may not necessarily reflect the wider industry nor develop broader skills that profit graduates' careers and industry needs. Full-time undergraduates, without industrial experience, may be less critical of their formal learning as they have nothing with which to compare it, or knowledge or expectations of what might be appropriate to help their learning.

It is also possible that curriculum design or pedagogic practice, or both, may, perhaps, be skewed towards one or other group of students. This is a point that requires further investigation.

Potentially, students may conflate education and training, not appreciating the distinction between the two. Students may perceive higher education as courses that enable them to be more proficient in their day-to-day employment tasks, but do not recognise the value of broader aspects for their professional development.

It was interesting to note the slightly smaller number of responses to the question regarding feedback (Table 3). Different conceptions of feedback, ranging from promoting learning to critique of the final submission (Evans 2013), may also affect students' ability to comment on it. Some of these students who responded had an unfavourable evaluation of feedback by the mid-point of the semester. These evaluations of feedback indicate an opportunity to enhance pedagogic practice. Either students do not recognise feedback or tutors make insufficient use of feedback as a pedagogic device, each of these being rather unsatisfactory, as feedback is considered important to help learning (Hattie and Timperley 2007). Given that feedback on performance is usually "the most important factor in learning" (Eraut 2004: 803), feedback has an especially important pedagogic role to play. Learning from reflection (Schön 1991), with feedback as integral to this, is a valuable yet perhaps under-used device.

It is also interesting to observe that full-time students expressed less dissatisfaction with feedback than the part-time students. Reasons for this difference in response between the modes of study are unclear. Possibly part-time students may be more critical, anticipating that formal HE study will offer them new perspectives on their own practice or they may expect feedback to align with their own professional practice. Nevertheless, the depth of feeling and difference between the two groups in response to this question was unexpected and further investigation of this finding considered necessary.

## CONCLUSIONS

These findings suggest that there is opportunity to enhance the student learning experience. It seems that there may be different learning needs of part-time and full-time students. This may necessitate finding solutions to the different learning needs of students with these different modes of study, since employment as a built environment professional seems to have some bearing on student perception of their academic learning.

Although based on a relatively small sample, and findings should be treated with caution, this paper nevertheless suggests there is scope for further research. This study has shown that students' perception of their learning experience may be shaped by their mode of

study. There is also scope to examine how tutors can enhance the feedback aspect of their practice earlier in the semester for students' benefit, and also to explore how students could recognise and benefit from this.

Developing students' knowledge and skills through a more tailored pedagogic approach has potential to enhance the efficacy of built environment HE courses. Although it is recognised that students perceive they are developing appropriate knowledge and skills, nevertheless there seems to be the potential to enhance this. To further develop their learning and development as effective practitioners, students with different modes of study may benefit from tutors deployment of revised pedagogic approaches.

One key role of HE is to provide industry with effective practitioners (Leitch 2006). Indeed, employers value academic qualifications but also want graduates to possess appropriate professional skills (Hoxley and Wilkinson 2006). This paper suggests there may be scope to enhance students' learning experience by tailoring it to suit their particular needs associated with mode of study, rather than taking a one-size-fits-all approach. In view of the need for HEIs to be as efficient and effective as possible in the current uncertain economic and political climate, this paper suggests a challenge and an opportunity.

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# **ENVIRONMENTAL MANAGEMENT AND SUSTAINABILITY**

# REPORTING CORPORATE SUSTAINABILITY AND THE CHALLENGES OF POLITICAL RHETORIC

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Where organisations set out their sustainable values and make publically available their sustainable strategy, the rhetoric establishes an agenda against which, should deviation occur, the company can be publically held to account. As a result of recent scandals, it is not surprising that some people remain cautious or even cynical with regard to corporate sustainability, especially where it is found that the actual practices of an organisation are different to that reported. The research provides a review of company reports to identify how multinational organisations advocate their sustainable position. Both construction and non-construction companies are considered with regard to the use of the term 'sustainable'. The review finds that the multinational organisations, both construction and non-construction have in recent years provided a position on sustainability. While heavy construction companies are setting a commitment toward sustainability, the positions stated against which the companies may be measured are often vague. There were, however, company reports where commitments to sustainability were detailed and the statements could be considered measureable. Nevertheless, most company reports use sustainability terms that remain generic and lend themselves to a more flexible approach to sustainability or, cynically, are providing the rhetoric for public relations.

Keywords: corporate reporting, sustainability, sustainable values

## THE SUSTAINABLE DIRECTION

Over the last few decades, pressure has been placed on companies to ensure that they align their operation with sustainable values (International Labour Office, 2011). And, although the evidence might be considered tentative, for those companies that trade on the open market, there are benefits associated with a 'sustainable' market image. For example, there are differences in stock market performance when organisations are classed as 'Low Sustainability' and 'High Sustainability' (Eccles *et al*, 2011). Adams *et al*, (2014) have also noted differences in performance when evaluating the companies on the Dow Jones Sustainability Index between 2008-2009, showing that those companies scoring low on the SAM (Sustainable Assessment Management) index did not perform so well on the stock markets and were less likely to be able to find shareholder value creation opportunities. In the work reported by Eccles *et al*, (2011), the benefits of those classed as 'High Sustainability' companies were more closely associated with the companies that competed on the basis of 'brand'; were interested in the influence of 'human capital' or were involved in extracting large amounts of natural resource, where

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potential negative impact on local communities can affect global trade. However, Eccles *et al*, noted that even with such pressures to become sustainable many companies remain reluctant to invest in sustainability, waiting until required to do so.

It has been suggested that most of the companies can be divided into two groups: those voluntarily adopting socio-environmental policies and those maintaining a more traditional model of maximising profits, only responding to environmental concerns when required to by law and regulation (Eccles *et al*, 2011). Between these two polarised positions, many companies will claim to be sustainable, by way of third party accreditation, but may not do much to change their practice. Upstill-Goddard *et al*, (2015) found that when gaining BES 6001 (BRE, 2009) certification for responsible sourcing of products, the construction companies did not seem to adopt a strategic approach to certification, generally sticking with their existing environmental management system rather than adapting their practice in a way that would result in greater recognition within the scheme. The result is surprising, especially when companies may be competitively judged against the criteria.

In practice, organisational sustainability is now established prerequisite, with many prequalification questionnaires requiring environmental criteria to be met (Oke and Aigbavboa, 2017; Hamani and Al-Hajj, 2015). However, when evaluating the tendering process and ranking prequalification criteria, sustainability was not identified as a main or sub-criteria for bid evaluation and thus was not one of the factors listed that influenced success (Puri and Tiwari, 2014). Based on the findings of prior research, it is not surprising that adopting new sustainable processes in construction has been relatively slow, as the construction industry is often reported to be traditional in their practice, lagging behind other organisations (Peansupap and Walker, 2004). Furthermore, the Global Reporting Initiative (Lamprinidi and Ringland, 2008) found that reporting the practice of sustainability was not well established in construction when compared to other sectors, such as the financial services or the electric utilities sectors. While some argue that sustainability can be classed as part of the '6th wave of innovation' representing a key company attribute for companies to be accepted by their peers (Silva and Di Serio, 2016), a lower risk position on sustainability may be preferred, although the research on the construction strategies adopted is relatively uncharted.

This paper therefore provides insight into the reporting practices of multinational heavy construction organisations compared with a sample of other multinational organisations, to help appreciate the value companies place on the term sustainability, based on its use within company policy. The paper will also make note of how companies that do not follow their policy of sustainability may or may not be affected by their rhetoric

## **METHOD**

The work reported here presents part of a recently completed study, which reviewed multinational global company reports with regard to their use of the term 'sustainability' within their published reports (Duwebi, 2017). Under the review, the position and strategy the company reports presented during 2010-2012 is discussed.

Of the 10 industry sectors, based on the Dow Jones Sustainability and Robeco SAM Sustainability Index that were reviewed in the main study, observations made from 3 of the industry sectors are reported here. In each sector, the five highest-ranking companies identified from the SAM sustainability list were selected and reports captured and the content reviewed.

Based on the reports of three sectors, comparisons are drawn across the heavy construction, automobile and chemical sector. The paper will examine how the companies' interpretations of sustainability align with the Brundtland definition, and also how they have positioned themselves in taking up the sustainability agenda. The publically available information, reported by the company is taken as evidence of how the company wish to convey their sustainability agenda, and does not necessarily represent the sustainable actions and activities undertaken.

Purposive sampling was adopted to capture an insight into the sustainability rhetoric of the higher ranking organisations. The review of archival research data provides insight into use of the term sustainability through content analysis, thus by systematically searching coded categories, quantifying and comparing the occurrence of related terms the text is analysed (Hsieh and Shannon, 2005). And, though an analysis of the surrounding discourse, deriving the intended meaning of sustainability by virtue of the non-linguistic factors, discourse analysis, in a situational context, is used to interpret use of the term sustainability (Yang and Sun, 2010). While the interdisciplinary uses of both content and discourse analysis are diverse, the approach adopted here is to systematically search for sustainability and related terms and present the context to understand the position the company wish to convey. The full research method is presented in the main body of work (Duwebi, 2017).

The work is cross-sectional in that each report provides a snapshot of the company activities at that moment in time and across companies, and is also longitudinal in that three annual reports were investigated, for the three years 2010 to 2012 (Duwebi, 2017). In light of recent political changes and to capture any trends or departures, more recent reports are brought into the discussion, but did not undergo the quantitative content analysis reported.

Different types of company reports were recognised as information sources for this study and included; citizenship reports, corporate social responsibility reports CSR, sustainable development reports SD, corporate reports CR, beyond the mine reports BTM and summary review reports. Overall, 308 reports were included within the review for the study. Within this paper we focus on one set of code and discourse linked to sustainability, namely how the company defines sustainability and the proximity with the Brundtland definition of sustainability. However the main study also considered issues associated with the local political, geographical and economic factors (linked to sustainability), management of sustainability, knowledge management and supply chain issues. The broad issues of enquiry was used to gain a greater understanding or how sustainability was being reported (Duwebi, 2017).

With the aid of NVivo software, queries relative to sustainability were used to explore and extract related data. It is noted that many of the company reports were not produced with sustainability or the management of sustainability in mind. The method of searching and querying was an iterative search process, looking for terms, capturing information, recognising different related terms used (compared with those initially searched) and then repeating the search, using broader search terms (Duwebi, 2017). This formed an initial enquiry from which more detailed investigations can be taken forward.

### **Results: Sustainability within Company Reports**

The analysis of the raw data relating to use of the term 'sustainability' showed that the use of sustainability is not limited to environmental and humanitarian definitions, as would be expected. Thus, the context within which the term is used is fundamental to

interpretation. The information surrounding the word sustainability was expected to be of more relevance than the term itself. Considering the context of individual words is a logical step in developing understanding and, in most cases, the nature of a word's meaning and intent can be distinguished as the surrounding non-linguistic and context discourse is considered. The occurrence of discourse related to environmental 'sustainability' is recorded in the tables below (tables 1, 2 & 3).

*Table 1: Heavy Construction Sector*

| Company in the SAM index              | Number of reports found containing relevant references Sources (and reference to the word) |
|---------------------------------------|--|
| Acciona                               | 2 (3)  |
| Fomento de Construcciones y Contratas | 3 (4)  |
| GS Engineering & Construction         | 1(1)   |
| ASC                                   | 0 (0)  |
| Hyundai E&C                           | 0 (0)  |

Not all heavy construction companies use the term sustainability, as considered here. However, based on the content analysis alone, the leading organisations of the heavy construction sector are not found to be particularly different or as has been suggested 'lagging behind' other sectors. In the larger sample of research, other industries such as Aerospace, Banking, Food and Drugs, Mobile Sector, Oil Sector, Automobile, Chemical, Mining and Pharmaceutical were reviewed (reported by Duwebi, 2017). In comparison to these industries, the degree to which the heavy construction sector refer to environmental 'sustainability' within their reports is comparable to that used in the mining and pharmaceutical sectors. It is interesting that the companies using a greater amount of 'sustainability' content were the chemical and automobile sectors. Within these sectors, the top listed companies were most explicit about their commitments, placing emphasis on how their companies are progressing in their commitment to sustainability. It is interesting that the top level 'generic' statements are relatively consistent across different companies.

*Table 2: Automobile sector*

| Company in the SAM index | Number of reports found containing relevant references Sources (and reference to the word) |
|--------------------------|--|
| BMW                      | 5 (9)  |
| Daimler                  | 6 (9)  |
| Fiat                     | 1(1)   |
| VW                       | 1 (1)  |
| Toyota                   | 0 (0)  |

BMW's (BMW Annual Report 2010: 171) commitment aligns closely with the philosophical content of the Brundtland definition, giving equal consideration to ecological, social and economic development. They also use the term sustainability from an organisational perspective referring to the relevance of corporate sustainability and its importance in three areas: resources, reputation and risk.

Similarly, Daimler, in their annual reports from 2010 (Daimler Annual Report, 2010: 251) define sustainability in line with Brundtland, as:

...using natural resources in such a way that they continue to be available to fulfil the needs of future generations. In the view of the Daimler Group, sustainable business operations have to give due consideration to economic, ecological and social aspects.

Also, in the following year's Sustainability Report (2011: 10) sustainability is defined as:

...responsible corporate behaviour that leads to long-term business success and is in harmony with society and the environment. The company moves toward its goals by making sustainability a firmly integrated aspect of their operations and by requiring and promoting a strong sense of responsibility for sustainable operations among all of their managers and employees throughout the Group.

With a lesser degree of emphasis than the two previous companies, Volkswagen, in their sustainability report (2012: 16), interpret sustainability as:

...a call for a balance of economic, environmental and social objectives.

The comments from the Volkswagen group precede the emissions violations, which started to emerge, following a 'tip-off' in 2014. However, it is claimed that some of the cars affected, were in production as early as 2009 (Atiyen, 2017). A recent review of the affair concluded that the root cause of the "unethical scandal goes back to business culture and structure of the company". Furthermore, the review suggests that compliance-based business ethics, such as those used by Volkswagen, are failing to treat employees ethically and present employees with the dilemma of either losing their jobs or taking unethical action. The difference between the report and actual company culture and practice that led to the problem is evidenced through the company confession. Volkswagen attracted all the opprobrium for this, but were following EU-wide policy in the drive to reduce carbon dioxide emissions. Government policy was based on the single issue of carbon dioxide emissions to the exclusion of all else, including air quality and health considerations. Other manufacturers have since confessed to similar practices, and this incident exposes some of the dangers inherent in maintaining a single-issue focus by governments.

Table 3: Chemical sector

| Company in the SAM index | Number of reports found containing relevant references Sources (and reference to the word) |
|--------------------------|--|
| AkzoNobel                | 1 (1)  |
| BASF                     | 1 (1)  |
| Bayer                    | 6 (9)  |
| DMS                      | 3 (17)   |
| Dow chemical             | 0 (0)  |

The chemical sector also provided the highest number of references to sustainability. BASF Corporation in their annual report (BASF Annual Report 2010: 205) aligns to the Brundtland definition of sustainable development. Meanwhile, AkzoNoble in their 2012 annual report (AkzoNoble Annual Report 2012: 163) only make a tangential reference to global sustainability. They see sustainability as connected to every area of business, stating that:

...by doing more with less, sustainability value will be fundamentally connected to business value. We are making sustainability profitable by tailoring solutions to our customers' needs today and in the future and by future-proofing our supply chain.

The chemical corporation DSM (Dutch State Mines) introduced their approach and understanding of sustainability in their integrated annual reports (2010) as a purpose to

create 'brighter' lives for people today and generations to come through connecting life science and materials sciences to create solutions that nourish, protect and improve performance. DSM suggest they focus on the triple bottom line in order to create value for all stakeholders. Furthermore, they state why the commitment is important for the company's future, "sustainability will be the key differentiator and value driver over the coming decades" (2010: 11).

### **Comparison with Construction: Discussion**

Within the companies listed, there is some evidence to suggest the heavy construction sector is cognisant of sustainability, comparable to that found in other fields and is concerned with improving its social, economic and environmental sustainability indicators.

Acciona's annual report 2010 (10) referred to the company's commitment to sustainability, as it goes beyond generating economic value, and stated that "we aim to contribute to development with a balanced business model for the benefit of future generations." They go on to suggest that the company's sustainability master plan 2010-2013 (Acciona Annual Report 2010) rests on six pillars: innovation, environment, engagement with society, people, the value chain and governance, all aimed at achieving concrete goals of sustainability.

Fomento de Construcciones Contratas (Report 2012) makes reference to the importance of sustainability in both the construction product and process. The report (2012: 447) states that "sustainable construction refers not only to the managing of environmental impact while the works are being executed, but also to the management of the "product" throughout its useful life."

GS Engineering & Construction (Annual Integrated Report 2012: 6) differ from this view and instead interpret sustainability as, "creating value that can be shared among various stakeholders, as well as fulfilling their responsibilities as a corporate citizen." The company vision of sustainability (Annual Integrated Report: 7) relies on: "maximising organisational competence based on core values of great innovation, great challenges and great partnerships to earn trust to grow as a sustainable global company." The company aim is defined as being to "Pursue growth by creating sustainable value together." (Annual Integrated Report 2012)

The related terms and expressions used in the company reports, link sustainability to environmental, social and economic values to create company principles that claim to add corporate value, for future markets.

#### *Deeper into sustainability: Acciona a more recent enquiry*

A review of Acciona Annual Report in (2015a) found no specific reference to 'sustainability', however, there is a significant shift from early towards sustainable reports with greater detail. The growth in renewable energy and the need to strategically position itself with emergent markets, where companies will need to operate in a sustainable manner, was recognised as a key business driver. The company has shifted from an acknowledgement of sustainability issues to one where it has positioned itself to take advantage of emergent energy markets and to adapt company practice to suit. The company's Sustainability Report (2015b) details training and development initiatives-performance incentives linked to sustainability and covers many aspects of practice which makes some commitments measurable. It is interesting that this is done even after the preceding years were seen as financially challenging and where the company had to

restructure itself. Sustainability and business development are no longer seen as opposing agenda, but very much one and the same.

Acciona has assumed these challenges (United Nations General Assembly Sustainable Development Goals) as its own, and incorporated them into its business model... (with a plan)...to make Acciona a carbon neutral company (Acciona Sustainability Report, 2015b)

One of Acciona's key values remains a "concern for the environment"

ACCIONA sees the fight against climate change, sustainable use of natural resources and protection of biodiversity as the main principles of its environmental strategy." Acciona (2015a: 13) and "to play a leading role in transforming the planet's infrastructure and in sustainable energy, while focusing on having a strong balance sheet, remunerating our shareholders appropriately, and constantly seeking growth opportunities. Acciona Annual (2015a: 10).

The reports show commitments being made to a sustainable agenda, such observations are of interest, as this was similar to VW where their public commitment was high but divergence from agreed standards resulted in legal and financial consequences. A question is raised as to whether it is wise for companies such as Acciona, to make strong sustainable commitments, when political and commercial markets are transient.

*Sustainability: Policy departures and reactions*

Recently there is degree of uncertainty in sustainability policy brought about as a result of political developments such as BREXIT and the US presidential election (Watson, 2017). In light of changes to UK markets, leading firms, including Kingfisher, BAM and ARUP have lobbied the UK Government to use its Clean Growth Plan to tackle emissions from buildings (letter to Greg Clark Secretary of State, WWF, 2017). Furthermore, concern has been raised by the Head of Energy and climate change at WWF:

The low carbon economy represents a huge opportunity for UK businesses so it's no wonder that they're desperately looking for longer term clarity that will enable them to invest in the technologies that we know can help to tackle climate change... (Bairstow, 2017).

However, most of the organisations reviewed have not committed totally to sustainability, they provide an overarching position with regard to sustainability. For many of the organisations there remains a question of how far such rhetoric accounts for real change in company practice. In most of the reports little is discussed in the way of detail that can be measured. This is not the case for some organisations that do set down some firm commitments in a manner that can be used to publically hold them to account, such as the reports produced by Acciona. However, the reporting of sustainability remains contentious (Murguia and Bowling, 2013). And for many, the reports where generic sustainability rhetoric is used without measurable content, may be viewed more as a public relations and marketing exercise. It is noted that even when reporting is mandatory, organisations have been found to disclose their management approach but fail to consistently disclose performance indicators (Aktas, Kayalidere and Kargin, 2013), noting an apparent difference between that advocated and the practice undertaken. The review of the reports here, found all organisations disclosing their strategic approach with regard to sustainability with a few companies committing and providing measurable statements. Where the companies have committed heavily, will the rewards be forthcoming?

A change in direction from the USA was recently signalled as the President signed an executive order placing economic and employment concerns above those of the climate change agenda (Merica, 2017). The USA President argued that both growth in business and tackling issues of climate change can sit alongside each other, which is not so

dissimilar to the position set out by the UK's former Chancellor of the Exchequer in its 'Fixing the foundations' review.

Productivity is the challenge of our time. It is what makes nations stronger, and families richer. Growth comes either from more employment, or higher productivity... we need to focus on world-beating productivity, to drive the next phase of our growth and raise living standards. (Osborne, 2015: 3)

The UK Department for International Trade is prioritizing trade and growth ahead of climate change, in the wake of the BREXIT referendum (Shipman, 2017). For both the USA and UK, the discourse signals a relaxation of some the climate change legislation in favour of trade and economic growth.

As a result of this discussion, a question is raised: If companies have positioned themselves for sustainability, what impact are recent changes likely to have on their markets if company and political strategies are not aligned?

## CONCLUSIONS

Over the years many companies have positioned themselves for sustainability and the emergence of related markets. While the uptake is viewed as conservative, each of the companies reviewed were found to have introduced sustainability into their strategic vocabulary. The review of Acciona's more recent company reports in 2015 show that the company has aligned its operations to embrace sustainability, ready for the emergence of the new energy and sustainability markets.

Reports for 2016 are not yet available, so the evidence of how companies will react to recent political changes and relaxation of legislation has not been formally reported. However, at a UK domestic level, there is some evidence of government lobbying, by construction firms, requesting clarity and change for the industry in the form of the Clean Growth Plan. It is clear that over the years, commerce has acknowledged the need to develop sustainable policies and to invest so that it is ready to engage. The lack of clarity with regard to public policy is of concern for those in the industry that have invested to ensure that they can continue to operate when sustainability legislation is introduced. Without policies that are robust and stable, it is questionable why companies would make commitments beyond the generic position currently provided. Further research is required to evaluate the value or consequences of a strong commitment to sustainability.

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# MATURITY MODEL FOR STRATEGIC COLLABORATION IN SUSTAINABLE BUILDING RENOVATION

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To enable the construction industry to execute sustainable renovation projects which entails a reduction in use of resources, an increase in productivity and a more socially sustainable construction process, new tools are needed. A maturity model can be a simple and effective tool for a company to evaluate the quality of a process and in recent years a number of maturity models have been proposed to evaluate the construction industry. The construction industry has seen a trend in the last couple of decades towards a higher level of integration of the supply chain and strategic collaboration can now be found in several countries. A maturity model has been synthesized from the examples and experiences of the construction industry based on, interviews, workshops and case studies, to further develop the potential within strategic collaboration. The maturity model can potentially be used as a research tool to analyse why some strategic collaborations are successful and others not. With the model companies in the construction industry are able to make an assessment of their own development potential regarding strategic collaboration and be guided in their further development.

Keywords: building renovation, maturity model, strategic collaboration, sustainability

## INTRODUCTION

The built environment is at the heart of our modern society. We spend more than 90 % of our time in buildings and they create the space for work, social interactions and are our homes (WHO 2014).

But the building stock is aging. More than 90% of the current building stock in Europe was constructed before 1990 and most of this will still be standing in 2050 due to the low rate of demolition (Artola *et al.*, 2016). Furthermore, our knowledge and understanding of how buildings influence our productivity, health and wellbeing has increased tremendously since these buildings were built and so there is numerous reasons for bringing the building stock into the 21st century (Acre and Wyckmans 2015). There is also an increased awareness of the impact our buildings and the construction of buildings has on the environment. The buildings in Europe constitute 40 % of the total final energy use and this is another reason why the renovation of our buildings should reduce the energy use (Buildings Performance Institute Europe 2011).

The building industry has access to a wide range of technology, which only a few decades ago was unthinkable. Building Information Modelling has transformed the way buildings

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are designed, Virtual Digital Construction enables the whole building process to be simulated before even the first construction equipment is brought on-site and cheap networked sensors enable a much greater understanding of the current building performance and aids in assessing damage or where the renovation focus should be.

With all the new demands for improved building quality and performance and all the new tools available it is striking, how little the actual process of how we build has changed. By and large the traditional division of labour and the way most buildings are procured is the same as it has been for decades. And this has been suggested as one of the main reasons why the construction industry finds itself in a productivity crisis, with low innovation and frequent conflicts (Clarke and Wall 2000) (Haugseth *et al.*, 2014).

The purpose of this paper is to examine how the construction industry can take advantage of strategic collaboration as a way to change their traditional construction process. This is done by proposing a maturity model, which uses the different approaches found in the construction industry today and enables the companies to access themselves and others.

Strategic collaboration has been found to be a very potent tool to improve the budget certainty, improve building quality and reduce conflicts in construction projects. It enables organizational learning and has been used as an innovation tool (Dewulf and Kadefors 2012). The use of strategic collaboration in the construction industry on a large scale can be found in the UK programme "Achieving Excellence" launched in 1999 by the Office of Government Commerce (OGC). Based on the ideas found in "Constructing the Team" (1994) by Sir Michael Latham and "Rethinking Construction" (1998) by Sir John Egan - also known as the Egan report (Government Construction Client Panel 1999) (Sustainability Construction Action group of the GCCP 2000). A National Audit Office report "Improving Public Services through Better Construction" (2005) found that this approach had led to substantial results in the span of only five years. Public construction projects finished to budget was up from 25% in 1999 to 55% in 2004 and project delivered on time was up from 34% to 63%.

This approach has subsequently been copied by Swedish municipalities with a wide range of benefits from increased quality of buildings to a better work environment reducing employee turnover and enabling talent retention (Kadefors *et al.*, 2013).

It is therefore of great interest to construction industries in countries with little or no experience with strategic collaboration to learn how to make a transition to reap the benefits of strategic collaboration. The maturity model is one way for companies and clients to start this transformation and to highlight the requirements for executing successful strategic collaborations. The Danish construction industry has therefore been the subject for this research.

## **THE ORIGIN AND TYPES OF MATURITY MODELS**

To understand complex processes and to direct an organization in a given direction models are of tremendous value. They highlight key aspects which needs attention and enables management to make sound and logical steps to improve the quality of a given process (Wendler 2012).

Maturity models first saw widespread adoption in the early 90's in the software industry and has since then spread to other fields. The Capability Maturity Model for Software (CMM) was developed by the Software Engineering Institute (SEI) to assess the capability of software contractors.

The CMM was based on the notion that there were five discrete observable states which the software development process could have; Initial, Repeatable, Defined, Managed and Optimizing (Paulk *et al.*, 1993).

Maturity models have been further developed in a multitude of contexts and to assess a wide variety of processes. They fundamentally fall into two categories or perspectives; life cycle perspective or a potential performance perspective (McBride 2010).

Maturity models based on the lifecycle perspective describe a process, which starts at a beginning stage, immature, and over time the process will naturally progress to the end stage, maturity. In this type of model the progression through the maturity model stages will naturally happen due to improvements and learning effects but can be accelerated (Wendler 2012).

Maturity models based on the potential performance perspective in contrast do not have a natural progression through the levels of the model. The model shows the potential benefits of a higher maturity level and it is up to the user to decide if it is desirable to progress to the next level. Most maturity models available today follow this potential performance perspective (McBride 2010).

The maturity model presented in this paper will be utilizing the potential performance perspective, since the construction process is heavily influenced by the nature of the specific project and the relations between the stakeholders in the individual project or project portfolio. It is therefore not a given that construction projects starting out with a low level of maturity will progress to a higher level of maturity and in some cases it will not be advantageous to have a high level of maturity since this entails a higher level of complexity which e.g. for small and easily defined construction projects do not provide substantial value.

In the following sections the literature on the subject of maturity models and construction will be reviewed as well as some of the application areas within construction where maturity models have been used.

## **LITERATURE SEARCH METHOD**

An extensive literature search has been conducted to serve as inspiration and as a theoretical foundation for the maturity model presented in this paper. The literature search has utilized a number of search engines, both scientific and public to get a general understanding of the variety and use of maturity models in construction.

As method a broad search was applied using search terms with Boolean operators. The subsequent results were categorized according to relevance by title and relevance by abstract content. Maturity models used to evaluate IT systems like Building Information Modelling tools were excluded from the search, since this paper concerns a maturity model focused on the construction process.

Following the identification of relevant literature, a full reading of the entire text was condensed into a document containing relevant models and important observations to be used as the basis of the model creation.

Pivotal works were also identified through an analysis of cross references in the literature found in the search.

## **MATURITY MODELS IN CONSTRUCTION**

A maturity model review article published in 2012 (Wendler 2012) analyses a great number of scientific papers to identify the use and application area of maturity models. In

the article 10 papers are identified as having a focus on the application of maturity models to "Construction Processes / Engineering".

In the literature review done for this paper, a number of recently published maturity models relating to the construction process were identified. The Public Commissioning Maturity Model (PCMM) first published in 2014 was made to raise awareness among public construction clients' organisations (Hermans *et al.*, 2014). A model focusing on the maturity of the construction management organization was published in 2016 and named Management Maturity Model (MMM). (Langston and Ghanbaripour 2016) In order for a construction organization to guide innovation actions the Collaborative Innovation Capability Maturity Model (CICMM) was published in 2015 (Knoke 2015).

Some maturity models utilized Key Performance Indicators (KPI) as a measurement tool, while others describe the levels by Key Attributes (KA) to describe different behaviour at the different maturity levels.

As can be seen by the previous three examples a maturity model lends itself to explore and quantify a number of different topics within construction management. As a pivotal work with numerous citations in relevant literature "Maturity model for supply chain relationships in construction" has been identified.(Meng *et al.*, 2011) The maturity model presented in that paper consist of four levels and eight main criteria are used to describe the different levels.

The model was tested in a case study of a building project with a public sector client in the United Kingdom. This showed that in individual projects there is a tendency to start out at a low level, Level 1, and throughout the project phases the relationship can progress to higher levels. It was concluded that to achieve relationship improvements it is very valuable to have an appropriate measuring tool and a maturity model can be useful in this regard.

## **EMPIRICAL INFORMATION GATHERING**

As part of gathering empirical information to lay the foundation to create the Strategic Collaboration in Construction Maturity Model (SCCMM) previous published work was used together with industry surveys conducted previously. The potential for improving the construction process in building renovation was identified by a survey conducted in 2014 with 277 participants from the Danish building industry. This survey identified the construction process as the area with the highest potential for improvement among the survey participants (Uhd and Hornbek 2014). A number of case descriptions from the UK and Sweden were used to determine how the renovation process could be improved and strategic collaboration was found to be a potent driver for improving construction project on multiple parameters.

Two workshops were conducted in autumn 2016 with participants spanning the Danish building industry from architects, consulting engineering, contractors to producers of building components and social housing non-profits as clients. The goal was to examine the challenges in the existing building renovation process and to examine how strategic partnerships could be used as a method to meet some of these challenges. An in-depth description of this process can be found in (Jensen *et al.*, 2017) and the conclusions on the prerequisites of strategic collaboration.

As a result of these workshops it became apparent that the participants were very interested in a way to discriminate between different levels of collaboration. To facilitate discussions and to make informed decisions regarding collaboration, the authors

introduced the workshop participants for the concept of maturity models. Following this introduction to the concept, individual interviews were conducted to identify how, why and to which extent the participants had experience with different collaboration types. This was done using the semi-structured research interview method (Kvale 2009) with critical incident technique (Miles and Huberman 1994). Six one and a half hour interviews were conducted and analysed over the course of six months in the winter and spring of 2016-2017 among the above mentioned parties leading to the development of the development of the Strategic Collaboration in Construction Maturity Model (SCCMM).

The analysis method used to arrive at the model is based on the Template Analysis method using existing construction industry related maturity models as an inspiration for the prior category generation (King 2004)(Saunders *et al.*, 2009). The transcription of the interviews as well as the coding and analysis was done using NVivo 11 software.

## **THE STRATEGIC COLLABORATION IN CONSTRUCTION MATURITY MODEL**

During the workshops, interviews and case studies previously described, it was found that existing maturity models did not sufficiently describe the possible construction process configurations.

"There is a tendency to view renovation projects as not being different from other types of construction. This is not the case since you have to take into account both the existing building, tenants and the building operator." (Translated) - Head of division, contractor [participant in workshop].

An example which was not covered by (Meng *et al.*, 2011) was found in framework contracts which contained multiple renovation projects but where the only selection criteria were price. In such a project organizational learning is possible but limited, there is the advantage of repetition but low or no cost transparency. This was not seen as sufficient covered by previously proposed models and led to the creation of a new maturity model described in his section.

The Strategic Collaboration in Construction Maturity Model (SCCMM), seen in figure 1, consists of five maturity steps defined by two axes; Complexity and Value. The Complexity dimension denotes the different challenges and requirements associated with moving to a higher maturity level. In the Value dimension the possible benefits can be described.

|                            |   |
|----------------------------|---|
| Level 1: Price             | The only evaluation parameter in a given tender is price  |
| Level 2: Value for money   | The evaluation parameter is to a lesser degree price and other parameters are considered such as quality, work safety, sustainability profile and other.          |
| Level 3: Development       | The evaluation parameter involves price, quality and some form of development goal such as a product or a service   |
| Level 4: Strategic partner | The evaluation parameters involves price, quality, development goals and there is focus on improving process links between the companies in the building process. |

Level 5: Strategic collaboration

The evaluation parameters involve price, quality, development goals, improving process and there is a firm commitment from top management to prioritize the collaboration.

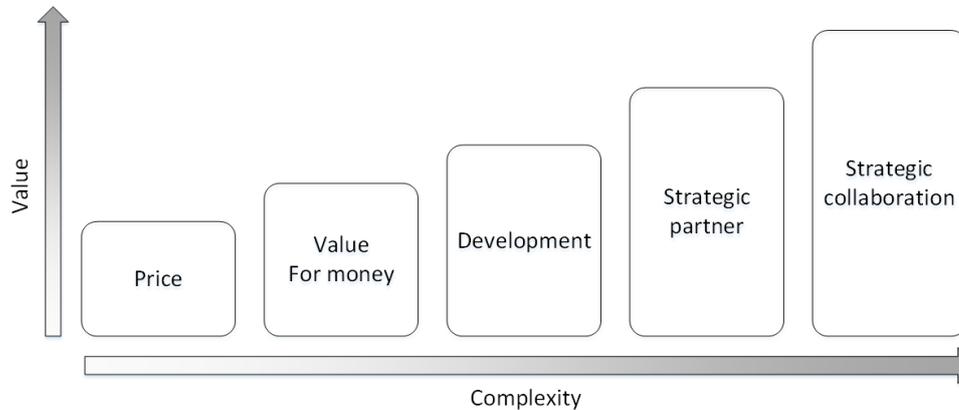


Figure 1: Strategic Collaboration in Construction Maturity Model's graphical representation.

At level 1 price is the only evaluation criteria and while this is a very simple metric and easy to communicate, it is also a very simplistic evaluation method. It is however, the most common way of procuring renovation projects reported by all participants in the workshops and interviews described previously. Progressing from this to level 2, the evaluation criteria become more numerous and price does not take centre stage but a number of criteria are used to evaluate the tenders received. This is a way of procuring, which all participants were familiar with, but it is by no means the norm. Renovation projects with a development dimension as described in level 3 were also something, which all of the construction companies interviewed were familiar with and seen as a way of aligning goals between the companies in the renovation process. The use of strategic partners was not common among the participants although it was found that many did have strategic partnerships with other companies outside the construction industry; usually with regard to secondary services e.g. work clothes procurement. Strategic collaboration as described by the literature from the UK and Sweden was not something the participants had first-hand experience with but something which they saw as having great potential.

It is important to note that since the maturity model is based on the potential performance perspective, it does not present a natural progression, although in many projects this progression happens unintentionally and unguided; some construction projects will benefit from a lower maturity level and others from a higher (Meng *et al.*, 2011).

It was also deemed necessary to formulate two maturity models one for single projects and the other for project portfolios. Although they share the same structure seen in figure 1 they differ in the Key Attributes of the description of the complexity and value dimensions.

### Single Projects Key Attributes

#### Complexity

The evaluation criteria become more qualitative and numerous with each maturity step. For each step of maturity level increase, a higher level of senior management involvement is required and communication is required on multiple management levels. In the

construction project organization each maturity step means extra effort is required to align goals, values and improve inter-organizational communication.

### *Value*

A key aspect of getting a higher maturity level in a project is the possibility to get a greater budget transparency, which means that design choices and changes can be made with a greater understanding of the impact on final renovation cost and quality. With higher maturity levels, it is also possible to draw on experience and expertise from multiple professions, while making assessments of the existing building. It is possible to change incentive structures with higher levels of maturity to achieve shared pain and shared gain as well as risk sharing. Higher maturity levels also offers more control in terms of price and quality of the renovation being performed and as such can be used as a driver to achieve higher performance in terms of sustainability parameters.

### **Project Portfolio Key Attributes**

In a project portfolio consisting of several renovation projects the construction project organization can be used on multiple renovation sites and this affords a number of advantages. The organization can also evolve more independent of the companies involved in terms of maturity level. While project portfolios have overlapping Complexity and Value descriptions with single projects, some further traits can be identified.

### *Complexity*

Cost competitiveness with market prices becomes less transparent with higher levels of maturity and requires dedicated research and attention.

### *Value*

It is possible to improve process performance and increase development and testing of innovative solutions when using higher levels of maturity. Higher maturity levels also enable increased use of dedicated renovation process facilitators, who can improve building quality to meet the requirements of multiple stakeholders.

### **Application of Key Attributes**

To make the model operational a table can be formed using the KA's described in the previous two subsections. In this table the complexity and value KA's can be seen separately and scored from maturity level 1 to 5 when analysing a renovation project. The KA evaluation table can be seen in table 1. Attributes marked with \* in table 1 are relevant for project portfolios.

Following this analysis it is possible to ascertain if a current renovation process has the desired maturity level. It is also possible to identify KA's which need attention to improve the current maturity level.

Table 1: Key attribute evaluation table for SCCMM

| Maturity level                       | Level 1   | Level 2 | Level 3  | Level 4 | Level 5   |
|--------------------------------------|---|---------|----------|---------|-----------|
| Maturity requirement for level       | Very low  | Low     | Moderate | High    | Very high |
| Complexity                           | Complexity of tender bid evaluation                                     |         |          |         |           |
|                                      | Number of qualitative tender bid evaluation criteria                    |         |          |         |           |
|                                      | Senior management involvement   |         |          |         |           |
|                                      | Number of management communication levels                               |         |          |         |           |
|                                      | Goal alignment  |         |          |         |           |
|                                      | Company value alignment   |         |          |         |           |
|                                      | Quality of inter-organizational communication                           |         |          |         |           |
|                                      | Attention required to ascertain market prices of renovation*            |         |          |         |           |
| Value                                | Budget transparency   |         |          |         |           |
|                                      | Transparent link between design changes and renovation cost             |         |          |         |           |
|                                      | Transparent link between renovation cost and quality                    |         |          |         |           |
|                                      | Pre-renovation building assessment with input from multiple professions |         |          |         |           |
|                                      | Incentive structure with shared pain/gain                               |         |          |         |           |
|                                      | Risk sharing and holistic risk management                               |         |          |         |           |
|                                      | Control of price related to quality                                     |         |          |         |           |
|                                      | Control of sustainability parameters                                    |         |          |         |           |
|                                      | Development and testing of innovative solutions*                        |         |          |         |           |
|                                      | Dedicated renovation process facilitators*                              |         |          |         |           |
| *Specific KA's of project portfolios |   |         |          |         |           |

## DISCUSSION AND FURTHER RESEARCH

A maturity model can be used to describe the very complex interactions, which take place in a renovation process in a way that enable clients and the renovation design and construction teams to evaluate their processes and relationships. While models emphasize certain aspects of the renovation process, using the model requires that the project at hand is suited to be evaluated by the said model.

The maturity model presented in this paper takes in to account not only the benefits of increasing maturity level but also the challenges associated with this transition. This is done to highlight the fact that it is not trivial to increase maturity level and not all renovation projects are suited for very high levels of maturity.

It is important that both the client and the design and construction team have the necessary competences to execute projects with high maturity levels. If there is not a sufficient understanding of the importance of goal alignment, management engagement or other vital aspects, the project will not be able to realize the expected benefits.

As a topic of further research, validating the model on renovation projects with different client types and with different types of renovation project organizations is essential. This

can be done by using the model to analyse construction clients and construction project organizations to help determine the level of maturity and then compare this to the described maturity in the individual project. It would then also be possible to get feedback from practitioners on, whether or not the KA's are sufficient or should be modified.

Generalizing the maturity model to study supply chain behaviour in other fields with relation to construction could also yield interesting insights.

### CONCLUSIONS

The maturity model presented in this paper, Strategic Collaboration in Construction Maturity Model (SCCMM), consists of five steps; Price, Value for money, Development, Strategic partner, Strategic collaboration. To describe these five steps, two dimensions are used, Complexity and Value, to pinpoint the challenges and potential performance benefits, respectively. The model was developed based on case studies, workshops and interviews with building industry experts from across the building industry.

The SCCMM can potentially be used as a research tool to analyse, why some strategic collaborations are successful and others not. It can also be used by the client or the renovation design and construction organizations to evaluate their process in terms of, which level of maturity is suitable for the individual renovation project or portfolio. This will enable the renovation process to be tailored to suite the project requirements and enable higher budget certainty, increase renovation efficiency and facilitate sustainable building renovations.

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# CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT ON THE BUILDING SITE: A LITERATURE REVIEW

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The construction industry is under increasing pressure to reduce costs and improve environment quality. The construction and demolition waste management (CDWM) is a serious contender to achieve these two goals. Countries have provided legislation and professional associations and large companies have issued rules and guidelines to efficiently dismantle and organize the evacuation of these materials, especially addressing hazardous waste. A large focus in the literature on CDWM has been on minimization of waste, but less attention has been given to practices of how to minimize waste or how to manage CDW during the construction process. In order to gain an understanding of CDW during the construction process and on the building site we have performed a systematic literature review. Our goal is to identify and document the actual topics and debates related to CDWM, avoid to repeat already existing results and uncover less researched issues or topics. To do so we built on a systematic literature review on CDWM. Our initial search had 628 articles on CDW and CDW management. Through multiple selection procedures we ended up with 100 articles published in 21 scientific journals listed on Web of Science since 2010. We focus on articles referring directly to the building site as well as the management of CDW. We systematically organize the review according to the following criteria: topic, discipline, contribution, method, theory, and audience. The preliminary results show a large production of materials analyses, LCA assessment and performance, optimization of process models and economic comparison. The actual practices on the building site and the related management issues however are largely ignored by this academic production justifying that it may be worth studying these in the future.

Keywords: construction sites, demolition waste management, literature review

## INTRODUCTION

The European Union has decided that the EU member states need to increase the reuse and recycling of non-hazardous construction and demolition waste to at least 70 percent by 2020 (2008/98 / EC). In 2015, the EU came with a new proposal concerning the circular economy including a new plan for waste management. These regulations have urged EU countries to include new measures for waste prevention and recycling (de Guzmán Báez *et al.*, 2012). Even though most EU-countries have started setting up regulations and guidelines for CDW, waste reduction activities are often not considered as cost-effective, efficient and compatible with core construction activities (Bølviken *et al.*, 2016). In Sweden, construction waste is estimated at 8 million tons a year and half of

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it is still outside of the recycling loop. This situation is placing pressure on the construction sector which needs to drastically improve its waste management processes towards re-use and recycling. To align with the new legislation and EU policy, professional associations and large companies have delivered instructions and guidelines to efficiently dismantle and organize the reuse, recycling or deposit of these materials. The Swedish Construction Federation (2015) has issued a very detailed step by step description of the processes to improve resource management and addressing specifically the handling different types of waste. The goal of the association is to adopt a standard for the industry. Even though the introduction of the landfill tax and regulations on hazardous waste have been positive for CDW, the Swedish policies concerning CDWM tend to build on “soft” incentives rather than penalising measures which outcomes may be difficult to assess (OECD report 2015). Whereas CDWM is subject to many guidelines and recommendations in the country, the site inspections are under the responsibility of municipal environmental administrations. The scope of these inspections varies between municipalities who not always possess the necessary time and information to efficiently organise these inspections. Especially, the work undertaken by SME contractors tends to avoid inspections (Deloitte, 2016). Other EU countries such Germany, Belgium or Spain have clearer economic incentives, stronger enforcement and higher sanctions in case of non-conformity regarding the management of hazardous waste, and on site sorting<sup>2</sup>.

However, accounts from the building sites reveal that these instructions and models to optimise waste management may be overlooked during the actual construction phase. The organization of the work on site with a long chain of multiple sub-contractors, the lack of training of the employees or long delays before the delivery of building permits, may interfere and disturb the detailed planning. Moreover, especially in the case of demolition and renovation the material to collect and recycle is often the result of an amalgam of different components altered during the years and preventing an easy and quick identification of the singular elements (Sezer, 2015). The previous description constitutes the background of the present literature review. The goal of the review is to identify and document the actual topics and debates related to the management of CDW, avoid to repeat already existing results and uncover less researched issues or topics. To do so we built on a systematic literature review on CDWM to answer to question of how is CDW managed during the construction process and at the construction site. The preliminary results of the review show a large production of materials analyses, LCA assessment and performance, optimization of process models and economic comparisons. The actual practices on the building site and the related management issues however are largely ignored by this academic production justifying that it may be worth to uncover current practices on the construction site concerning CDWM.

The structure of the paper is as follows. First, we discuss how we have selected our data for the systematic literature review and how we have reviewed the articles in a method section. Second, we present the descriptive findings of the review. Third, we discuss particular themes that are neglected in the CDW literature and we finalize the paper with a conclusion

## **METHOD**

We performed a systematic literature review through identifying, critically evaluating and integrating findings of relevant, high-quality individual studies addressing our research

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<sup>2</sup> [http://ec.europa.eu/environment/waste/studies/mixed\\_waste.htm](http://ec.europa.eu/environment/waste/studies/mixed_waste.htm)

question. Systematic reviews are characterised by being objective, systematic, transparent and replicable and our review followed the following steps: scoping, planning, searching, screening, eligibility (Moher *et al.*, 2009). A review can support identifying relations, contradictions, gaps, and inconsistencies in the literature, and explore reasons for these, can comment on, evaluate or develop theory and can describe future research directions.

We applied a search on Scopus and Web of Science databases for the following terms: waste management AND construction; Construction AND Demolition waste management for the years 2010-2017 (till February). From the search pattern, we initially received 628 papers in total, in different areas from business, management and accounting, computer science, engineering, environmental science and social sciences. From the initial list, we only selected *journal/review articles* and language *English*. We performed the first screening of the search based on title to see how they would be related to our research question. We checked for titles that fit our search categories and we took out all articles that focused on materials, chemistry, biology, disaster waste (e.g., earthquake debris), city waste systems, recycling factories etc. After the first screening, we had a total of 224 papers left. The second screening included reading through the abstracts in order to see if the papers would fit our search criteria of waste management and management of CDW, which diminished the list to 149 articles. We made a list of the articles and decided to only focus on articles that are published in web of science (WOS) cited journals and emerging WOS journals which leaves us with 100 articles. See list of journals below in table 1.

*Table 1: List of journals included in the review.*

| WOS and Emerging WOS Journals included in review                   | No. of papers selected |
|--|------------------------|
| Architectural Engineering and Design Management                    | 2                      |
| Automation in construction   | 2                      |
| Building Research and Information                                  | 4                      |
| Civil Engineering and Environmental Systems                        | 1                      |
| Clean Technologies and Environmental Policy                        | 1                      |
| Construction management and economics                              | 3                      |
| Ecological indicators  | 1                      |
| Environmental Engineering and Management Journal                   | 1                      |
| Environmental Impact Assessment Review                             | 1                      |
| Environmental technology   | 1                      |
| Facilities   | 1                      |
| International journal of life cycle assessment                     | 2                      |
| International journal of project management                        | 1                      |
| Journal of Cleaner Production                                      | 9                      |
| Journal of construction engineering and management                 | 2                      |
| Journal of green building  | 1                      |
| Project management journal   | 1                      |
| Resources, Conservation and Recycling                              | 31                     |
| Revista Tecnica de la Facultad de Ingenieria Universidad del Zulia | 1                      |
| Waste management   | 19                     |
| Waste management and research                                      | 15                     |
| Total amount of papers   | 100                    |

## **Descriptive Analysis**

The methodological approach of most articles is a natural science approach in which different types of methods are applied. Most articles develop a mathematical model often

applied for waste generation (10 articles) or software model like BIM (4 articles) that they validate in the literature and in case studies (cf. Li and Zhang 2013). Some of these models are optimization simulation models (6 articles). The larger part of the articles adopts a more quantitative approach (23 articles) in which one set of articles applies mathematical equations, estimations of waste generation models and validations, LCA assessments and quantitative evaluations (7 articles). Other articles focus more on a quantitative survey and hypothesis testing (11) and 5 articles perform big data analysis from either governmental agencies or construction site data. Only a small number of articles applies a mixed methodology of both surveys and interviews (7 articles, cf. Al-Hajj and Hamani 2011; Lu and Yan 2012; Udawatta *et al.*, 2015) or only a qualitative approach with interviews and focus groups (3 articles, cf. Ajayi *et al.*, 2015; Alwan *et al.*, 2017; Polesie 2012).

Many articles contextualise their findings in a particular geographical region. 45 articles have a regional focus in which Europe (18 articles) and Asia (17 articles) are strongest represented. Asia is primarily represented by China (12, cf. Ding *et al.*, 2016; Wang *et al.*, 2014; Yuan 2013) and Hong Kong (4, cf. Chen and Lu 2017) 38%, Europe stands for 40% of the articles of which primarily Spain (7, cf. de Guzmán Báez *et al.*, 2012; Gangolells *et al.*, 2014) and Portugal (3, cf. Coelho and De Brito 2011) and UK (4, cf. Alwan *et al.*, 2017; Ajayi *et al.*, 2015) are discussed

Table 2: Number of articles per method.

| Methods applied                                       | No. of articles | %           |
|---|-----------------|-------------|
| Interviews, focus groups                              | 3               | 5%          |
| Mixed method (survey, interviews)                     | 9               | 14%         |
| Survey (hypothesis testing)                           | 11              | 17%         |
| Reviews   | 5               | 8%          |
| Conceptual papers                                     | 2               | 3%          |
| Secondary data  | 2               | 3%          |
| Big/site data analysis                                | 5               | 8%          |
| Developing models and testing                         | 10              | 16%         |
| Development of software model (BIM, DSS)              | 4               | 6%          |
| Estimations, mathematical equations, assessments, LCA | 7               | 11%         |
| Simulations   | 6               | 10%         |
| <b>Total</b>  | <b>64</b>       | <b>100%</b> |

Table 3: Number of articles that specifically focus on a geographical area.

| Country                            | No. of articles | %    |
|------------------------------------|-----------------|------|
| Australia                          | 2               | 5%   |
| Europe                             | 18              | 40%  |
| Asia                               | 19              | 42%  |
| North America                      | 1               | 2%   |
| Africa                             | 2               | 4%   |
| International (multiple countries) | 3               | 7%   |
| Total                              | 45              | 100% |

For those articles that studied the construction process, we also looked into the particular construction project phase and found that design (8 articles) and construction (16 articles) are the main areas. For articles concerning construction, production or the site, the focus is on estimation of waste and minimisation of waste (7 articles), supply network and other stakeholders (2 articles), performance and success factors (2 articles) and one article on behaviour on site (Bakshan *et al.*, 2017).

Few articles discuss demolition (5 articles) and renovation/refurbishment is hardly studied (2 articles). The mixed articles discussed CDW more in general terms and mentioned multiple construction phases.

Table 4: Number of articles representing different construction project phases.

| Construction Phase           | No. of articles | %    |
|------------------------------|-----------------|------|
| Design                       | 8               | 22%  |
| Construction/production/site | 16              | 44%  |
| Demolition                   | 5               | 14%  |
| Renovation                   | 2               | 6%   |
| Mix (multiple phases)        | 5               | 14%  |
| Total                        | 36              | 100% |

While several authors mention that the management of CDW is neglected in literature (China, 2016), we found some articles that discussed aspects like benefits (4 articles), hindrances to CDW implementation (5 articles), legal and policy issues (8 articles), economic factors and the use of IT in relation to CDW (9 articles). Articles discussing IT often focused on decision support systems (Yuan *et al.*, 2012), BIM (cf. Alwan, *et al.*, 2017; Akinade *et al.* 2015; Porwal and Hewage 2012) or GIS (Su *et al.*, 2012). In the last couple of years, the European Union (EU) has focused on the reduction of CDW with 70% for 2020. This has led to the drawing up of many regulations on CDW during the past years, forcing EU countries to include new measures for waste prevention and recycling (de Guzmán Báez *et al.*, 2012). The EU regulations are reflected in a number of European papers.

Table 5: Number of articles representing other managerial issues for CDW management.

| Other managerial issues                | No. of articles | %    |
|--|-----------------|------|
| Success factors/indicators             | 4               | 13%  |
| Hindrances implementing CDW            | 5               | 17%  |
| Legal issues, policy, EU               | 8               | 27%  |
| Economic factors                       | 4               | 13%  |
| IT, BIM, decision support systems, GIS | 9               | 30%  |
| Total                                  | 30              | 100% |

### Thematic analysis

Even though several authors have listed indicators that influence construction and demolition waste management (Yuan 2013). There are only few studies that focus on the managerial aspects of CDW in the construction process and how these could be improved (Chinda 2016). In the thematic analysis the key managerial topics within CDW from the review are discussed to give an insight in CDW management research and argue for new future research areas.

#### *Design for deconstruction*

While most articles in the review focus on the construction or production phase, there are a number of articles that discuss the relevance of designing for waste minimization. One particular area in this field has been on the role of the architect who selects the design and material (Akinade *et al.*, 2015; Li *et al.*, 2015; Porwal and Hewage 2012; Wang *et al.*, 2015; 2014). The consideration of CDW reduction during design as a key strategy to minimizing construction waste and an early stage is discussed by several (Wang, *et al.*, 2015; 2014; Yuan 2013). Others study the influence of the attitude of designers on waste minimization (Li *et al.*, 2015) or the use of technology (BIM) to design for deconstruction (Akinade *et al.*, 2015). Future research could strengthen the focus of design for deconstruction with the support of new technology to minimize waste generation and improve recycling or re-use of materials.

#### *Strong focus on construction phase for CDW management*

From the descriptive analysis CDW articles are found in all construction project phases but the primary focus for management of CDW has been the construction or production phase (see table 3). The role of the contractor in construction project success is often discussed as relevant (Alzahrani and Emsley 2013), one of the important aspects is how contractors deal with waste management and waste disposal. In project management literature, the contractor's role is perceived as important to project success. Even though most EU-countries have started setting up regulations and guidelines for CDW, waste reduction activities are often not considered as cost-effective, efficient and compatible with core construction activities. Moreover, waste management is not often valued in the industry, because of the inability to predict the production environment; unique characteristics of each project; time pressure and cost limitation (Kareem *et al.*, 2015). The majority of the papers in this area focus on new-build and especially buildings (houses and offices), while only a few studies represent infrastructure or civil engineering projects in relation to CDW management (exception of e.g., de Guzmán Báez *et al.*, 2012).

Furthermore, the review shows a clear gap in studies concerning renovation/refurbishment (exception Li and Yang 2015) which is stated to have a different process for CDW than for new-build, primarily because renovation waste contains mixed material and becomes more difficult to sort and recycle or re-use. This particular area would need to be strengthened especially since renovation is a large and relevant area for CDW in which there has been a lack of focus.

#### *Management practice and behaviour for CDW on site*

A majority of the articles (16) have a focus on minimizing waste during construction. With a focus of CDW on the construction site, studies focus on investing in CDW management and education, as well as having site space for CDW and sorting waste on site (Wang, *et al.*, 2010). Research has also looked into changing the waste management culture within an organization. For example, Udawatta *et al.*, (2015) studied approaches to changing the attitudes and industry behaviour towards waste minimization; engage all stakeholders in construction waste management, have adequate supervision of waste management activities, good company policies, training and education for all stakeholders as well as financial rewards and incentives (Udawatta *et al.*, 2015). Other authors discuss behavioural aspects as relevant for improving practices in CDW management (Bakshan *et al.*, 2017; Teo and Loosemore, 2001) as well as improving stakeholder's awareness about environmental and economic considerations of CDW is vital for changing a culture and encourage adoption of sustainable practices (Bakshan *et al.*, 2017; Osmani *et al.*, 2008; Yuan 2013). These studies raise considerable attention to the role of human factors in minimizing and managing construction waste (Yuan and Shen 2011). While human factors and behavioural factors are discussed as relevant, few articles study behaviour and practices in-depth or for a longer period of time, which makes it difficult to gain a good insight in current practice or developments towards new practices on site. Future research could focus on the current practices and behaviour on site from contractors as well as multiple subcontractors in relation to CDW.

#### **Focus On Technology Use for CDW**

A number of articles discuss the use of technology to support CDW management, minimize waste generation as well as giving possibilities to design for deconstruction. Especially, Building Information Modeling is discussed as a possible technology that can be used to design for deconstruction (Akinade *et al.*, 2015) or support strategic sustainable development using BIM (Alwan *et al.*, 2017). While the review primarily focused on management of CDW, new technologies were mentioned to support this, however, a more detailed analysis of research on the use of BIM for CDW would be needed to see the benefits of BIM in empirical settings.

#### *Urbanization and CDW*

Literature on CDW is strong in Asia and Europe, but there are different perspectives and contexts in these areas. Whereas the focus of Asian studies is related to pollution, but also to urbanization and how to deal with CDW in small spaces, highly urbanized areas and off-site CDW (cf. Li and Yuan, 2012), this has less been discussed in European studies. Especially, with an increasing urbanization in many countries, and a major focus on renovation of existing buildings in urban areas, it becomes relevant to study how the AEC industry can alter and align their CDW practices towards a more sustainable process in urban areas (Buser and Bosch- Sijtsema, 2017).

## CONCLUSIONS

This paper intended to gather the different studies and perspectives mobilised to discuss the management of CDW of the construction process and in particular the building site. Focusing on the topics and methods, we have carried out a systematic review of international publications in this area relevant for the Swedish context. The review found that, though there are a large amount of publications on the subject of waste on the building site, only a few are addressing management issues. Besides these studies often present a list of factors or hindrances influencing CDWM based on survey or other literature review. Only three are drawing on qualitative material to document the current situation although none of them is building of a specific theory to do so.

Equally, the topic of renovation and reuse of material is fairly overlooked by the literature. The main management topics relevant from the review for future studies are: design for deconstruction, a focus on infrastructure as well as renovation of the construction phase, a qualitative long-term focus on practice and behaviour on site, influence of BIM and new technology in CDWM, and urbanization in relation to CDW. Whereas the introduction of stricter legislation in Europe has not yet created noticeable academic interest for studying the practices of the industries, some of the contractors in Sweden have added recycling competences to their portfolio and innovation practices concerning CDWM would become relevant to study. So, it is maybe time to look beyond the quantitative models for estimating waste and observe and analyse what the actual practices on site are, and how to possibly improve their performance.

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# THE IMPACT OF THERMAL IMAGING ON USERS' PERCEPTION OF ENERGY CONSUMPTION: THE ROUND HILL PROJECT

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In the UK, a significant proportion of energy consumption is associated with buildings, with the single highest sector being housing. Due to this high proportion of energy consumption, it is important to focus on household energy use in order to meet the national energy reduction targets. Whilst measures such as the Energy Performance Certificates (EPC) have been introduced to help homeowners identify how they can improve energy performance of their properties, there have been criticisms as to their effectiveness. To understand how further improvements could be made on energy consumption, a preliminary study was carried out on 10 households using thermal imaging to highlight energy loss to homeowners and subsequently ascertain the impact it had on their perceptions as opposed to the EPCs alone. The findings of this study were promising indicating that in many cases, the use of thermal imaging alongside EPCs had a much greater impact on user perceptions. This paper presents findings from a larger sample size conducted in the Round Hill residential area of Brighton. The area has approximately 1000 homes and the sample selected is representative of the overall household types of the community. Thermal imaging was conducted and presented to occupiers in addition to interviews to identify user perception of thermal efficiency in their properties. Unlike the preliminary study, financial constraints were found to have little influence on how householders perceived energy use and thermal efficiency. Householders believed in improving their properties but living in a conservation area meant they had many restrictions on how much they could change. As part of community engagement, recommendations from the findings of this study will be disseminated to the Round Hill community and other similar areas in city of Brighton and Hove with similar construction methods in order for residents to make useful improvements to thermal efficiency of their dwellings.

Keywords: thermal imaging, energy loss, Energy Performance Certificates, householder perceptions

## INTRODUCTION

Reduction of energy consumption and energy loss are often used in similar contexts in the UK (Armitage *et al.*, 2015). Improving the thermal performance of existing buildings have proved difficult and these are based on numerous factors including energy efficiency uptake trends, financial restrictions and overall public awareness (Dowson *et al.*, 2012). Key issues identified with many of the existing housing stock across the nation are poorly performing solid walls, single glazed windows, uninsulated roofs and floors as they

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dissipate most of the heat energy in the households (Ibid.). Remediation of the above issues require a holistic approach. Thus factors such as financial constraints cannot be resolved without incorporating a good understanding of the needs of the building fabric such as traditional listed buildings (see Menconi *et al.*, 2016). This research follows an initial study that was conducted to ascertain whether Energy Performance Certificates (EPC) alone were capable of helping householders to reduce energy consumption of households (see Aboagye-Nimo *et al.*, 2016). The initial paper concluded that more techniques were needed to be incorporated (e.g. visual aids such as thermal images) in order to help householders understand and manage energy consumption more efficiently. In this paper, the standard EPCs are used alongside thermal images to help householders in a 'conservation area' gain a better understanding of their property's energy loss and which areas to tackle as a means of attaining thermal efficiency.

A literature review on household energy consumption in the UK is presented first. This is followed by a description of the setting of the case study namely the *Round Hill Conservation Area* in Brighton, UK. Following this, the research methods and the findings of the empirical work are presented. The paper is concluded by highlighting the practical implications of the study and recommendations for future research.

## **HOUSEHOLD ENERGY CONSUMPTION**

The thermal efficiency and energy performance of UK housing are governed by the Energy Performance of Building (Certificates and Inspections) Regulations 2007 (Parkinson *et al.*, 2013). This follows the European Union Directive 2002/91/EC; Directive on the energy performance of buildings (Official Journal of the European Communities, 2003). EPCs are used as the main means of measurement of energy performance of households in the UK (Davis *et al.*, 2014). Thus it has a direct impact on householders' perceptions of thermal efficiency and energy performance (Ibid.).

### **Energy Performance Certificates**

Energy Performance Certificates (EPC) are certificates issued by certified assessors who examine households based on insulation, heating systems and window types to evaluate a particular property's energy efficiency (Parkinson *et al.*, 2013). EPCs show property details such as address, type (e.g. detached house), date of inspection, certificate date and floor area (Department of Energy and Climate Change (DECC), 2013). The DECC set energy consumption targets in a scheme known as 'The Carbon Plan' whereby emissions would be cut by at least 34% by 2020 and 80% 2050. Figure 1 shows a typical Energy Efficiency Rating and Environmental Rating section of the EPCs where property owners and occupiers can see scales from A to G. EPCs offer rating scales from 'A' to 'G'.

Figure 1 shows that the property being used as an example has a current energy efficiency rating of low D (57). The property has the potential to attain a rating of high D (68). Also, the property's carbon emissions have a grade E (50) rating but could be improved to grade D (61). The EPC gives householders a suggestion of how much they could save financially. These ratings are supposed to help occupiers make their properties perform more efficiently. However, there are grave concerns that these depictions are not motivating people as much as they were intended to (see DECC, 2013; Amecke, 2012). Such concerns led to the initial concept of this study.

### **Thermal Imaging as a Solution?**

In innovative building surveying and defect diagnosis practices, thermal imaging is very helpful in indicating heat loss areas of buildings (Gade and Moeslund, 2014). Thermal

imaging is the technique of using the heat given off by a building or object to produce an image of it or to locate it (Titman, 2001).

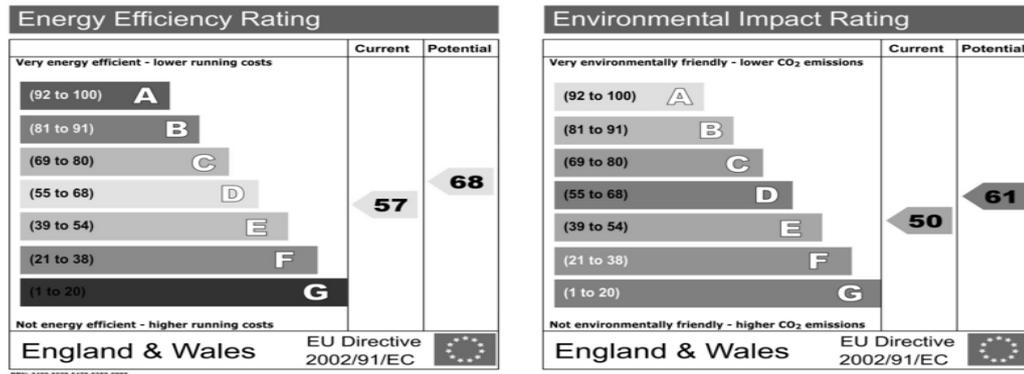


Figure 1: typical EPC (Source: Oakwood Energy Group, 2016)

It is a non-invasive method of testing structures (Ibid.). They give more accurate information on heat loss areas and defects such as cold bridging etc. (Gorse *et al*, 2016). Temperature scales are produced alongside thermal images to show users spot temperatures and temperatures of surrounding surfaces (Ibid.). As the EPCs do not show how buildings can make improvements, pairing them with thermal images have been recommended to help better inform occupiers (see Aboagye-Nimo *et al.*, 2016).

The location and nature of the Round Hill Conservation Area is presented next.

### Round Hill Conservation Area

The Round Hill area falls under the purview of Brighton and Hove City Council. The council offers a detailed history of the area on their dedicated webpage (see Brighton and Hove City Council, 2015 for further detail). The Round Hill area was developed in the 1860s. Local materials were used in the 19th century when the development of the area began. Materials such as bricks were not readily available in the region and hence would have been expensive if they had been adopted. The main indigenous materials at the period were flint and bungaroosh but harder cements, replica stone, and made render (for aesthetic value) became more popular with time. Most of the buildings in the area were originally rendered and had timber sash windows. Welsh slate roofs were previously used for most of the buildings but most of these have subsequently been replaced with concrete tiles. Although most of the development was carried out in the late 19th century, there were a few additions in the 1920s.

An area of 12.05 Hectares (i.e. the Round Hill area) was designated as a conservation area on 6th January 1977. The left hand section of Figure 2 shows a general map of a section of the city of Brighton and Hove. The right hand section of the image (which can also be traced to the larger map) shows an outline of the Round Hill Conservation Area.

The scope of this research project is specifically targeted at the Round Hill area described above. The data collection methods are presented in the following section.

## RESEARCH METHODOLOGY

This research utilises case study research methodology with a single case and multiple units of analysis. A case study is a phenomenon is intensively investigated in its natural or conventional setting, where a variety of data sources are used (Benbasat *et al.*, 1987). It is popular in social sciences and has a long history in many other disciplines (Creswell, 2007) building upon a constructivist paradigm (Stake, 1995).

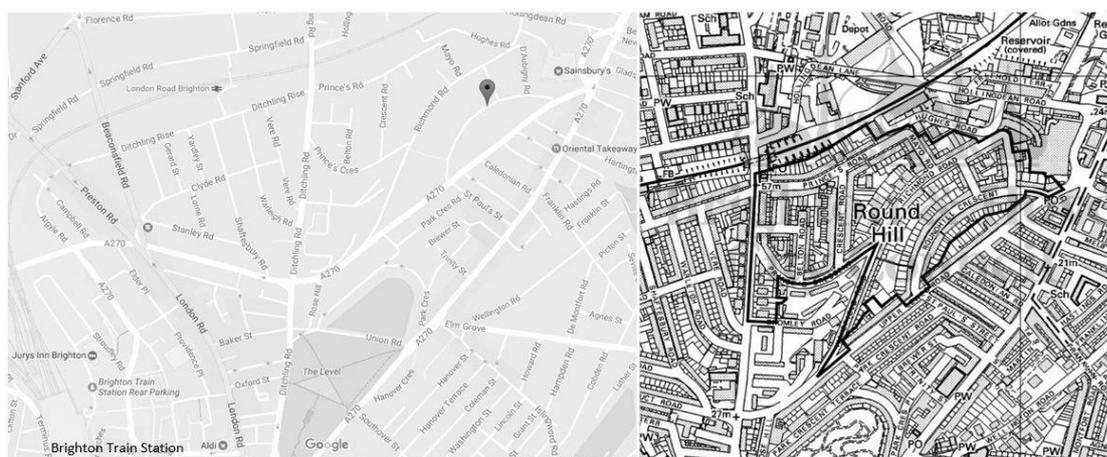


Figure 2: Round Hill Area (Google, 2017 and Brighton and Hove City Council, 2017)

The robustness of case study as a methodology is argued for by highlighting that "a fatal flaw in doing case studies is to conceive of statistical generalization as the method of generalising the results of the case study" Yin (2009:38) because cases are not sampling units and should be treated as experiments (Tsang 2013). Furthermore to elaborate on the single-case (and multiple-units) studies, Yin (2014) suggests that thinking in such confusing terms as "small sample size of cases" - as if a case were equivalent to a respondent in a survey - should be avoided, to aim towards analytic generalisation. A mainly qualitative approach was adopted for this study hence the views and opinions of the respondents were sought over numerical and statistical outcomes (Fellows and Liu, 2015).

In collaboration with the Round Hill Society (see The Round Hill Society, 2017), this research project has an overall aim of establishing a continuous long-term working relationship with local communities in Brighton and Hove under the University of Brighton's Community University Partnership Programme (CUPP). Thus a longitudinal study into occupants' behaviours and social trends has commenced.

Data collection for this research was carried out in three different chronological phases. The initial phase was a structured interview of householders followed by collection of thermal image data in the second phase during heating season in 2016. The final phase comprised semi-structured interviews with householders using information collected from the initial phases.

In order to carry out a study with findings that are valid and reliable, it was important that robust and ethical measures were taken into consideration during the data collection stages (Fellows and Liu, 2015). Since the data being collected was specific to a relatively small locality, ethical measures were critical to the overall integrity of the study. Participants were informed of the confidentiality and anonymity that would be used while handling their information especially personal opinions and household choices.

### Phase One: Structured Interviews

Building upon the advantages of structured interviews, where an interviewer can administer questionnaires based on standardised and predetermined questions (Fellows and Liu, 2015). and where the standardised schedule of this approach helps with the specific themes or topics being explored (Saunders *et al.*, 2009), in this phase, the questions sought to gain insight into the states of households such as recent improvements or alterations in relation to thermal energy loss and sustainable measures that had been adopted. The time householders had owned/occupied their properties was also asked in

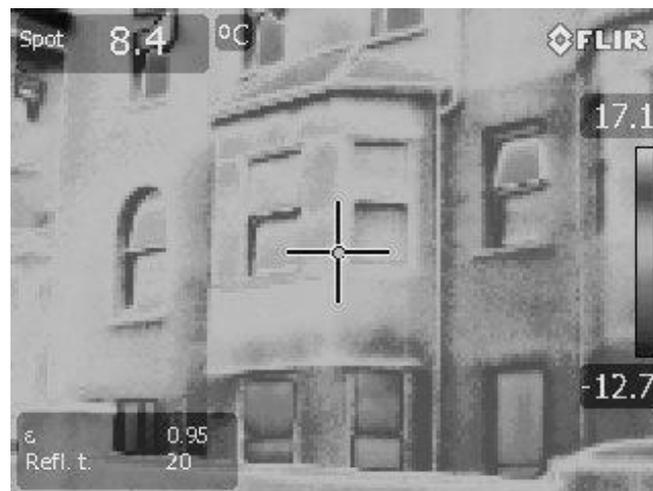
order to gain an overview of the common practices available at the time of moving in. Furthermore, participants were asked to give their views on their EPCs and whether they believed they could further make changes based on the certificates.

Having gained an overview of the physical states and layouts of the various properties, a selection of participants/properties were selected for thermal imaging. A purposive sampling method was used in order to gain a generalizable outcome of the Round Hill area. The selection criteria included number of bedrooms, number of floors, types of windows, and occupants' views on EPCs. That is, so that the research team was ensured that every type of house in the area was represented in the study. More importantly, because the Round Hill area was developed in phases, it was imperative that every street was also represented in the research.

### **Phase Two: Thermal Images**

Thermal images of chosen households were captured on a winter night to ensure that the heat loss of households would be captured more accurately. In order to ensure that the various properties would fall under similar/controlled conditions, the chosen properties were asked to turn on their heating systems prior to and during the period of data collection.

The original photos and thermal images were taken from consistent locations/angles in order to give the research participants (householders) a contextualized view of their properties' heat loss patterns. Figure 3 shows a thermal image of a bay window of one of the households used in the study.



*Figure 3: Thermal image of a bay window in the Round Hill Conservation Area*

In the image, it can be observed that the basement is radiating more heat in comparison to ground floor. A total of 40 properties were included in the thermal imaging phase.

### **Phase Three: Semi-Structured Interviews**

Semi-structured interviews were subsequently conducted with the householders included in the thermal imaging phase. The participants of the semi-structured interviews were solely or partly responsible for making decisions in the household with regards to energy consumption. Open-ended questions were used to encourage participants to share their views and opinions on the various topics presented. The questions and topics ranged from general issues (e.g. climate change/global warming) to very specific issues (e.g. how they had attempted to reduce energy consumption and improve thermal efficiency in their various properties). The interviews were recorded (with participants' permission) and

transcribed verbatim. Views presented in the findings and analysis section of this paper are attributed to pseudonyms and not the real names of the respondents for ethical reasons.

## **FINDINGS AND ANALYSIS**

In this section, findings and analysis presented include the current state of the housing stock. Furthermore, the thermal efficiency of these properties according to householders will be discussed. The general awareness of participants with regards to the technical aspects of the properties and the participants' views on adopting innovative measures will be explored.

### **Round Hill Housing Stock and Participants' Awareness**

To a large extent, many householders were aware of technical components of their properties. It was revealed that during the processes of improving thermal efficiency and carrying out routine maintenance works, occupants had conducted personal research on the technical components of their buildings and subsequently contacted tradesmen to work on their properties.

Many of the participants of the study had altered their properties by some means. The main areas that had been altered included sash windows, loft space insulation, chimney breasts and draught proofing.

Efforts had evidently been made to improve the thermal efficiency of the properties. Many of the properties were also considered as work in progress. Anthony stated that he and his partner were looking forward to making further improvements:

I am planning on renovating the area by the basement front door as a lot of heat is lost. A new door was fitted in 2009 but draught still comes from that area as the door had to be eased because it did not open during prolonged periods of wet weather. - Anthony

Similar to Anthony, other householders implied they wanted to make improvements to their properties in order to save energy and cost. Most participants had some form of idea about how they wanted to improve their properties' energy efficiency.

Brian, who works as a professional in construction, indicated that many of his neighbours had made '*supposed improvements*' to their properties but were ill-advised and hence had inherited residual issues or defects including condensation and damp. Although he explained that he was happy to share his wealth of knowledge with other householders, he admitted that he had not had the opportunity and time to do so.

### **Thermal Efficiency and EPCs**

EPCs were shown to not have influenced participants' views. Particularly, many participants could not find their EPCs or had not received new ones after making improvements. When asked about the thermal efficiency of their properties, the participants all agreed that thermal efficiency was a problem in the area. The responses regarding this thermal efficiency included the following:

Not efficient, like many loosely constructed Victorian properties. Sanded floor boards in hallway and two reception rooms on ground floor have no insulation beneath and, just 18 inches above bare earth, will suck in cold air. - Hannah

[We are] Looking to replace the bathroom window and improve draught proofing in front bays when I next overhaul them. This is a conservation area so strictly I should not install UPVC replacement windows, and would not in any case change the front sliding sash bays as they are part of the way the house should look. - Matthew

There was a general opinion amongst the participants that there were inherent thermal efficiency issues with the type of housing in the Round Hill area. The above views were expressed before the introduction of thermal images. Most participants believed the main way they were losing heat in their properties was because of the windows and doors, and this was yet to be confirmed or debunked using thermal images.

Following the collection of thermal images, participants were then introduced to the collected data. Figure 4 shows one of the properties used in the study.



Figure 4: Typical photo of house and corresponding thermal images

Although Jerry (the owner of property in figure 4) thought he could not make much improvements as indicated by his EPC, the thermal image gave him a completely different opinion. He confessed that he knew he could not do much about the windows but he was '*surprised*' that he was losing heat through the solid walls. His bedroom walls upstairs were giving off more heat than his windows and this was of some concern to him. As far as he was concerned, this should have never been the case.

Some participants had also noticed that they had to heat up the basements much more than other parts of their houses and the thermal images revealed that their solid walls coupled with single glazed windows were the main reason for this loss.

### Issues with 'Hard-To-Treat' Homes

'Hard-to-treat' homes are defined as dwellings which usually contain solid walls, no loft space to insulate, no connection to the gas network or are high-rise (Dowson *et al.*, 2012). Dwellings that fall under this category cannot be upgraded easily or cost effectively using conventional measures such as cavity wall insulation, loft insulation and modern gas central heating (Ibid.). The Round Hill properties fall under this category and the participants' stories on how difficult it was to prevent draught and heat loss puts the name 'hard-to-treat' into perspective. One of the main problems with such properties is the resultant issues that arise following attempts to manage heat loss such as damp and condensation issues.

### *Damp and condensation*

Damp, condensation and mould conditions were common with many of the properties according to the occupants. Although many householders had '*plastered and damp-proofed their walls*', they were not certain that their solutions were '*100% efficient*'. An expert in restoration, David (not a Round Hill Society member) was consulted for his views and he explained that buildings of that era needed to be '*dried out for months*' in order to be certain that the damp is completely eradicated. Many of the participants believed there were simple solutions to eliminating damp issues, for example: "*We've blamed it on the windows*" - Mark

Mark had ordered new windows at the time of the study. However, David recommended a holistic approach that involved the following:

- Changing lifestyle and producing less moisture
- Better ventilation to remove moisture, whether natural or mechanical
- Improving insulation and draught proofing
- Introducing damp proof courses
- Avoiding intermittent heating

Insulation and draught proofing seemed to be the main method adopted by most of the participants. The other practices recommended in the above list had not been considered by householders.

### **Barriers to Uptake of Innovative Trends**

Householders are happy to take on innovative ideas to improve their thermal efficiency and improve their overall energy consumption. In a pragmatic manner, they were all weary of the limitations. A participant stated the following:

I think we knew it was an old house which needed a lot of help - Jerry

Due to conservation, some households are not able to place solar panels on specific faces of their buildings.

The barrier of maintaining the conservation value of the building and therefore, you're limited in what you can do... I like living here because I love the look of the buildings Sarah

Sarah was particularly interested in '*clever ways*' to help improve energy efficiency especially with her floors. John also stressed that he was happy to take up new and innovative ideas that would help the thermal efficiency of their property as long as it was environmentally friendly. He added that he would not mind saving up enough money for such improvements giving a typical example of a £14,000 bill for recent window replacement. Unlike findings from Aboagye-Nimo *et al* (2016) and Power (2008), costs did not seem to deter the occupants of the Round Hill area as far as practical improvements were concerned.

### **Conclusions and Practical Implications**

This paper has presented findings from a study on the Round Hill Conservation Area in Brighton. It has been identified that property owners and occupiers in this area are keen on improving thermal efficiency and wanted to use innovative approaches to manage the hard-to-treat properties. Unlike previous studies (especially the initial research upon which the current study was based), the participants in this situation did not consider financial constraints as the main barrier to improving thermal efficiency. EPCs had not made any difference to the participants because they had accepted that conservation areas meant they would have to accept the poor thermal efficiency that came with it.

Furthermore, shortage in housing in the city of Brighton and Hove means occupants are compelled to accept their properties as they are.

Findings from this study are firstly being disseminated to members of the Round Hill Society. A community engagement meeting will be organised whereby David (the conservation expert) will discuss innovative ways of improving thermal efficiency based on the research data. The findings will be further extended to designers, housing associations, tenant associations and local councils. Also similar local communities such as Kemp Town in Brighton will be informed on how they can improve their energy performance without having to solely rely on EPCs.

As part of the ongoing project, data loggers will be placed in selected homes to assess indoor air quality of properties in the Round Hill area in the near future to shed further light on other aspects pertaining to energy refurbishment of hard-to-treat dwellings.

## ACKNOWLEDGEMENT

The authors are grateful to the Round Hill Society for their collaborative effort in developing this practical research project which will go a long way to help the wider community of the East Sussex County.

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# A MORPHOLOGY-BASED MODEL FOR FORECASTING COOLING ENERGY DEMAND OF CONDOMINIUM BUILDINGS IN SRI LANKA

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Building morphology has significant influence on operational energy demand of buildings. Energy consumption for space cooling accounts for more than 75% of electricity use in typical condominium buildings. With increase in the number of condominiums in Sri Lanka, the requirement for space cooling has increased resulting in significant energy demands. Accordingly, this study developed a morphology-based model for forecasting cooling energy demand of condominiums. The study employed a quantitative approach involving questionnaire survey and document review to collect data from thirty (30) condominiums in Sri Lanka. The correlation analysis performed on the data collected indicates that the number of floors (0.940), building height (0.930), building shape (-0.686), grouping of buildings (-0.647) window-to-wall-ratio (0.597), gross internal floor area (0.489), and wall-to-floor-ratio (-0.457) have significant correlations with the cooling energy demand of condominiums in Sri Lanka. A multiple linear regression model developed shows that the number of floors and window-to-wall-ratio account for 91.2% accuracy of the cooling energy estimation for condominiums in Sri Lanka. Thus, using the developed model, the annual cooling energy demand of a condominium can be forecast, considering significant design factors that could inform decisions at the building design and construction stage to ensure energy efficient designs.

Keywords: building morphology, condominiums, cooling energy, Sri Lanka

## INTRODUCTION

The building sector consumes more energy than both industrial and transportation sectors. For example, end-use sector shares of total energy consumption in the US in 2011 shows that the building sector contributed 41% of total energy consumption, with the residential sector dominating by consuming 22% (United States Department of Energy [USDOE] 2012). According to USDOE (2012), the two largest energy using residential sub-sectors are single-family homes and multi-family condominiums. A significant share of electricity consumption is by Heating, Ventilation and Air Conditioning (HVAC) systems and these generally reaches 50-60% in developed countries, and could be up to 70% in Australia (Australian Green Organization [AGO] 1999).

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In Sri Lanka, the building sector has become the dominant end-user of primary energy consumption (Ministry of Power & Energy 2011). The building sector consumes 170.6 quads of energy, which is 46% of the total energy consumption while the industrial sector and transportation sector consume 94.7 quads (25%) and 107.4 quads (29%) respectively. Anecdotal evidences from construction professionals suggest that both government and private sector investments on condominium buildings have significantly increased in recent past. Consequently, the requirements for space cooling energy demand have increased significantly. In Sri Lanka, comparison of the electricity bills and aggregated sub-metering data of buildings for an annual average of electricity end-use breakdown for HVAC system accounts for about 51% (Rajapaksha, Hyde and Rajapaksha 2010).

Given the dramatic increase in energy demand for HVAC of condominiums in Sri Lanka, this research develops a regression model based on principal building morphology data for forecasting cooling energy demand of condominium buildings in Sri Lanka. Since, morphology data of buildings are known at early stages such as construction or acquisition, the developed model could be used to predict the required energy for space cooling in condominiums. With this focus, the study believes such information could help both building owners and contractors to make informed decisions over properties. Further, being the prime factor in running costs of a building, the energy demand for space cooling will indicate the future implications on running costs of condominiums.

## LITERATURE REVIEW

### **Building Morphology Factors and Cooling Energy Demand of Buildings**

The drivers of HVAC energy consumption in buildings are many and different in nature. Susorova, Tabibzadeh, Rahman, Clack, and Elnimeiri (2013) indicated that the space cooling energy demand of a building is influenced by internal and external heat gains, although heat gain through building facades contributes more highly to space cooling energy demand. Subsequently, Zangheri *et al.*, (2014) explained that three major determinants of cooling energy demand include building geometry, internal gains, and building technologies. Brown, Cox, Staver, and Baer (2014) established the linkages between weather and energy use in buildings, indicating that warmer climate will increase the demand for electricity due to air conditioning but will decrease the end-use demand for natural gas and fuel oil. In another light, Bousquet, Cremel, and Loper (2014) contend that socio-demographic, economic and building characteristics play an important role. In addition, a study by a team at the London School of Economics and Political Science (Rode 2014) indicated eight factors that determine the space cooling energy demand of buildings. These factors are building typology, building density, surface-to-volume-ratio, average building height, surface coverage, insulation, glazing ratio and the climate.

The foregoing review show that building morphology factors play important roles in cooling energy demand determination. In this context, building morphology refers to building characteristics, building structure and design, building geometry, and use intensity drivers. Useful studies in this regard, include those of Catalina, Virgone, and Iordache (2011) that investigated 12 buildings with varying building forms and glazing percentages. Catalina *et al.*, (2011) concluded that the impact of building shape is most important in hot climates with higher solar radiation and outdoor temperature values. Further, Alanzi, Seo, and Krarti (2009) analysed several building shapes including rectangular, L-shape, U-shape, and H-shape with different building aspect ratios, Window-to-Wall-Ratios (WWR), and glazing types. The results of a detailed parametric analysis indicate that the effect of building shape on total building energy use depends on

primarily three factors: the relative compactness, the WWR and glazing type. For buildings with low WWRs, it is found that the total energy use is inversely proportional to relative compactness independent of its form in severe cold and scarcely sunny winters. Moreover, Ayeb (2016) elaborates that south and north oriented buildings are the most energy efficient building structures in hot and dry climates.

Besides, window area or WWR and Wall-to-Floor-Ratio (WFR) are another two vital factors affecting energy performance of buildings. Yang *et al.*, (2015) analysed the variation of annual heating energy demand, annual cooling energy demand, and the annual total energy consumption in different conditions. Yang *et al* (2015) included different orientations, patterns of utilization of air conditioning system, WWR, and types of windows in hot summer and cold winter zones in China and concluded that total energy consumption increased with the increase of WWR. It appears more obvious when the window orientation is east and west. Also, Ayyad (2011) investigated the impact of WFR on the thermal performance of office buildings in Dubai, hot and humid climate and concluded that the higher WFR were responsible for reduced energy consumption.

In another light, Omari (2015) found that heating cost is influenced considerably by the relationship between the area of roof and walls, as roofs are a major element in heat loss. However, the impact of other building morphology factors such as building height, number of floors, Gross Internal Floor Area (GIFA) and grouping of buildings on the cooling energy consumption of buildings are not evident in both international and local context. Therefore, those factors were considered within this study.

### **Models for Estimation of the Cooling Energy Demand**

Literature shows that most of the models, which attempt to predict the cooling energy demand, have employed a statistical data analysis technique called Regression Analysis. For example, Kirkham, Boussabaine, and Grew (1999) applied a regression technique to model the energy cost of sports centres where the floor area and the number of users were used as two independent inputs. Mack and McWilliam (2013) proposed a model that contains eight predictors to calculate the percent change in cooling energy consumption to an accuracy about of 20%. Mack and McWilliam's model is applicable during the running stage of buildings, where there are adequate historical building operational data available. Other models seem less accurate and restricted to a specific life cycle. However, building morphology data are known at the pre-construction stage of a building and therefore, could serve as predictors of cooling energy demand of the building.

Further, the lack of reliable and consistent data make it impossible to establish energy models to predict energy demand for space cooling of condominiums in Sri Lanka at the early stage of buildings. This research, therefore, analyses energy consumption behaviour for space cooling of luxury and high-rise condominiums in Sri Lanka and develops a simplified regression model based on principal building morphology factors for forecasting annual cooling energy demand. With this model, one can forecast the annual cooling energy demand of a condominium and give due considerations to significant design factors to make informed decisions at the building design and construction stage to ensure energy efficient designs.

## **RESEARCH METHODS**

A quantitative approach was employed to develop a morphology-based model for forecasting annual cooling energy demand of condominium buildings in Sri Lanka. A questionnaire survey was administered to collect data related to building morphology factors and annual energy consumption for space cooling. Given the time constraints and

limited access to data, a sample of thirty (30) (out of 70) registered luxury residential condominiums with 12 or more floors, constructed after 2010 were selected considering the minimum sample required for a survey design. A sample size between 30 and 500 at 5% confidence level is generally sufficient for many researches (Altunışık, Coşkun, Bayraktaroğlu, and Yıldırım 2004; Borg and Gall 1979). The data was collected from architectural drawings, sub-metering logs, records on annual energy consumption and utility bills. Questionnaire survey participants included professionals who have more than 10 years of experience in condominium operations and maintenance and having extensive knowledge on building morphology and energy consumption patterns in condominiums. A summary profile of survey participants is presented in Table 1.

*Table 1: Profile of the survey respondents*

| Designation | Number of participants |      | Work experience    | Number of participants |      |
|-------------|------------------------|------|--------------------|------------------------|------|
|             | No.                    | %    |                    | No.                    | %    |
| Engineers   | 19                     | 63.3 | More than 20 years | 8                      | 26.7 |
| Managers    | 11                     | 36.7 | 20 - 15 years      | 7                      | 23.3 |
|             |                        |      | 15 - 10 years      | 15                     | 50   |
| Total       | 30                     | 100  | Total              | 30                     | 100  |

As observed from Table 1, majority of the participants (63.3%) are engineers whose designations are: Maintenance Engineer (7), O&M Engineer (5), Chief Engineer (4), Facilities Engineer (1), Mechanical Engineer (1) and Electrical Engineer (1). Rest of the participants are managers including Maintenance Managers (5), Facilities Managers (4) and Operations Managers (2).

For data analysis, basic descriptive, correlation and multiple linear regression analyses were employed in the study. Firstly, the set of significant morphology factors, which cause changes in cooling energy demand of condominiums were identified using Pearson correlation coefficient statistics. Seven out of nine morphology factors, which significantly correlated with the average annual cooling energy demand were forwarded for further analysis, based on the significance of correlation. Correlation strength determination followed suggestions by Ricciardy and Buratti (2015). Accordingly, correlation coefficient 'R' is  $0 < |R| < 0.3$  - weak correlation;  $0.3 < |R| < 0.7$  - moderate correlation; and  $|R| > 0.7$  - strong correlation respectively.

Later, a model for forecasting cooling energy demand of condominiums in Sri Lanka is developed using a stepwise multiple linear regression analysis. In regression analysis, there are several criteria to be tested to select the best-fit model. Initially, the effect of multicollinearity should be checked. Although there is no formal criterion for determining the bottom line of the tolerance value or Variation Impact Factor (VIF), Chatterjee and Hadi (2012) suggest that a tolerance value of less than 0.1 or VIF greater than 10 generally indicates a significant multicollinearity. Besides, the commonly used measure of the goodness of fit of a linear model is  $R^2$  (the coefficient of determination) which ranges between 0 and 1. However, in multiple linear regression modelling, the best model is defined by its highest adjusted  $R^2$ , as it is more accurate than  $R^2$ .

## DATA ANALYSIS AND FINDINGS

### The Relationship between Building Morphology Factors and the Cooling Energy Demand of Condominium Buildings

In order to identify significant set of building morphology factors, building morphology details of the 30 condominiums were correlated with the average annual cooling energy

demand using the SPSS Statistics 19.0. The result of the correlation analysis is shown in Table 2. The table depicts the Pearson correlation (R), the coefficient of determination (R<sup>2</sup>) and the significance of building morphology factors with respect to the annual cooling energy demand of condominiums in Sri Lanka.

*Table 2: Correlations of average annual cooling energy consumption and building morphology factors*

| Building morphology factor | Average annual cooling energy consumption |                |                 |
|----------------------------|---|----------------|-----------------|
|                            | R   | R <sup>2</sup> | Sig. (2-tailed) |
| Area of roof               | -0.180                                    | 3%             | 0.341           |
| Orientation                | 0.319                                     | 10%            | 0.085           |
| WFR                        | -0.457*                                   | 20%            | 0.011           |
| WWR                        | 0.489**                                   | 24%            | 0.006           |
| GIFA                       | 0.597**                                   | 36%            | 0.000           |
| Grouping of buildings      | -0.647**                                  | 42%            | 0.000           |
| Building shape             | -0.686**                                  | 47%            | 0.000           |
| Building height            | 0.930**                                   | 86%            | 0.000           |
| No. of floors              | 0.940**                                   | 88%            | 0.000           |

\*. Correlation is significant at the 0.05 level (2-tailed).

\*\*. Correlation is significant at the 0.01 level (2-tailed).

As observed from Table 2, based on Pearson correlation coefficients and the significance of correlations at 5% and 1% significant levels, seven out of nine factors resulted in significant correlation values. The factors include the number of floors, building height, building shape, the grouping of buildings, WWR, GIFA, and WFR. Amongst, all correlations except WFR are significant at the 0.01 level. Although building orientation did not result in a significant correlation, it has moderate and positive correlation with the cooling energy demand (0.319) while having 10% impact. Weak and a negative correlation is shown by the area of roof (-0.180). Factors having significant correlations are discussed in more detail below.

*Correlations with cooling energy demand: Number of floors and building height*

As observed from Table 2, the number of floors (0.940; 88%) and building height (0.930; 86%) have strong positive relationship with cooling energy demand. This indicates that cooling energy demand will increase with increase in number of floors and building height. Building height would most definitely increase in proportion with number of floors. Thus, once the number of floors increases, energy demand for space cooling of condominiums increases due to the increase of occupancy, appliance used and building volume. Further, it is obvious that the space required to condition will be increased with the increase of building height, therefore, resulting in growing cooling energy demand. Moreover, the increased wall area caused by increased height generates extra heat gain from environment. For number of floors, the coefficient of determination is 0.88, which means that 88% of the variation in mean cooling energy demand can be predicted from the relationship between number of floors and cooling energy consumption. Similarly, 86% of cooling energy, demanded by a condominium building depend on the building height while 14% depending on the other factors.

*Correlations with cooling energy demand: WWR and GIFA*

Both WWR (0.597; 36%) and GIFA (0.489; 24%) have positive and moderate relationship with the cooling energy demand of condominiums. It indicates that the

energy consumption for space cooling increases with the increase of WWR and GIFA. High WWR can be resulted when the net glazing/window area becomes larger than the gross exterior wall area. Thus, wide glazing areas increase the external heat gain and lead to excessive cooling energy demand. Furthermore, the correlation analysis shows that the WWR is positively correlated with the height of the building (0.455) and number of floors (0.458). The coefficient of determination calculated indicates that the WWR determines 36% of the mean cooling energy demand of condominiums. Similarly, the increased GIFA will lead to more occupancy, excessive usage of heat emitting appliances and additional building volume to be conditioned. With the increase of aforementioned factors, the space cooling energy demand is definite to increase. Nevertheless, 24% of coefficient of determination resulted by GIFA indicates that building size is not the only factor which influences the energy demand of space cooling.

*Correlations with cooling energy demand: Building shape, grouping of buildings and WFR*

Contrary to number of floors, building height, WWR, and GIFA, correlations of building shape (-0.686; 47%), grouping of buildings (-0.647; 42%) and WFR (-0.457; 20%) with the cooling energy demand are negative. In addition, all negative correlations have moderate impact on the cooling energy demand. Here, building shape is considered as irregular and regular shapes with values 0 and 1 respectively. The resulting negative correlation indicates that where the shape is regular, the consumption of cooling energy is reduced as it generates less external heat compared to irregular configuration, which has same building volume. However, building shape is not the only parameter, which determines the cooling energy demand of a condominium in tropical climates as it has only 47% of coefficient of determination. Besides, when grouping of building exits, the energy demand for space cooling may decrease due to covering effects. However, when a building is located separately, there will be an increase in energy consumption for space cooling. Only 42% of the mean value of cooling energy demand could be explained by this parameter. Finally, when there is a high WFR, the cooling energy demand of that particular condominium would decrease. In order to result in high WFR, the external wall area of a building should be greater than its GIFA. Correlation value obtained for GIFA also indicates that little GIFA consume low energy for space cooling, as it offers space for limited number of occupants and limits the number of appliances used within the area. However, the coefficient of determination of WFR is 20%, which means 80% of the mean value of cooling energy demand of condominiums in tropics will be determined by other factors.

These seven significantly correlated building morphology factors were forwarded for regression analysis, and the results are described in the following section.

**A Morphology-Based Model for Forecasting Annual Cooling Energy Demand**

Initially, the regression model was fixed with the seven independent variables: number of floors, building height, building shape, the grouping of buildings, WWR, GIFA, and WFR using a stepwise method. Stepwise regression process systematically adds the most significant variable or removes the least significant variable during each step by eliminating correlations between independent variables, which can reduce the model accuracy. Accordingly, the regression analysis offered two models and Table 3 represents the coefficients and collinearity statistics of the two regression models.

Table 3: Coefficients of the Regression Model

| Model |               | Unstandardized Coefficients |            | Standardized Coefficients | Collinearity Statistics |           |
|-------|---------------|-----------------------------|------------|---------------------------|-------------------------|-----------|
|       |               | B                           | Std. Error |                           | Beta                    | Tolerance |
| 1     | (Constant)    | -34732.863                  | 45087.186  |                           |                         |           |
|       | No. of floors | 21356.009                   | 1470.347   | 0.940                     | 1.000                   | 1.000     |
| 2     | (Constant)    | -194913.837                 | 60759.881  |                           |                         |           |
|       | No. of floors | 19160.987                   | 1409.023   | 0.843                     | 0.790                   | 1.265     |
|       | WWR           | 4339.533                    | 1275.393   | 0.211                     | 0.790                   | 1.265     |

a. Dependent Variable: Average annual cooling energy consumption

The collinearity statistics in Table 3 show that the tolerances are large and the VIF is considerably low. As mentioned in research methods, both the models 1 and 2 are considered for non-existence of multicollinearity. Table 4 provides the summary of the two models for forecasting the cooling energy demand of condominiums in tropics. Accordingly, the second model, which yields the highest adjusted R<sup>2</sup>, was selected as the best model and goodness of fit of the model is 91.2%.

Table 4: Summary of Model

| Model | R      | R <sup>2</sup> | Adjusted R <sup>2</sup> | Std. Error of the Estimate | Change Statistics     |          |               |
|-------|--------|----------------|-------------------------|----------------------------|-----------------------|----------|---------------|
|       |        |                |                         |                            | R <sup>2</sup> Change | F Change | Sig. F Change |
| 1     | 0.940a | 0.883          | 0.879                   | 69268.28675                | 0.883                 | 210.960  | 0.000         |
| 2     | 0.958b | 0.918          | 0.912                   | 59013.17120                | 0.035                 | 11.577   | 0.002         |

b. Predictors: (Constant), No. of floors

c. Predictors: (Constant), No. of floors, Window-to-Wall-Ratio

d. Dependent Variable: Average annual cooling energy consumption

Based on these statistics, the annual cooling energy demand of condominium buildings in tropical climates could be expressed by:

$$\text{Cooling energy demand (Kwh/y)} = -194913.837 + 19160.987 (\text{Number of floors}) + 4339.533 (\text{WWR})$$

This developed model consists of two independent variables: number of floors and WWR. Thus, the cooling energy demand can be forecasted if the proposed number of floors and the WWR can be determined at the early stages of condominiums located in tropics.

## DISCUSSION

Unlike previous studies, which revealed altogether five morphology factors influencing the cooling energy demand of buildings in both hot and cold climates, the current study provides an extensive set of seven variables. The cooling energy demand is significantly influenced by number of floors (0.940, 88%), building height (0.930, 86%), building shape (-0.686, 47%), grouping of buildings (-0.647, 42%), WWR (0.597, 36%), GIFA (0.489, 24%), and WFR (-0.457, 20%).

Similar to Catalina *et al.*, (2011), the current study found that building shape has a significant impact on cooling energy demand, reasoning that regular building configurations are more energy efficient compared to irregular building forms. Further, this study confirms the findings of Ayeb (2016) and Yang *et al.*, (2015) who studied hot and dry climate, and hot summer and cold winter zones in China, respectively by concluding that buildings, which have long south and north axis, result in a reduction in energy consumption compared to east and west oriented buildings. Moreover, similar to Yang *et al.*, (2015), the current study found that buildings with high WWR are more likely to experience high-energy demand and that would further increase with having east and west oriented window area. In addition, buildings with high WFR would result in low energy consumption for space cooling of condominium buildings. This result confirms previously held conclusions of Ayyad (2011) for office buildings in Dubai, which is a hot and humid climate.

The current study further determined the following vital relationships between building morphology and cooling energy demand. That a positive and strong correlation found between number of floors, building height and GIFA with the cooling energy demand of condominiums in tropics, indicates that cooling energy demand increases with increase in aforementioned variables. This could be due to the growing internal heat gain (i.e. by increased occupancy and usage of heat emitting appliances) and external heat gain (i.e. additional heat gain from the building façade). Further, where grouping of building exists; cooling energy demand for condominiums reduces due to their covering effects.

In terms of significance, only seven out of the analysed nine factors, resulted in significant correlation. Building orientation (0.319) and area of roof were the two exceptions. The impact of orientation on cooling energy demand could be mitigated by the covering effects caused by the grouping of buildings; therefore, this did not determined as a factor, which has a significant impact on cooling energy demand. Then, the area of roof resulted in a minimum correlation value (-0.180). Since roofs are a major heat gain element, most buildings in hot and tropical climate ensure buildings' thermal comfort through insulation. With that note, most of the buildings included to the research sample are roof insulated; therefore, the impact of roof area on cooling energy demand has been mitigated.

Unlike previous studies: Bousquet *et al.*, (2014) and Mack and McWilliam (2013), the developed model in the current study is based on only two simple predictors: number of floors and WWR, which are frequently known at the pre-construction stages of buildings. The goodness of fit of the model is over 91%, indicating that this model could predict over 91% of the mean value of cooling energy demand of condominiums in tropics. Further, the mean value of accuracy of the developed model for forecasting cooling energy demand of condominiums in Sri Lanka is much improved compared to the mean value of accuracy (20%) reported by Mack and McWilliam (2013) in their cooling energy consumption by the climate model.

## CONCLUSIONS

In this study, a correlation analysis was initially performed to identify significantly correlated morphology factors with cooling energy demand and thereby developed a regression model for forecasting cooling energy demand of condominiums in Sri Lanka. It is concluded that number of floors, building height, building shape, grouping of buildings, GIFA, WWR, and WFR have significant effects upon the cooling energy demand of condominiums. Except for building shape and grouping of buildings, increase of other variables result in increase of cooling energy demand. Results further

highlight that regular building configurations (i.e. square, rectangular circle) and having grouping of buildings consume less energy for space cooling of condominiums in a tropical climate.

The main finding of the study is the morphology-based model for the estimation of cooling energy demand of condominiums in Sri Lanka. The developed model shows over 91% accuracy on the estimation of cooling energy demand. This model is based on two principal morphology factors: number of floors and WWR. The selected independent variables are positively contributing to the cooling energy demand. Therefore, energy demand for space cooling of condominium buildings can be predicted to make informed decisions at the early stages of buildings' life cycle. This would have implications on the operational costs and the running costs of residential condominiums.

It is hoped that these findings would provide useful knowledge towards energy efficient building designs. Building morphology factors could then be appropriately varied for condominium buildings in line with passive energy conservation strategies, consequently reducing cooling energy consumption in Sri Lanka. Finally, the study recommends that the model developed in this study, to be validated in other tropical climates.

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# GREEN BUILDING PROJECTS: PROCESS INNOVATION LEADING TO PROJECT INNOVATION

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Green Building (GB) project delivery is complex since these projects have many different requirements compared to conventional construction. There is not yet an agreement on which delivery approach is more effective in delivering more innovative and environmentally conscious GB projects. This paper investigates the GB project delivery approaches from an innovation perspective by reviewing the various empirical findings from previous research. Using 13 relevant studies identified through a systematic search, the relationship between innovation in delivery process and project innovation is identified. Depending on the extent of innovative features incorporated, each Project Delivery Method (PDM) is found to have the capacity to produce successful results. Incremental process innovation through the use of traditional PDMs is typically associated with a low level of project innovation and environmental performance while radical process innovation using integrated delivery method is found to be associated with a high level of project innovation and environmental performance in GB projects. Delivery process that encourages team work can be valuable as this promotes team integration and collaboration thereby leading to innovative solutions.

Keywords: green building, green performance, innovation, project delivery method

## INTRODUCTION

Green Buildings (GBs) require the use of innovative construction techniques and delivery processes. Slaughter (1998) defines innovation as the actual use of a nontrivial change and improvement in a process, product, or system that is novel to the institution developing the change. GB projects are innovative projects and their level of green performance can be considered an indication of their level of innovation, which significantly depends on the project delivery approach. Unlike conventional building development where the environmental effects of construction activities are often disregarded, GBs focus on improved environmental performance.

For successful GB projects, delivery process can be as important as the technical aspects. Various Project Delivery Attributes (PDAs) are involved which are basically a set of circumstances, facts, influences or forces that either facilitate or impede project outcomes. Project Delivery Method (PDM) is one of the key PDAs for project success as it defines how project teams form, their working relationships, and levels of involvement during project timelines, and incentives to encourage contribution to the project. Two elements

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define a PDM: (1) relationships of project stakeholders; and (2) their timing of engagement in the project (El Asmar *et al.*, 2013).

In GB projects, coordination between the work of various design disciplines and contractors can enhance the constructability and innovation aspects in design to improve green building projects' success (Li *et al.*, 2011). Thus, innovative delivery approaches can result in higher levels of project innovation. Although a general understanding of the effect of PDMs on project innovation exists, there is relatively little research on the link between the level of innovation in GB projects and the level of innovation in their delivery processes. Accordingly, the purpose of this qualitative systematic review is to identify the role of project delivery approach on GB project outcomes, from an innovation perspective.

## **CONCEPTUAL FRAMEWORK**

### **Green Buildings as Innovative Projects**

The significance of innovation in GB projects is demonstrated by the rewarding of innovation. The Singapore Green Mark GB certification system gives a 15% weight to innovation. These innovative features include technological approaches as well as financing methods and management approaches, such as environmental management systems etc. (Li *et al.*, 2011). The USGBC LEED ver. 4 (Building Design & Construction) gives only 5.5% weight to design innovation, the other 94.5% points shared by other categories (e.g. water efficiency, indoor environmental quality, etc.) are directly and indirectly affected by innovation in terms of advanced machinery, equipment and effective software applications which are required for optimizing environmental performance in GB projects.

### **Innovation, Project Delivery Methods and GB Project Outcomes**

In construction, innovation can be characterised as incremental or radical innovations. Incremental means 'small, and based on existing experience and knowledge', whereas radical is 'a breakthrough in science or technology' (Slaughter, 1998). The delivery process of different GB case studies can be partially explained in terms of incremental and radical innovation. However, in order to gain a deeper insight into the factors for influencing delivery process innovation, 'architectural', 'modular' and 'system' innovations also need to be considered on GB innovation scale. 'Modular' is a change in concept within a component only, while 'system' means innovation within multiple components. Other than modular and system innovation to explain innovation within components, 'a change in links to other components or systems' is explained by architectural innovation (Figure 1) (Slaughter, 1998, Tidd, 1995).

Although the concept of incremental and radical innovation is easily applicable to processes as well as products, the concept of architectural and system innovation majorly evolved for products. One way of applying the idea of architectural innovation on processes is by considering different team members in project delivery process as the components of a delivery system. In these terms, architectural innovation will result from a difference in interrelationships among the components (team members) involved. This difference in interrelationships will arise from the variation in contractual terms, roles and responsibilities, etc. which are the specific characteristics of a PDM. Therefore, a PDM is subjected to architectural innovation in which interrelationships are changed compared to original approach.

The choice of a PDM impacts project innovation because coordination among project team members is strongly influenced by PDM. Traditional lump-sum contract is considered the most detrimental to innovation. It typically involves the highest cost risk, the highest occurrence of adversarial relationships, lowest integration level across the supply chain, and poorest innovation outcomes. From innovation perspective, it is the presence of a well-integrated team that is of most importance, as it is a key to driving the achievement of innovative features (Blayse and Manley, 2004).

### **Project Delivery Methods and Their Characteristics**

PDMs to be discussed in this paper are grouped into three, based on their most salient characteristics: Design-Bid-Build (DBB), Construction Manager at Risk (CMR) and Design-Build (DB), and Integrated Project Delivery (IPD).

#### *Category 1: The conventional delivery system- Design-Bid-Build (DBB)*

In DBB, bidders have a clear understanding of project scope since design and construction phases are separate and sequential. It is the most simple and popular PDM; the owner contracts with designers, and then when design is 100% complete the owner contracts separately with a General Contractor (GC) to build the facility. The design is restricted and the contractual structure does not promote collaboration between the design team and contractor leaving bidders and the contractor with little or no room for innovation. Though the early involvement of contractors is possible with DBB, it is typically not to the extent of a more integrated PDM (Mollaoglu-Korkmaz *et al.*, 2011). DBB typically uses one of the most basic payment options i.e. lump sum payments (interim or milestones).

#### *Category 2: Fast-tracking-orientated delivery system - Construction manager at risk (CMR) and Design-Build (DB)*

Fast-tracking means overlapping of design and construction phases. Construction Manager at Risk (CMR) and Design-Build (DB) are the common approaches. Although they are fundamentally different, in both, collaboration among the owner and other parties is not based on a multi-party contract. In DB, the general contractor (GC) is engaged when the design is not complete, and the designer will be novated to the GC, thereby providing a single point of responsibility for owner. With the CMR system, the constructor is involved early on in the project; the system usually includes a reimbursement solution based on incentives (Kenig, 2011). Although, DB and CMR are suitable for fast-tracking, they lack a particular focus towards project integration.

#### *Category 3: Integrated delivery approach*

IPD is a relatively new concept and evolving, having multiparty agreement, shared risk and rewards, and early involvement of all parties whereby all key project stakeholders sign one multiparty contract before the start of design. It is based on the assumption that a project will suffer from lack of innovation if everyone is held solely responsible for their own scope and price. Thus parties agree to share project gains and lack of performance according to their participation (Matthews and Howell, 2005).

## **METHOD**

Using a systematic review of previously published GB case studies, this paper identifies the role of project delivery approach on GB project outcomes, from innovation perspective. However, due to the lack of research linking GB project innovation with process innovation, the substitute technique used in this paper is to review studies that have related GB project success/performance with different delivery approaches. This paper uses an assumption that green performance of GB projects is directly proportional

to innovativeness. It is also assumed that some PDMs are more innovative than others depending on their history and popularity of use. Thus, comparative studies relating the use of different delivery techniques for GB projects are reviewed. Relevant publications were obtained through a systematic and extensive search of thesis, and refereed journal, conference, and review articles using the title/abstract/keyword' fields in major databases such as "Web of Science (ISI)", "Scopus (Elsevier)". Publications issued until October 2016 were considered. Originally developed code used include: ("green" OR "sustainable" OR "high performance" OR "energy efficient" OR "sustainability" OR "nZEB" OR "ZEB" OR "zero carbon" OR "low carbon" OR "LEED") AND ("building") AND ("project") AND ("delivery" OR "procurement") AND ("performance" OR "success"). 518 publications were obtained in the "the first round". They were scrutinized using their titles and keywords and 75 publications were shortlisted in "The second round". By scrutinising the abstract and conclusion sections in the "The third round", 13 relevant publications were finally shortlisted for qualitative review. Publications were selected only if they relate to the delivery of GB projects; and if they relate different delivery approaches for successful GB project delivery.

## **FINDINGS**

The search results show that not many studies have examined the link between PDAs and performance outcomes of GBs. In order to investigate trends of GB delivery processes in terms of innovation, the review findings are now presented. The only available literature relates PDAs with project success/performance (i.e. level of green performance, etc.) - conceptualised as the level of innovation. The current trends of innovation in GB delivery process are then identified. The effectiveness of different PDMs for successful delivery of GB projects is examined first, followed by the reasons for the associated increase in project performance. Finally the role of PDAs (Project Delivery Attributes) other than PDM is highlighted.

### **Effect of PDMs on GB project outcomes**

In terms of Conventional DBB vs. Fast-tracking delivery systems, using inductive reasoning, Gard (2003) argued that the DB method of infrastructure delivery capitalizes on synergies between designer and builder, rather than exacerbating the conventional antagonism between these two actors, as typical in the DBB method. GB projects delivered by CMR and DB outperform DBB projects on different performance criteria particularly in terms of delivery speed (Korkmaz *et al.*, 2010a). Defining GB project success as a measurement of a project meeting or exceeding its initial LEED rating goals, Molenaar *et al.*, (2009) found that all PDMs (DB, DBB, CMR) could lead to all levels of LEED certification. However, success differs for each PDM. The majority of projects (75%) used DB and CMR as PDMs. CMR was identified as the most successful PDM with 94% success rate and exceeding owners' expectations 50% of the time. Furthermore, the use of DB approach in building mechanical systems of GB projects was found to result in better outcomes when compared to DBB approach (Riley *et al.*, 2005). Some US-based GB office projects were discussed in another study (Swarup *et al.*, 2011, Korkmaz *et al.*, 2010a). Table 1 summarises their findings. The total score provides the overall GB performance and is a sum of the scores a project has in the performance metrics of High Performance Green, Intended vs. Achieved green status, Post Occupancy Evaluation, as well as Cost, Schedule and Quality performance. In case a project performs up to the mark/expectations, then it gets a score of 0. However, if it performs better or worse, it gets +1 and -1 scores respectively. Table 1 shows that different PDMs

are related with different levels of integration in delivery process and this consequently affects final project outcomes, particularly sustainability goals.

Although many studies relate the difference in project performance with the PDM used, a unanimous agreement does not exist about differences in the effectiveness of PDMs. For instance, using US NAVY projects Carpenter (2005) found no noteworthy difference between DB and DBB in terms of LEED scores at the FACD (Functional Analysis and Concept Design) and design completion stages. Similarly, Bilec (2008) could not establish any explicit relationship between DB and green design.

Table 1: PDAs and Performance for GB projects (Swarup *et al.*, 2011, Korkmaz *et al.*, 2010a)

| Proj. Code | PDM | LEED Certification | Owner's commitment | Total Score | Level of integration | Contractual Terms |      |     |
|------------|-----|--------------------|--------------------|-------------|----------------------|-------------------|------|-----|
|            |     |                    |                    |             |                      | Des.              | Con. | D-B |
| A1         | DBB | Certified          | Low                | -2          | Low                  | LS                | LS   |     |
| A2         | CMR | Certified          | Medium             | -1          | Medium               |                   | LS   |     |
| A3         | CMR | Certified          | Medium             | -1          | Medium               | LS                | GMP  |     |
| B1         | DBB | Silver             | Medium             | -1          | Medium               | LS                | LS   |     |
| B2         | CMR | Silver             | Medium             | -4          | Medium               | LS                | GMP  |     |
| C1         | DB  | Gold               | High               | 3           | High                 |                   |      | C+F |
| C2         | DB  | Gold               | High               | 3           | High                 |                   |      | C+F |
| D1         | DB  | Platinum           | High               | 4           | High                 | C+F               | C+F  |     |
| D2         | CMR | Platinum           | Medium             | 1           | Medium               | C+F               | C+F  |     |
| D3         | DB  | Platinum           | Medium             | 0           | High                 |                   |      | LS  |
| D4         | DBB | Platinum           | High               | 0           | Low                  | C+F               | LS   |     |

Note: LS= Lump Sum; GMP= Guaranteed Maximum Price; C+F= Cost+Fee; Des. = Designer; Con. = Constructor; D-B= Designer-Builder

In terms of Integrated vs. Conventional and Fast-tracking delivery systems, IPD as a PDM is remarkably different from other PDMs. Kantola and Saari (2016) argued that IPD is the most suitable PDM for GB projects. El Asmar *et al.*, (2013) evaluated the performance of 35 IPD projects in comparison to projects delivered using other PDMs (i.e. DBB, DB, CMR), and showed statistically significant performance outcomes in the case of IPD. In another study, Matthews and Howell (2005) found that the use of IPD resulted in successful project delivery in a chilled water plant project. The project demonstrated how the increased coordination, innovation, and skill set resulting from the application of IPD helped materialize a successful project execution. Hanks (2015) compared 8 DBB projects to 8 IPD projects and found that 75% of the DBB case studies achieved the LEED target while 63% of the IPD case studies exceeded LEED target. Important attributes responsible for the outcomes are: the early involvement of key project participants, collaboration, and the use of technology. Although these attributes can be incorporated into both DBB and IPD methods, IPD facilitates the use of technology and incentivizes early participant involvement and collaboration. Thus, using IPD tends to provide higher assurance that project performance targets (e.g. LEED certification) will be met or exceeded.

Some studies examined, in detail, the factors that make some PDMs more effective than others. For instance, Molenaar *et al.*, (2009) found that success rates favour PDMs that do not seek pricing before selection and that use GMP payment provisions. According to the studies (Swarup *et al.*, 2011, Korkmaz *et al.*, 2010a) shown in Table 1, GB projects with high overall scores and also high levels of green certifications tend to have Cost+Fee contractual terms instead of GMP or Lump Sum terms. The difference in project

performance because of the difference in payment terms is reasonable because the payment systems used in PDMs are of much significance since it can minimize the principal-agent problem by aligning the interest of principal and agent parties. However, one of the owners of a project in Korkmaz *et al.*, (2010a) study stated that GMP and lump sum are ineffective, old school, old thinking, and a hindrance towards innovation and new technologies as they tend to make the stakeholders focus more on protecting their own interests. Cost+Fee structure can also be problematic. For instance, one designer in the study stated that Cost+Fee for the most part implies a percentage of the construction cost. Therefore, there are disincentives to achieve high performance: if the idea is to try to reduce system size, the associated cost will reduce and if fees are based on cost, there is no incentive for reducing costs and achieving a higher efficiency. Thus, it can be stated that some of the existing payment contractual terms are more effective than others in aligning the interests of project team members. However, there is room for further improvements in these contractual terms. The findings suggest that constituent elements of different PDMs set them apart when it comes to their ability of successfully delivering GBs.

### **Effect of PDAs on GB Project Outcomes**

The review also shows that there are many PDAs other than PDM which influence GB project success and innovation. For instance, Bilec (2008) study provided a series of best practices for GB delivery, which in some cases are related to a specific PDM, but in other cases are independent of the PDM used. PDAs such as timing of project participants' involvement in the delivery process and owner type can be important factors for successful project outcomes compared to the PDM used (Korkmaz *et al.*, (2010b)). In Korkmaz *et al.*, (2010a) study it was realized in 3 out of 11 cases that a certain level of project performance is not entirely based on the PDM being used. For instance (as shown in Table 1), D4 was an outlier project, since it had low level of integration, was delivered by conventional DBB but still performed significantly better because of the contractor's commitment and early involvement in the project; B2 was also an outlier since it had a medium level of integration, was delivered by CMR but still had low performance outcomes because of the lack of contractor's commitment; A2 was also an outlier since it had a medium level of integration, was delivered by CMR but still had a low sustainability performance because of the team's lack of experience with LEED. It was also realized from the study that there are some aspects differentiating gold certified (good), Platinum certified (exceptional), or low and high innovation projects.

From Table 1, the difference between low and high innovation projects is not only because of PDMs used but also because of other attributes (i.e. PDAs) under the partial influence of PDMs. Unlike low innovation projects, the high innovation projects used Collaboration Sessions, Green Design Coordinator and Design Charrettes. In comparison with low innovation projects, the high innovation projects had earlier constructor involvement, earlier introduction of green concept in the project and the green concept incorporated by the owner rather than designer. Although DB and CMR have better chances of facilitating integration, results show that DBB also has the potential to provide higher levels of integration if it informally involves the constructor in the earlier phases of the project. Design charrette, compatibility of team members, and commitment to project sustainability goals were also found to be crucial in achieving team integration and overall project success and innovation (Swarup *et al.*, 2011, Korkmaz *et al.*, 2010a, Mollaoglu-Korkmaz *et al.*, 2011). Using quantitative methods on 51 GB projects, Gultekin *et al.*, (2013) identify statistically significant correlation between in-process indicators (i.e. PDAs) with GB project performance outcomes (i.e. green level, cost, and

schedule). Besides the use of DB as a PDM, the other indicators, include: setting owner-initiated sustainable goals, having all major project parties attending design charrettes, running energy and lighting simulations no later than the schematics-design phase, adequacy in owner capabilities for scope definition and decision making, selecting contractors from a restrained pool, and enabling contractor involvement in the delivery process no later than the design-development phase.

The research highlights that although PDM is an important attribute, it is in fact one among many other attributes which cumulatively affect the success of GB projects. Although the selection of a certain PDM also influences other PDAs, the attributes (i.e. design integration, etc.) can still be optimized, selected and controlled even when a conventional PDM (DBB) is being used. This emphasizes that fate of a project is not decided with selection of a PDM only. Through localized innovation within the PDM and individual PDAs, remarkable performance results can be expected in GB projects.

## DISCUSSION

Findings show that the GB projects delivered through integrated and innovative delivery method (i.e. IPD) tend to result in more consistent successful outcomes in comparison with projects delivered through a conventional delivery method (i.e. DBB). Fast-tracking delivery methods (i.e. DB, CMR) perform better than conventional but worse than integrated delivery method in delivering various project outcomes including innovation. For assessing the delivery process innovation in different GB projects, the overall successful GB case studies can be divided in three types: Type-A in which conventional PDM (i.e. DBB) is used with adequately controlled PDAs; Type-B in which fast tracking PDMs are used and; Type-C in which integrated PDM is used. Type-A (conventional PDMs) qualifies as incremental innovation since it is based on traditional practice while linkages among core components of the system are unchanged. Type-B (fast-track PDMs) lie in-between incremental and radical innovation since core concepts/components are subjected to a medium level of change. Type-C (integrated PDM) can be considered as radical innovation as it is subjected to high level of change in core concepts/components.

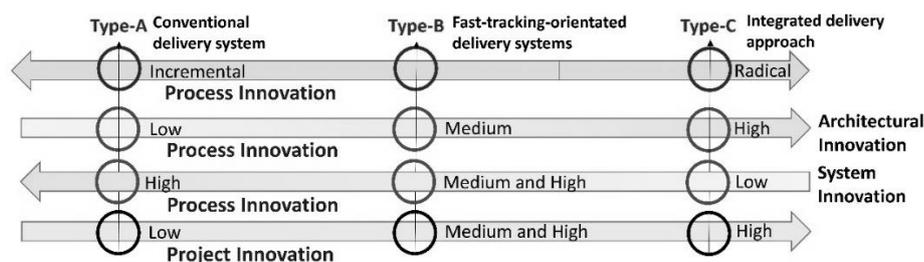


Figure 1: Process and Project innovation for Green Building Projects

The radical innovation of Type C can be attributed to its high level of architectural innovation (Figure 1). Similarly incremental innovation of Type A can be attributed to its high level of system innovation. The intermediate innovation status of Type B is between incremental and radical innovation, and can be attributed to its medium level of architectural and system innovations.

Depending on the number of total points achieved, LEED endorses GB projects as Certified (lowest level certification), Silver, Gold, and Platinum (highest level certification). These different levels of green performance directly correspond to the level of innovation in a project. Type-A (Conventional PDM) is majorly associated with low green performance in projects (i.e. certified or silver) and therefore a low level of

project innovation. Type-B (Fast-track PDMs) is typically associated with a mixed green performance in projects and therefore a medium to high level of project innovation. Type C (integrated PDM) is successfully applied on complex and large scale projects and exhibit better project performance in comparison to Type B, therefore it is related with a high level of project innovation as shown in Figure 1.

Different PDMs have capacities to deliver GB projects under varying constraints and needs. The constraints will vary from project to project and therefore an ideal PDM for one GB project may not be ideal for another project. For instance, Molenaar *et al.*, (2009) provided an account of best practices in GB project delivery not limited to a certain PDM: Owners that desire to achieve a specific LEED level at a fixed price prior to construction use DB-Lump Sum (LS) or DBB to specify the LEED level in procurement documents; CMR or DB-Guaranteed Maximum Price (GMP) provide the greatest likelihood of success in case level of green is to be maximized within the available budget; and DB allows for a transfer of the green liability while DBB and CMR maintain the liability with the designer/owner.

In IPD, the Primary Team Members (PTMs) may have different understanding and may be under pressure to revert back to old self-preservation concepts as the environment may not suit everyone (Matthews and Howell, 2005). Teams in IPD need to be carefully selected and must be prepared for new roles. An evident drawback of the IPD system is its dependence on individuals. Being unconventional, many times it is not understood correctly, which might cause difficulties (Kantola and Saari, 2016). New and innovative PDMs increase the number of PDMs that decision-makers can select from, for their particular project. Since the construction industry is slow to innovate, incremental rather than radical innovation would appear pragmatic. Although in comparison with traditional PDMs, innovative PDMs (i.e. IPD) can produce more innovative GB projects with better outcomes, innovation within the existing PDMs has better prospects of delivering GB projects than introducing new PDMs for every project. This is because IPD may not be suitable for some class of projects. However, it is possible that incremental innovation makes way for radical innovation. For instance, CMR system is already a well-known system; thus, a good way to move towards the unfamiliar IPD system would be to gradually add new features from the IPD system to the CMR or IPD lite in new projects (Kantola and Saari, 2016). CMR can help a project team to trial IPD features and understand how it can be implemented in practice.

In cases where radical innovation cannot be pursued by developing/using new PDMs (a case of architectural innovation), incremental innovation can be accomplished by making appropriate changes in traditional PDM along with other associated PDAs in the delivery process (a case of system innovation). The performance of a contract can be enhanced through the application of relationship management techniques, particularly the adoption of partnering concept or alliancing on projects. Even the performance of lump sum contracts can be improved through the application of a partnering concept (Blayse and Manley, 2004, Winch, 1998). The shift from competitive tendering to partnering and alliancing is an important opportunity to move towards a gain/risk sharing approach. Those in a position to innovate need to be rewarded for taking such risks. If they are so rewarded, they will have incentives both to adopt new ideas from outside the firm, and to capture the learning from problem solving to propose better ways of doing things for client (Blayse and Manley, 2004).

## CONCLUSION

Based on the review of previously published literature, this paper explored the effect of different delivery approaches on the green performance and therefore innovation of GB projects. The more innovative delivery approaches tend to result in more innovative GB projects. Different types of delivery approaches incorporate different levels of innovation and result in different GB innovation and performance. There are many factors that govern the use of innovative and radical delivery approaches. These factors can include project type, project sector, project team, complexity, etc. For instance, in case of a non-complex GB project in which design and construction stages need to be kept separate and for which low to medium level of green performance and innovation is acceptable, an incremental innovation approach in terms of DBB method can be used. In cases where a complex GB project is to be delivered with medium to high level of green performance and innovation, and where it is necessary to reconcile design and construction activities for expediting project development, fast-tracking PDMs i.e. DB and CMR seem as the reasonable choices. For delivering highly complex GB projects with high level of innovation and green performance, and where stakeholder firms are willing to show high level of collaboration under a non-traditional setup, a radical innovation approach in terms of IPD is preferable.

Some previous review studies on GBs have investigated different research trends and future directions, however the perspective of process and project innovation in GB projects as used in this review paper sets it apart from others. The paper is limited in terms of its methodology as it relied on case studies from previously published literature. While a substantial number of case studies have compared DBB, DB, CMR, and IPD delivery methods for successful GB project delivery, no studies are found that have compared life cycle oriented delivery methods (i.e. PPP/PFI) with other PDMs for GB project delivery. Future research needs to pay equal attention towards all kind of delivery processes/methods being used in GB projects. This paper used secondary data to explore the relationship between process innovation and project innovation and therefore used many assumptions. Future research relating innovation in GB projects should make use of primary data to minimize the use of assumptions and to extend the scope of research in this area to all the PDMs being used for GB projects.

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# LIFE CYCLE COST ANALYSIS: GREEN VS CONVENTIONAL BUILDINGS IN SRI LANKA

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Recently, the focus to green buildings has fore-fronted in the Sri Lankan construction industry. The green building investors continue to focus on minimising construction cost and fail to appreciate the impact on life cycle economic performances. The construction cost of green buildings tends to be higher than traditional buildings, with comparatively lower operation and maintenance costs. Therefore, this study assesses the life cycle cost of green certified industrial manufacturing building and that of a conventional building to establish the impact of sustainable features on life cycle cost. The quantitative data on construction, running and end of life cycle costs of the selected green and conventional buildings were collected and analysed using Net Present Value. The analysis shows that the construction cost of green industrial manufacturing building is about 28% higher than that of a conventional building. However, operation, maintenance and end of life cycle costs are in the range of 35 to 41%, 26 to 30% and 6 to 18% respectively lower than that of conventional building. The study found that the life cycle cost of green building is 24 to 28% less compared to conventional building. It is expected that the outcome of this research would contribute to the organisational learning of green built environment and thereby uplift the use of sustainable construction in Sri Lanka.

Keywords: green building, green rating systems, life cycle cost, Sri Lanka

## INTRODUCTION

The global implication on how heavily the built environment contributes to the natural environment had led to the evolution of green buildings over conventional buildings (Means, 2011). Green building is defined as the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from design to construction, operation, maintenance, renovation and deconstruction (U.S. Environmental Protection Agency, 2016). For example, United Nations Environment Program [UNEP] (2012) found that conventional buildings use about 40% of global energy, 40% of other resources, 25% of global water, and emit approximately 1/3rd of Green House Gas (GHG) emissions while green buildings have 19% lower aggregate operational costs, 25% of less energy, and 36% of fewer CO<sub>2</sub> emissions (U.S. General Services Administration [USGSA], 2011).

As per Dodge Data and Analytics (2016), the number of green buildings continues to double every three years and responsible for 24% of the total construction activities.

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However, there exists some barriers in deciding whether to execute a green building project. This includes higher perceived construction costs, lack of political incentives, lack of market demand, lack of public awareness, perception of green is for high-end projects only, unproven business case due to split between capital and operating costs, lack of trained or educated green building professionals, and the difficulties in accessing capital. As Wilson and Tagaza (2006) identified, perception on higher capital cost, investment on short term paybacks rather than lifecycle costing and lack of tenant demand contribute to financial barriers. Similarly, Durmus-Pedini and Ashuri (2010) pointed out that the return on investment needs more of a historical perspective to become more predictable and company budgets are not usually structured to track life cycle cost (LCC) for a project making longer term gain.

Cole (2000) highlighted that there is a widespread belief that the green buildings cost much more to build than traditional buildings. On a similar view, Kansal and Kadambari (2010) added that the initial cost of a green building is more compared to that of a conventional building while the operation cost of green building is less. A study conducted by Kats (2006), reviewing 30 green schools across the United States showed that the green schools cost more than 2% of conventional schools, but provided benefits that were 20 times more over a 20-year period. Another study that analysed 150 recent conventional and green office and school buildings in 33 states across the United States and 10 other countries, concluded that green buildings cost up to 4% more than conventional buildings and most of buildings only costing from 1-2% more than the similar type of conventional ones. The study also found that green buildings reduce energy use by an average of 33%, and that energy cost savings alone over a 20-year study period outweighed the initial cost premium (additional cost incurred to construct a green building) paid in these buildings (Kats, *et al.*, 2008).

Kats (2010) also found that green cost premium of school building is ranging from 0% to 18% and argued that the cost premium of more than 75% of the green buildings in his sample falls within the range from 0% to 4%. However, the above findings derived through a questionnaire survey with a single question responsible for quantifying cost premium. The participants of the survey were principal architects of the LEED-certified green buildings. Therefore, the reliability of the findings is questionable due to bias and method employed. Moreover, most of the studies used cost estimation methods such as comparing actual cost of green buildings against modelled cost of conventional buildings and comparing modelled cost of green buildings and conventional buildings, while a very few were able to compare the actual cost of green buildings with that of conventional buildings (Dwaikat and Ali, 2016). Moreover, previous authors have reported that higher levels of sustainability are usually linked to higher cost premium. Foregoing review further indicates that cost premium of green buildings varies within the type of buildings. For example, Bartlett and Simpson (1998) compared the estimated capital cost for energy efficient and environmentally friendly buildings and concluded that industrial green buildings incur the highest capital cost than the commercial buildings and houses. However, Dwaikat and Ali (2016) found that amongst the office, hospital, library, school, laboratory, house and apartment buildings, the highest green premium (21%) is from the office buildings. Despite, the current study analyses the LCC of green versus traditional industrial manufacturing buildings which have received the highest number of LEED certifications in Sri Lanka.

With the growing global interest on sustainability, the concept of green building construction has come to the forefront of the construction industry in Sri Lanka (Abidin, 2010). However, as studies highlighted there are some challenges for a developing

country like Sri Lanka when leading towards the sustainable construction. For example, Bombugala and Atputharajah (2010) concluded that the construction cost of green buildings is about 20-25% higher than traditional buildings. Waidyasekara and Fernando (2012) found that the green building investors focus on minimising construction cost while fail to consider the life cycle economic performances. Therefore, they completely ignore the other benefits which can be achieved through green buildings such as lower energy cost, lower annual electricity cost, reduce annual water cost and wastewater cost, lower annual fuel cost, and lower cost for waste disposal. Since cost is one of the most crucial concern in promoting green buildings there is a need to provide robust evidence to counter the high initial cost barrier. The foregoing review indicates that cost commitments of green buildings is the prime concern and of contradictory views with respect to different context, type of building, weather condition, site conditions etc. Hence, a comparative analysis of LCC of green buildings and conventional buildings in Sri Lanka would provide a clear understanding of the cost impact and thereby enable potential green investors to take informed decision about their green investments.

## **SUSTAINABLE FEATURES AND THEIR COST IMPACT**

Green buildings promote sustainability through principal areas such as sustainable sites, management, energy efficiency, water efficiency, materials and resources, indoor environmental quality, health and wellbeing (Fowler and Rauch, 2006; Nguyen, 2011). The high initial cost of green building is attributed to applications of sustainable features in the above areas. This section therefore reviews the various sustainable features that could be incorporated into green buildings and their impact on LCC. The identification of sustainable features was done based on a green rating system which is recognized worldwide. As, Fowler and Rauch (2006) highlighted LEED is the dominant and most widely used rating system around the world. To date, LEED encompasses more than 72,500 building projects over 150 countries and territories. Therefore, LEED BD+C: New Construction & Major Renovations (V.3-2009) rating system was used to identify the sustainable features that are available in the green buildings and their impact on LCC. This rating system has six (06) sustainable categories such as sustainable sites (SS), water efficiency (WE), energy and atmosphere (EA), materials and resources (MR), indoor environmental quality (IEQ), innovation in design (ID), and regional priority (RP)(USGBC, 2009). Table 1 summarises the literature findings on sustainable features and their cost impact. The cost impact of sustainable features was assessed on the four-point qualitative scale of Minimal (M), Low (L), Significant (S) and Minimal to Significant (M to S) and two-point scale of "Yes" or "No"(Davis Langdon, 2007). Further, BMCIS standard cost classification system was used in relating the sustainable features to respective LCC (main) element(s).

As observed from the Table 1, several of the sustainable elements of sustainable sites have very low initial cost impact (Davis Langdon, 2007). And those can be readily achievable at a little cost. 10 out of 14 applicable criteria in the sustainable site category contribute to the LCC of green buildings through fuel oil, electricity, service attendants, internal/ external surface and window cleaning, gardening, repairs and decoration, roads pavement, external glazing (shading), fuel, loose appliances, lamp replacement (BMCIS, 1984).

The applicable criteria of water efficiency also have a low initial cost impact, excluding the instances where the project involve high-end technologies like innovative waste water technologies (Davis Langdon, 2007). The LCC of the green building is affected by all three applicable criteria in the water efficiency category, through water charges, service

attendants, repairs and decoration, cold-water services, sanitary fittings, water meter readings, and built in fittings (BMCIS, 1984).

Energy applicable criteria requires a high degree of focus and can be challenging for many projects (Davis Langdon, 2007). In fact, those have very high initial cost with most readily calculated LCC to electricity, air conditioning and ventilation, gas meter readings, electricity meter readings, refrigerant equipment, loose appliances, repairs and decoration, and built in fittings (BMCIS, 1984).

Table 1: Summary of LCC impact of sustainable features

| Sustainable Features  |                            | Impact on Initial Cost |                | LCC Impact |    | LCC Elements (Main)  | % of Cost Savings  |
|-----------------------|----------------------------|------------------------|----------------|------------|----|--|--|
| Main Feature (Points) | No. of Applicable Criteria | Impact                 | No of Elements | Yes        | No |  |  |
| SS (26)               | 14                         | M                      | 6              | 10         | 4  | Utilities, Administrative works, Fabric, Services Cleaning, External works | Life cycle environmental benefits<br>25% reduction of Cooling cost<br>36% of fewer CO <sub>2</sub> emissions |
|                       |                            | L                      | 0              |            |    |  |  |
|                       |                            | S                      | 5              |            |    |  |  |
|                       |                            | M to S                 | 3              |            |    |  |  |
| WE (10)               | 3                          | M                      | 0              | 3          | 0  | Utilities, Administrative works, Services, External works                  | Reduce water cost by 22%   |
|                       |                            | L                      | 1              |            |    |  |  |
|                       |                            | S                      | 1              |            |    |  |  |
|                       |                            | M to S                 | 1              |            |    |  |  |
| EA (35)               | 6                          | M                      | 0              | 5          | 1  | Utilities, Services, External works  | 30% energy cost reduction  |
|                       |                            | L                      | 1              |            |    |  |  |
|                       |                            | S                      | 5              |            |    |  |  |
|                       |                            | M to S                 | 0              |            |    |  |  |
| MR (14)               | 7                          | M                      | 1              | 6          | 1  | Administrative works, Fabric, External works                               | 50%-75% solid waste management cost reduction  |
|                       |                            | L                      | 0              |            |    |  |  |
|                       |                            | S                      | 1              |            |    |  |  |
|                       |                            | M to S                 | 5              |            |    |  |  |
| IEQ (15)              | 15                         | M                      | 6              | 11         | 4  | Utilities, Administrative works, Fabric, Services Cleaning, External works | Productivity and health 70%  |
|                       |                            | L                      | 5              |            |    |  |  |
|                       |                            | S                      | 0              |            |    |  |  |
|                       |                            | M to S                 | 4              |            |    |  |  |

*Adapted from: BMCIS (1984); Kats (2006); Kats (2010); Davis Langdon (2007); USGBC (2009)*

Almost all the applicable criteria (5 out of 7) associated with material and resources have minimal and significant cost impact considering the compliance or other physical conditions (Davis Langdon, 2007). Considering the LCC impact of material and resources, all most all the applicable criteria contribute to the cost of waste disposal and fabric maintenance (BMCIS, 1984). With the building and material reuse greatly reduce the construction and demolition waste.

The applicable criteria in IEQ are readily achievable with low costs (Davis Langdon, 2007) and contribute to the LCC through glazing and windows, built in furniture, ceiling,

wall and floor finishes, air conditioning and ventilation, meter readings, lighting, lamp replacement, built in fittings, internal/ external surface and window cleaning, electricity, gas and service attendants (BMCIS, 1984). The points allocated for sustainable features; innovation in design and regional priority are either achieved with a minimal cost impact or the application of these two features is covered by other sustainable features which discussed earlier (Davis Langdon, 2007).

However, in return sustainable applicable criteria can bring benefits like conserve natural resources, enhance occupant comfort and health, reduce operating costs, create value within the compatible market, positive impact on the construction industry etc. (Durmus-Pedini and Ashuri, 2010). According to Hwang and Tan (2012), energy efficiency applicable criteria bring incremental economic as well as environmental benefits. Similarly, Waidyasekara and Fernando (2012) indicated that preservation of water resources for future generation and lower potable water resources are benefits due to water efficiency applicable criteria on green buildings. However, Kats (2006) analysed the cost benefits of green buildings and highlighted that green buildings ensure to achieve 13% saving of maintenance cost, 19% of lower aggregate operational cost, 22% reduction of water cost, 25% reduction of cooling cost, 36% of fewer CO<sub>2</sub> emissions, 30% of energy cost reduction, 50%-75% of solid waste management and cost reduction of productivity and health is 70%. Table 1 divides those benefits to the identified categories of sustainable features.

As identified in the above, the impact of sustainable features to the LCC of green buildings are attributed to number of costs elements in the operation and maintenance stage of green buildings. Therefore, it is difficult to measure the impact of sustainable features on a single entity of cost elements and the most appropriate way to reflect this impact is by considering the costs of green building over its life cycle and compare with that of a conventional building.

## RESEARCH METHODS

A comparative analysis between a green building and conventional building was adopted for this study. Prior to this, a preliminary analysis was carried out into green certified buildings to identify the most significant green space type, and the level of sustainability achievement in terms of main sustainable features within it. This analysis enabled to identify the relationship between sustainable features and its impact on initial cost as well as LCC. The preliminary analysis was performed on the secondary data collected from 38 of LEED Green certified buildings in Sri Lanka. Amongst eight (08) green industrial manufacturing cases which certified under LEED BD+C: New Construction & Major Renovations (V.3-2009) rating system were screened for further study. The eight (08) industrial manufacturing cases included Garment (04), Printing and Packaging (03) and Cleaning Products (01) buildings. The age, Net Internal Area (NIA), and occupancy rates differ for each case. However, the building height is mostly limited to 01 or 02 floors. Subsequently, a comparative analysis was performed by selecting two (02) green buildings and a conventional building with similar physical and performance characteristics. When selecting these two cases, the age, NIA, and occupancy rate factors were considered. The conventional case was identified conveniently, then careful selection of two (02) green cases with similar characteristics was carried out by eliminating the cases which have considerable differences in physical characteristics. Relevant real-life cost data: construction, annualised and periodic operation and maintenance, and simulated end of life cycle cost data were collected through document analysis according to the standard cost categories suggested by Building Maintenance

Cost Information Service (BMCIS). The documents relevant to the initial green building construction budget, and operation and maintenance expenditure budget records were used to collect the cost data. Simultaneously, physical and performance data such as constructed year, number of floors, NIA, life cycle, building height and number of occupants were collected from the selected green and conventional buildings. Statistical analysis techniques: NPV and sensitivity analysis was used to measure the LCC of green buildings. All the costs were escalated at assumed inflation rate and then discounted for the base year. The analysis was carried out for 50 years and the discount rate (4.26%) was obtained from the Central Bank of Sri Lanka.

## DATA ANALYSIS AND FINDINGS

### Preliminary Analysis and Findings

According to published information at USGBC Directory, under LEED category a total of 74 buildings have been registered to date. Of which only 38 buildings have achieved the certification (USGBC, 2017). Table 2 presents the profile of LEED certified green buildings which include green space type, and certification type.

Table 2: Demographic profile of the LEED certified green buildings in Sri Lanka

| Demographic Information                  |                            | Number | Percentage |
|--|----------------------------|--------|------------|
| Green Space Types                        | Laboratory                 | 1      |            |
|  | Warehouse and Distribution | 1      |            |
|  | Higher Education           | 2      |            |
|  | Retail                     | 3      |            |
|  | Lodging                    | 6      |            |
|  | Office                     | 7      |            |
|  | Industrial Manufacturing   | 18     |            |
| Green Industrial Manufacturing Buildings | LEED ID+C: CI(v3)          | 0      |            |
|  | LEED O+M: EB (v2)          | 0      |            |
|  | LEED BD+C: C&S (v3)        | 1      |            |
|  | LEED O+M: EB (v3)          | 4      |            |
|  | LEED BD+C: NC (v2)         | 5      |            |
|  | LEED BD+C: NC (v3)         | 8      |            |

According to Table 2, mostly (47%) available green space type in Sri Lanka is the industrial manufacturing buildings. Respectively, office (18%), lodging (16%), retail (8%), higher education (5%), warehouse (3%) and laboratories (3%) obtained the remaining of green space available in Sri Lanka. Most, over 40% (8 out of 18) of the industrial manufacturing facilities are certified under the LEED BD+C: New Construction (v3 -2009) rating system. Therefore, the study focuses on the LCC of green industrial manufacturing buildings in Sri Lanka, which certified under LEED BD+C: New Construction (v3 -2009). This provides the total population of 08 buildings. However, this initial research focused on a single case from this population. The logical justification for the case selection is specified in the 'Methods' section.

*Level of Achievement of Sustainable Features*

The points allocated for each sustainable feature was compared with earned points and identified the under scored areas of eight (08) industrial manufacturing buildings in the LEED BD+C: New Construction (v3 -2009) rating system. Figure 1 illustrates the on average points earned out of the possible points allocated for each main sustainable feature.

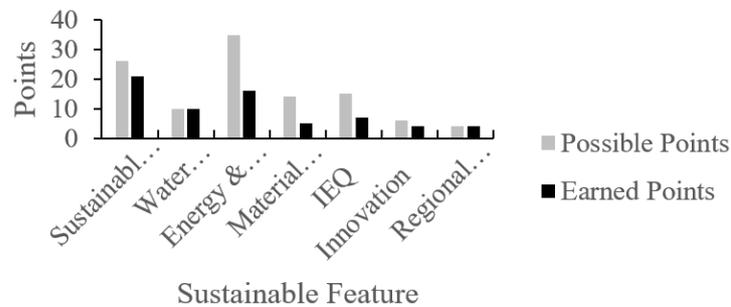


Figure 1: Level of achievement of sustainable features

As shown in Figure 1, water efficiency and regional priority features have achieved 100% satisfaction by earning the possible points allocated. Similarly, sustainable sites and innovation in design features have also been in a satisfactory level with the score of over 80% of achievement. In terms of energy efficiency and IEQ features, the industrial buildings have earned less than 50% of the allocated points while only a 36% is achieved in terms of material and resources.

In terms of energy efficiency, IEQ and material and resources, the certified I buildings have scored fewer points. This is due to the implication of those features consumes significant initial costs. Materials and resources, this feature is classified into two distinct categories with; A) most projects pursuing the credits related to construction waste management, local content and recycled content, and B) very few pursuing the other credits like material reuse, renewable materials, building reuse and certified wood. Often, the investors go for the projects in the category A due to the achievement of those features requires less cost compared to projects in the category B. Following this preliminary analysis, a detailed analysis on LCC was performed of a green industrial building compared to that of a conventional building. The next section presents the LCC analysis.

### Case Study Analysis and Findings

A cross case analysis of NPV between green and conventional buildings was performed. Though, it is difficult to find 100% identical buildings in the real world, the study managed to find a matching conventional building for the cost analysis. Having considered the factors influencing the sustainability, a conventional building constructed in similar location and climatic condition, with similar tenure, i.e. management style and quality of the selected green building was chosen. In addition, physical and performance characteristics such as year of construction, number of floors, shape, NIA, designed life cycle, building height and number of occupants were matched between the two buildings. Table 3 presents the profile of the selected three buildings.

Table 3: Profile of the cases

| Building     | Year | No. of Floors | Shape       | NIA (m2) | Life Cycle | Building height(m) | No. of Occupants | Type of Function |
|--------------|------|---------------|-------------|----------|------------|--------------------|------------------|------------------|
| Green 1      | 2013 | 1             | Rectangular | 3,809    | 50         | 3.8                | 1,400            | Garment          |
| Green 2      | 2013 | 1             | Rectangular | 3,567    | 50         | 4.0                | 1310             | Garment          |
| Conventional | 2013 | 2             | Rectangular | 4,032    | 50         | 7.8                | 1,340            | Garment          |

According to Table 3, the established year, shape of the building and designed life cycle are same for the selected three cases, whereas green building is a single storey building and the parameters: NIA and building height are less than that of conventional building. However, the number of occupants in the organizations are closely related.

*LCC comparison between green and conventional buildings*

As discussed in the methodology section, the NPV of the two cases were calculated to 50-year life cycle of buildings using the discount rate of 4.26%. Relevant cost data required for the NPV calculations were collected according to the standard cost categories suggested by Building Maintenance Cost Information Service (BMCIS). Table 4 illustrates the summary of comparison.

Table 4: LCC between green and conventional buildings

| LCC   | Green Building (GB) cost per Unit Area (LKR/m2) |            | Conventional Building | Green Building Cost Impact |                      |
|---|---|------------|-----------------------|----------------------------|----------------------|
|   | GB1   | GB2        |                       | PV of GB1 – PV of CB       | PV of GB2 – PV of CB |
|   |   |            |                       | PV of GB1 * 100%           | PV of GB2 * 100%     |
| Construction  | 80,306.53                                       | 81,081.68  | 58,699.34             | 27%                        | 28%                  |
| Operation   | 347,042.41                                      | 333,689.04 | 469,918.75            | -35%                       | -41%                 |
| Maintenance   | 69,408.48                                       | 67,278.20  | 87,763.17             | -26%                       | -30%                 |
| End of life cycle   | 180.88  | 251.03     | 192.04                | -6%                        | -18%                 |
| NPV   | 496,938.29                                      | 482,299.95 | 616,573.31            |                            |                      |
| Green Building LCC Impact = $\frac{\text{LCC of Green Building} - \text{LCC of Conventional Building}}{\text{LCC of Green Building}} * 100\%$ |   |            |                       | -24%                       | -28%                 |

All the costs were discounted back to year 2013 and normalised into net internal area. According to Table 4, the construction cost of the green building is 27 to 28% higher than the construction cost of the conventional building due to storm water design, heat island effect-roof, sewage treatment plant, optimize energy performance, certified wood and LEED professional fees. However, other costs: operation, maintenance and end of life cycle cost of the green building are comparably less than the conventional building, respectively by 35 to 41%, 26 to 30% and 6 to 18% due to energy cost reduction by 40 to 50%, water consumption reduction by 50 to 60%, 95% waste recycling, reduced absenteeism by 2%. And considering the LCC of green building it's less than the LCC of conventional building by 24 to 28%.

**DISCUSSION AND CONCLUSIONS**

Previous studies suggest that the upfront cost issue is one of the main barriers exist when deciding whether to execute a green building project (Dodge Data & Analytics, 2016; Durmus-Pedini and Ashuri, 2010; Wilson and Tagaza, 2006). However, Dwaikat and Ali (2016) stated that a reasonable level of sustainable design can be incorporated into most building types at little or no additional cost. Moreover, the high initial cost barrier is a result of sustainable features incorporated into green buildings. Previous studies found that most of the applicable criteria in sustainable features like sustainable sites, water

efficiency and IEQ are readily achievable with low costs, whereas, many applicable criteria in energy and atmosphere require a high degree of focus and can be challenging for many green building projects. The initial cost impact of almost all the applicable criteria of material and resources changes from minimal to significant in green buildings. This research indicates that the green building applicable criteria under energy and atmosphere, material and resources and indoor environmental quality is incorporated less in the green buildings in Sri Lanka. It seems that high initial cost of those criteria Prevents green buildings from achieving better sustainability levels.

Further, Bombugala and Atputharajah (2010) concluded through participants' survey that the construction cost of green buildings is 20-25% higher than traditional buildings in Sri Lanka. The findings of this study show that the construction cost of green building is 27 to 28% higher than that of traditional building. Therefore, the findings of the study are similar with the literature findings. However, the operation, maintenance, and end of life costs are less than that of conventional buildings by 35 to 41%, 26 to 30% and 6 to 18% respectively. Altogether, the LCC of green building is 24 to 28% less than the conventional buildings due to the LCC benefits of green buildings. Therefore, the investors can use those cost analyses as a base to execute green building projects.

However, this study is limited to three cases due to the lack of green industrial manufacturing buildings in Sri Lanka and the accessibility constraints of the cost data of industrial manufacturing buildings. It is believed that other factors such as project location, building type, site conditions, local climate and time integrate sustainable building practices into projects and architectural and engineering design time necessary etc. (Kats, *et al.*, 2008) could also affect the green building cost. Therefore, it is recommended the future studies to consider these and identify its impact on LCC and thereby facilitate green building investors to take better decisions of their green investments.

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# TRADE-OFF BETWEEN LIFE CYCLE COST AND GREENHOUSE GAS EMISSION IN CONSTRUCTION PROJECTS

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Sustainability challenges brought forth the need to develop and implement the life cycle perspective of a process in construction industry. In this paper two aspects of life cycle will be discussed: life cycle cost analysis (LCCA) and life cycle assessment (LCA). In a project, LCCA provides a decision support in selecting a suitable alternative to executing a work package based on its financial benefits while in LCA, decision is based on the environmental impact. An attempt is made here to develop a trade-off model integrating the LCCA with LCA so that the financial benefits and sustainability in construction projects are understood simultaneously. The performance of the model is checked on a zero energy 2-storey residential building which demonstrates the trade-off between the LCC and LCA in terms of Greenhouse Gas (GHG) emission in  $CO_2$  equivalent. A genetic algorithm (GA) optimization model is used to establish a trade-off between LCC and GHG emission. The results show that the slab, exterior finish, stem wall, and footing construction produce around 60 % of LCC and GHG emission. The proposed model may help the stakeholders to study the long-term analysis of construction projects not limited to construction phase alone.

Keywords: life cycle, greenhouse gas, sustainability, genetic algorithm, trade-off

## INTRODUCTION

The contribution of the construction industry to the global economy is about one-tenth of world's total GDP (PwC, 2015). The growth of construction industry leads to further consumption of resources at a higher rate. The construction industry is dependent on the environment for most of the primary and essential resources. Also, construction activities are known to bear a clear impact on the environment due to the use of excessive consumption of the resource. Thus, the construction industry is not only a significant contributor to the economic growth; it also affects environmental aspects. The residential and commercial buildings contribute 7.9% of total anthropogenic Greenhouse Gas (GHG) emission in terms of  $CO_2$  (Parry *et al.*, 2007). A construction activity contributes one-third of the GHG emission throughout its repair, maintenance, and operational phase (UNEP, 2009). Therefore it is imperative to make it an important aspect of planning stage so that early mitigation can be done.

Life cycle assessment (LCA) is an indispensable part of sustainability concept. According to ISO 15686, Part 5, to establish a robust sustainable construction, life cycle cost

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analysis (LCCA) should be included with the LCA. But in several studies, LCA is done neglecting the economic aspect, leading to little interest of construction professional towards environment impact analysis. It is, therefore, essential that at the time of life cycle assessment (LCA), the economic consequences of an alternative mode of execution must be taken into consideration so that the decision of optimal execution alternative can be made with respect to the entire life span of a construction project. However, financial characteristics of the decisions are not considered in most of the developed LCA methodology. Even the ISO 14040:2006 standard for LCA practice has not mentioned the incorporation of cost analysis with LCA. The main focus is on the integration of reduction of environment impact and LCC of erection activities. The study shows how LCA and LCCA together can be used as a tool in decision-making for construction sustainability.

LCCA and LCA despite being relatively similar in names, have major differences in term of methodology, origin, and problem statement. They provide solutions to two different problems. LCA deals with the environmental performance of a project which is determined by integrating all major inter-connected processes, all-important resource, and consumption flow, regardless of their impact on the construction activity. LCCA compares the cost-effectiveness of alternatives from the perspective of an economic decision maker. These differences in their purpose reflect in their scope and methodology.

The significant aspects of LCCA should be included in LCA so that a relationship can be established between environmental and cost consequences, thereby providing the most cost-effective means to lessen the environmental impact (Norris, 2000). Therefore, the goal of this work is to develop an optimization model to give a set of optimal alternatives of an activity's execution mode from the project life cycle prospect. To achieve this, a literature review has been done on the existing studies of LCA, LCCA and on their integration. By understanding the existing limitations, an optimization model is developed to fulfill the proposed objective.

## **LITERATURE REVIEW**

Literature study shows that the past study is done in three different groups namely LCA, LCCA, and integrated model considering life cycle. Major work based on the life cycle is done on LCA of construction. Though the concept of LCCA is older than LCA, due to lack of practice and standards, it is yet to be explored in the construction industry (Arditi and Messiah, 1996). Some studies in the past have tried to integrate LCA and LCCA to deal with the environment and economic aspect in the same dimension.

### **Life Cycle Assessment**

Life cycle assessment (LCA) approach assesses environment impact considering the entire life cycle of a product. The LCA method analyses a large amount of inventory data to estimate environment impact of construction or assembly process. LCA essentially consists of four steps - goal and scope definition, inventory analysis, impact assessment, and interpretation. The input data required to analyse LCA is provided by life cycle inventory (LCI) as quantified environmental information. The data needed for the LCA are construction data, usage data, and demolition data (Norris, 2001). Some of the studies assumed in the construction phase have negligible environment impact (Junnala and Horvath, 2003) while others have considered this phase to be a compelling factor influencing the environment (Hendrickson and Horvath, 2000).

### Life Cycle Cost Analysis

It is important to consider life cycle costs when evaluating the construction alternatives of civil infrastructure. Asiedu and Gu (1998) reported that most of the LCC (around 70 to 80 % of a process) is committed at the time of design phase without considering any LCCA (Arditi and Messiha, 1999). Even though the concept of LCCA was recognised a century ago but the thorough application started only two to three decades back. The main obstruction in LCCA is that it is time intensive, costly, computationally exhaustive, less standardized and there is unavailability of a coherent methodology to evaluate LCC (Novick, 1993). The researcher also asserts that collection and execution of available data for LCCA is important for a construction project. The data required for the LCCA are cost data, quality data, physical data, performance data, and occupancy data (Schade, 2009). In spite of the aforementioned drawbacks, LCCA is gaining recognition in construction industry due to its indubitable benefits towards life cycle of a project. It is a tool which can give insight to the decision maker on the options which will be more financially rewarding at the time of planning stage itself (Gluch and Baumann, 2003).

### Integrated Model Considering Life Cycle

It is seen that LCA and LCCA are fundamentally different in their methods of evaluation. LCA and LCCA performed quite well and gave satisfactory results when considered separately by decision makers (Settanni, 2008). When merged together, the differences in framework lead to inconsistent and obscure results (Heijungs *et al.*, 2012). Some studies identified this challenge and tried to find an optimal solution by aligning them together. Studies related to the integration of LCCA and LCA are established in highway pavement design, optimal HVAC system for building and choice of economical construction material which also bears least environmental impact (Zhang *et al.*, 2008; Heijungs *et al.*, 2012).

Despite voids in the study of the integration of LCA and LCCA, numerous initiatives to effectively harmonize them have been taken in the past. Zhang *et al.*, (2008) provided a pavement overlay system to indicate sustainability by integrating LCCA and LCA. The researchers divided LCA in six modules starting from material acquisition to the product end of life and LCCA into two costs namely the agency cost which includes construction and maintenance cost and social cost comprising of user and environment cost. Kendall *et al.*, (2008) also developed an integrated LCA and LCCA model for choosing the better alternative for a concrete bridge deck from two promising options: conventional mechanical steel joint and engineered cementitious composites (ECC) link slab design. The study found that ECC offers more monetary benefits and reduced environmental impacts as compared to the conventional design.

A research project CILECCTA developed a life cycle cost and assessment model based on probabilistic approach with the aim of bringing together economic cost and environmental implications of a construction project (Vennström *et al.*, 2010). The model developed different matrices combined in an eco-portfolio diagram for an integrated LCCA and LCA discipline which compares cost and environmental effect by assigning relative weights. A probabilistic model is used by defining the possible value of the rate of change and is converged within a certain range for further utilization in calculations. With this approach, the researchers also try to resolve the issue of uncertainty in life cycle analysis (Fawcett *et al.*, 2012).

Fesanghary *et al.*, (2011) developed an integrated model for LCCA and LCA based on harmonic search (HS) algorithm to minimize LCC and GHG emission of building

envelope. The envelope is defined by a number of factors like the geometry of the building, weather status, HVAC system, lighting and inhabitants' schedule. The initial value for decision variable (envelope material) is assigned by HS, and an optimal envelope is found through simulation results. A multi-objective optimization model is developed by using non-dominating sorting genetic algorithm (NSGA) to analyse life-cycle costs and environmental impacts by Cerri *et al.*, (2012). The researchers compared the developed model with two other optimization models and found better results with NSGA.

### OBJECTIVE AND RESEARCH METHODOLOGY

The objective of this paper is to develop a trade-off model that is able to provide the best alternatives of the cost and environmental aspect at the time of planning stage of a construction project. A GA-based optimization model is developed which is able to choose the optimal set of alternatives for the construction activities. GA has been widely used to evaluate optimal solution for similar problems due to ease of implementation and for finding comparatively better solution (Cerri *et al.*, 2012). The essential terminologies used in the GA are population - set of all possible solutions for the given problem; chromosomes - one possible solution to the given problem; gene - one element position of a chromosome. An example of a representation of chromosome for the study is shown in Figure 1.

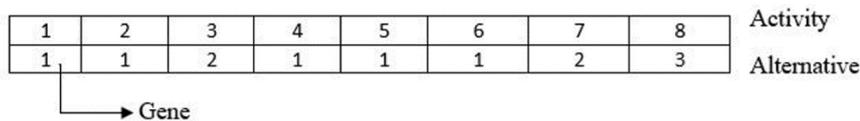


Figure 1: Representation of chromosome

The methodology used for the developed model is shown in Figure 2. There a number of alternatives are identified to execute the construction activity. The equipment and material used in each of the alternatives are listed, and the corresponding life cycle cost and the GHG emission for the same alternative are calculated for all activities.

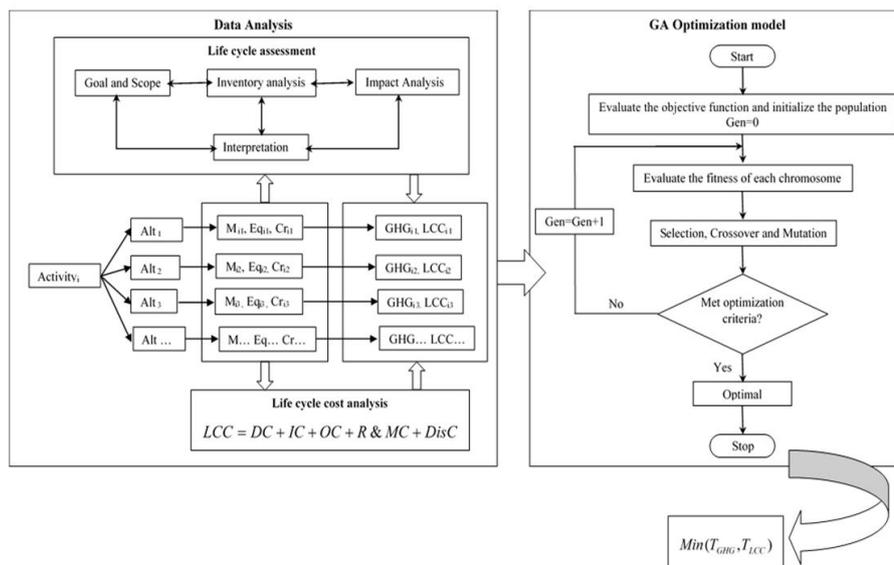


Figure 2: Flowchart of proposed model

The GA initializes the population by assigning one alternative each for all activities randomly and thus obtains initial solutions (initial population) of the total project life

cycle cost and GHG emissions. Subsequently, the program considers another population based on selection, crossover, and mutation process to find another set of solutions. Each child solution (next population) is obtained by comparing the parents' solution (previous population). Based on their fitness value, the child population is generated. In this manner, the GA sets new values for decision variables based on the obtained results, and another iteration is performed to evaluate the new set of solution. This process is continued until a pre-specified maximum number of iterations (i.e., 100) or any other stopping criterion for the GA is reached. To validate the precision and utilities of optimization model a case study is taken from the literature.

**Bi-objective Optimization for LCCA and LCA**

In this paper, the goal of the study is optimization of LCCA and GHG emission as a bi-objective optimization problem. To develop the optimization model, genetic algorithm is used based on Darwin’s theory of evolution proposed by John Holland in 1975.

**Genetic Algorithm (GA)**

The GA uses principles of selection, crossover, and mutation to generate optimal solutions. Selection is the process that determines which solutions from the population are to be preserved based on fitness values. Commonly used selection operators are tournament selection, roulette wheel selection, proportionate selection, etc. Crossover process is used to create new population from the existing population in mating pool. Mutation is a small and random change in the existing chromosome's gene to get a new solution.

The purpose of mutation is to maintain diversity within the population. In the presented model, tournament selection process is used followed by simulated binary crossover (SBX) and polynomial mutation process. Elite preservation is also used to attain the best optimal solution. Elite preservation is a process in which population is allowed to carry over the best solution for the current generation to the next generation so that the good solution is not diminished in the process. The GA parameters are considered as follows: Population size 20\*P; P=11 (number of variables which in this case is equal to the number of activities); generation = 100; crossover probability = 0.9; mutation probability = 2/P (Deb, 2003).

The objective function and decision variable are as follows:

$$Objective\ Function = Min (T_{GHG}, T_{LCC}) \tag{1}$$

Subjected to:

$$T_{GHG} = \sum_{i=1}^n GHG_i \tag{2}$$

$GHG = CO_2$  equivalent produced by greenhouse gases ( $CO_2, CH_4, N_2O$ ) emission from material and equipment used in corresponding activities.

$$T_{LCC} = \sum_{i=1}^n LCC_i \tag{3}$$

$$LCC = DC + IC + OC + R \& MC + DisC \tag{4}$$

Where,  $T_{GHG}$  is the total GHG emission;  $T_{LCC}$  is the total life cycle cost of project;  $LCC_i$  is LCC of activity i and  $GHG_i$  is GHG emission of activity i. DC represents direct cost;

IC - indirect cost, OC - operational cost (OC=0); R&MC - repair and maintenance cost (included in the available activity data); DisC- disposal cost (not included in the study).

## MODEL IMPLEMENTATION

To evaluate the effectiveness of the proposed model a case study has been chosen from literature. The algorithm for the proposed model is coded in MATLAB R2015b.

### Case Study

The case study of a two storey zero net energy building is considered from literature (Ozcan-Deniz *et al.*, 2011) to demonstrate the utility of the proposed optimization model. The study considers 11 activities, each activity possessing more than one execution alternatives as shown in Table 1. For example, activity 1 can be performed in two ways with cost implications of US\$5039.7 and US\$4924.9 respectively. The corresponding GHG emission is listed beside each alternative in Table 1 to provide input to the optimization model.

The LCC data is modified from the real cost data. The operational cost for energy consumption is taken as zero for this building as it is a zero net energy building as mentioned earlier. Repair and maintenance cost is added for individual alternatives in only those activities which require future maintenance. Some other costs included in life cycle costing such as the cost of disposal, recycling, etc. are not considered due to the lack of data.

Table 1: Activity data and execution alternatives

| Activity        | Alternative 1 |         | Alternative 2 |         | Alternative 3 |         | Alternative 4 |         |
|-----------------|---------------|---------|---------------|---------|---------------|---------|---------------|---------|
|                 | LCC           | GHG     | LCC           | GHG     | LCC           | GHG     | LCC           | GHG     |
| Site work       | 5039.7        | 1728.9  | 4924.9        | 2938.4  |               |         |               |         |
| Excavation      | 360.7         | 317.7   | 297.1         | 399.3   |               |         |               |         |
| Footing         | 84232.7       | 9541.2  | 90392.3       | 9715.5  |               |         |               |         |
| Stem wall       | 80056.1       | 9647.7  | 86174.9       | 9822    |               |         |               |         |
| Slab            | 14636.1       | 15790.3 | 16758.6       | 15964.7 |               |         |               |         |
| Exterior wall   | 40497.1       | 9152.5  | 69064.4       | 35518.3 | 131206.9      | 35518.3 |               |         |
| Interior wall   | 76650.8       | 6228.3  | 95415.5       | 6246.2  | 51623.2       | 15056.4 | 58480.2       | 15062.4 |
| Flooring        | 66598.4       | 236     | 62465.2       | 544.3   | 50238.9       | 3030.7  |               |         |
| Exterior finish | 159486.5      | 4219.2  | 250999.8      | 61163.9 |               |         |               |         |
| Interior finish | 4006.8        | 256     | 1746.6        | 256     |               |         |               |         |
| Roof            | 119558.2      | 12871.7 | 71966.1       | 6747.3  |               |         |               |         |

Where LCC is in term of (US\$) and GHG in term of (kg CO<sub>2</sub> eq.).

The repair and maintenance cost (R&MC) is considered for activities 6, 7, 8, 9, and 11. To demonstrate the calculation of R&MC, flooring construction is taken with bamboo flooring as its first alternative. The data required for the calculations are the life of the material, maintenance period, the life of the building and floor area.

$$T_{R\&MC} = \left( \frac{\text{life of structure}}{\text{life of material}} - 1 \right) \times \text{Cost} + \frac{R \& MC \times \text{life of structure}}{R \& M \text{ period}} \quad (5)$$

Where,  $T_{R\&MC}$  is total repair and maintenance cost of activity; life of structure = 50 years, life of material = 25 years, Cost = US\$28,341.60 floor area = 2940sq. ft., R&M period = 2 years, R&MC =0.1349 per sq. ft. (Ozcan-Deniz *et al.*, 2011; Moussatche and Languell, 2001)

So, R&MC = US\$38,256.75 and Total LCC = US\$66,598.35

## RESULTS AND DISCUSSION

To check the effectiveness of the developed model, a previous problem is analysed and comparative results were found (Ozcan-Deniz *et al.*, 2011). Based on the input as explained earlier, the GA program generates the result as shown in Table 2. The obtained optimal solutions are further scrutinised activity wise to provide further insight to the decision maker. Each project and their owners come with different requirements and priorities. To address this, results are discussed under three common priorities which can be preferred in any project. The first one giving the highest priority (weight=1) to cost and zero priority to the environment impact, second giving the highest priority (weight =1) to the environment impact and zero priority to cost and lastly giving equal priorities to both the objectives (weights for the two objectives=0.5). The three optimal solutions based on these three favourable conditions are:

Table 2: Optimal solution

| S.No. | A 1 | A 2 | A 3 | A 4 | A 5 | A 6 | A 7 | A 8 | A 9 | A 10 | A 11 | $T_{LCC}$<br>(US\$) | $T_{GHG}$<br>(kg $CO_2$ eq.) |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|---------------------|------------------------------|
| 1     | 2   | 2   | 1   | 1   | 1   | 1   | 3   | 3   | 1   | 2    | 2    | 520,560.6           | 67,950.8                     |
| 2     | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 2    | 2    | 537,098.5           | 63,865.0                     |
| 3     | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 3   | 1   | 2    | 2    | 520,739.0           | 66,659.7                     |

(i) For the first case, the optimal solution considers alternative 1 for activities 3 to 6 and 9; alternative 2 for activities 1, 2, 10 and 11; and alternative 3 for activities 7 and 8. The corresponding optimal solution is US\$520,560.6 for LCC and 67,950.8 kg  $CO_2$  eq. for GHG emission.

(ii) For the second case, the optimal solution considers alternative 1 for activities 1 to 9 and alternative 2 for activities 10 and 11. The corresponding optimal solution is US\$537,098.5 or LCC and 63,865.0 kg  $CO_2$  eq. for GHG emission.

(iii) For the third case, the optimal solution is obtained by the GA model assuming equal relative weight to LCC and GHG emission; the solution considers alternative 1 for activities 1 to 7 and 9; alternative 2 for activities 10 and 11 and alternative 3 for activity 8. The corresponding optimal solution is US\$520,739.0 for LCC and 66,659.7 kg  $CO_2$  eq. for GHG emission.

The LCC and GHG values are plotted on activity basis for all the three cases (See Figures 3(a), 3(b) and 4) so that the variation can be seen across the activities.

The results are summarised to distinguish the activities with high GHG emission from the low ones. Similarly, the activities with high LCC can be distinguished from the low ones. These will be useful for planning future alternatives for a given activity.

The optimal solution shows that about one-fourth (24 %) of the total GHG emission is contributed by slab construction which makes it the most prominent activity to be considered with respect to the GHG emission followed by stem wall (16%) and footing (15%). The cost of the exterior finish is maximum with 18 % share in the total LCC. This is followed by footing (16%) and stem wall (15%). These three constitute the top three high-cost activities.

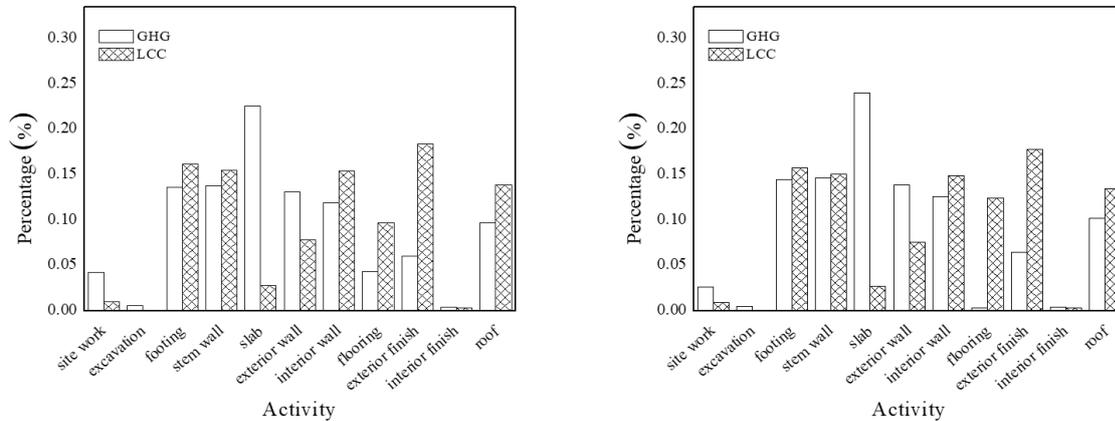


Figure 3: Activity LCC and GHG emission in percentage (a) for min LCC (b) for min GHG

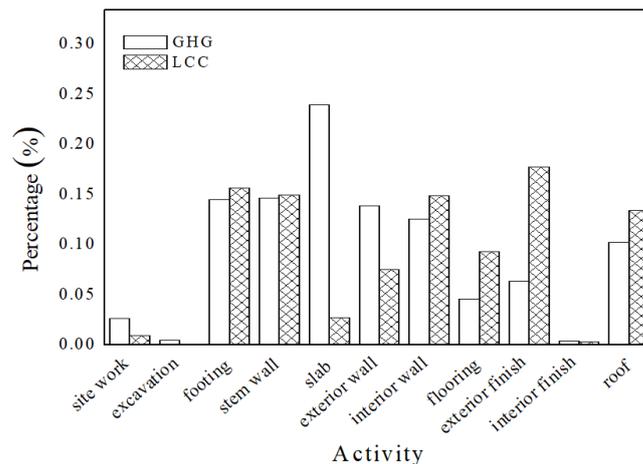


Figure 4: Activity LCC and GHG emission in percentage (Optimal solution considering equal weight to LCC and GHG emission)

## CONCLUSIONS

In the construction industry, a number of intrinsic characteristics directly or indirectly affect the environment. On the other hand in the today's competitive market, the cost is an essential factor for any practitioner to survive in the industry. This study gives an insight on how the environment and economic aspects of a construction project can be harmonised. To address this issue, an optimization model is developed to integrate life cycle cost and environment impact of the construction industry. A GA program is developed to analyse the trade-off between LCC and GHG emission. The developed model has been demonstrated by a case study with 11 activities having different alternatives for two objectives (i) minimization of LCC and (ii) minimization of GHG emission. The result shows that the slab, stem wall, and footing construction generate large junk (around 55 %) of total GHG emission. Similarly, exterior finish, footing, and stem wall constitute around half (50 %) of the total LCC. So it is advisable to look

forward to better alternatives for those activities which accelerate the cost and GHG emissions, thus minimizing the project LCC and GHG emissions. Further research is needed to analyse the life cycle cost by taking data on disposal and recycle cost into account so that a clear view can be developed before taking the decision.

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# **HEALTH, SAFETY AND WELLBEING**

# THE HUMAN CONTRIBUTION TO UNSAFE CONSTRUCTION ACTS AND CONDITIONS IN THE CENTRAL REGION OF SOUTH AFRICA

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There are limited empirical studies on acts and conditions that influence safety on construction sites in South Africa. To close this gap, two phenomenology research projects assessed the link between accidents, unsafe acts, and poor working conditions on construction sites in South Africa. The studies show that there is a relationship between unsafe acts, working conditions, and accidents. The studies also affirm the notion that accidents stem from human contributions through varying failure types. For example, situational failure occurs when workers violate standard operating procedures and ignore safety rules due to work pressures. Also, unsafe working conditions are either created by workers when proper use of tools, plants, and equipment are ignored, or set up by management when workers are forced to work at heights and inclement weather without adequate protection. The two reported studies reinforce the view that people produce unsafe acts that are implicated in errors and violations that leads to harm in the workplace. There is, therefore, a major scope for tackling routine and situational failures on construction sites.

Keywords: construction industry, unsafe acts, unsafe conditions, site work

## BACKGROUND

In 'working construction,' the nature of the industry regarding the kind of work and its impact on people is illustrated (Paap, 2006). Paap (2006) and other authors show that physical work in construction is a dangerous task that is undertaken in outdoor operations. The physical work may involve working at heights, and working with complicated on-site machinery (Carter and Smith, 2006; Chi, Yang, and Chen, 2009; Chi, Han, and Kim, 2012; Dong and Platner, 2004). The intricacies of physical construction activities combine with the attitudes and behaviours of people to produce consequences that are detrimental to their health, safety, and wellbeing.

Human failure due to violations, for example, could emerge from systemic problems in the workplace (Lingard, Pink, Hayes, McDermott, and Harley, 2016). An analogy of this idea is when people assume different roles on a project site based on their health and safety (H&S) predispositions that could be influenced by time pressures, experience, risk perception, and safety culture (Choudhry and Fang, 2008; Oswald, Sherratt, and Smith, 2013). The prevailing culture in a workplace can either be safe or unsafe (Reason, 1998; Zou, 2010). Where unsafe culture exists, it is more likely to be involved in the causation

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of organisational rather than an individual accident (Reason, 1998; Zou, 2010). The work of Reason on accident causation shows how organisational factors, local workplace conditions, and individual or team unsafe acts could break down defences in a system and produce adverse outcomes (Reason, 2016).

When workers exhibit traits and actions considered dangerous in a workplace, they are sometimes likened to be 'human-as-hazard' (Reason, 2008). One reason for referring to workers as a hazard is the observed ability of the acts of people to break down the defences within a system with detrimental results that implicate safety (Reason, 1990; Reason, 2008). For example, through human fallibility (which can only be moderated) activated hazards may become risks that people, 'as agents,' convert into accidents through human failure (errors and violations) (Reason, 1990, 1995, 1998; Reason, 2008).

In construction, management actions/inactions, unsafe acts of workers, non-human-related events, hazardous conditions within normal construction site activities, have been established as the root causes of accidents (Abdelhamid and Everett, 2000). Some of these causes 'morph' and continue to harm people in South African construction (Emuze and Smallwood, 2012a; Emuze and Smallwood, 2012b; Emuze, van Eeden, and Geminiani, 2015).

Although accidents could be explained in different ways depending on the aspects addressed by a model (Katsakiori, Sakellaropoulos, and Manatakis, 2009), the critical theories found in 'person model' and 'system model' of unsafe acts indict the contributions of individuals to accident manifestation. According to Reason (2008), the person model views unsafe acts as arising from wayward mental processes in the form of forgetfulness, inattention, distraction, carelessness, poor motivation, inadequate knowledge, skills and experience, culpable negligence and recklessness. In contrast to the person model, a system model goes beyond local events to identify contributory factors in the workplace, organisation, and the complete system in a context. The implication of the system view is that frontline construction workers may not always be the instigators of an accident. Rather, resident pathogens that have accumulated for a long time in the workplace may have instigated the manifestation of an accident (Reason, 1990, 2016). The resident pathogens metaphor lay emphasis on causal factors existing in a system before an accident sequence begins (Moray, 2005). The disadvantage of the system model is its utmost attention to the system, which ignores human contributions and then instils "learned helplessness" in people (Reason, 2008: 103).

As a result of the human contributions mentioned above, two exploratory studies sought responses to "what is the relationship between working conditions and accidents; and why unsafe acts and conditions are of greater concerns in construction." The studies were conducted in the central region of South Africa in 2016 to explore possible responses to the postulated questions. The next section of this paper presents the research method of the two studies. After the method section, a short version of the results from the studies is used to lay the foundation for a discussion on human contributions to unsafe acts and conditions in construction.

## **RESEARCH METHOD**

This paper reports on two similar phenomenology studies that were conducted in the central region of South Africa (Bloemfontein and Kimberly) in 2016. The two studies attempted what Silverman referred to as 'situated phenomenology' to produce the data that are intended to be illustrative (Silverman, 2013). The first study obtained the views of construction professionals responsible for safety on project sites in Kimberly, South

Africa (Study A). Face-to-face interviews were conducted on several project sites with 22 professionals. Before the compilation of the interview guide, four accidents records were textually analysed to observe the issues around the topic. A safety manager that was interviewed at the early stage of the study provided access to the accident records of the construction firm where he is employed. It is unclear if the safety manager witnessed the four accidents, but he provided verbal information to clarify observations in the records. The four cases found in the safety record of the firm were used by the safety manager to buttress the view that accidents involve human constructions. The identified issues were after that used to compile the open-ended questions of the interviews. The semi-structured interviews follow the reviewed literature and the findings of analysed accident records. The data collection process began with an email and telephonic approach of contractors busy with projects within Kimberly, South Africa. The interviewees were purposively selected, and they were free to elaborate on all the questions based on their experiences. With various job titles such as H&S Manager, Site Agent, Safety Officer, and Civil Engineer, the field work was able to engage professionals occupying site management positions. All the 22 interviewees in this study have post-secondary qualifications in the built environment disciplines, and the average length of working experience recorded for the cohort was 16 years.

The second phenomenology study was conducted among contractors in Bloemfontein, South Africa (Study B). The face-to-face interviewing of workers, their supervisors, and managers on seven construction sites were done with the aid of a protocol that contains open-ended questions that were informed by the central research question. The interviewees were contacted through email and telephone to ascertain that they are busy on projects within Bloemfontein and they are willing to participate in the study. Eleven contractors were contacted, but four declined to take part in the study. All the interviews took place on project sites. The seven interviewees in this particular study include three safety officers, two artisans (electrician and carpenter), one assistant SHEQ (Safety, Health, Environment & Quality) manager, and a managing director who also doubles as the project manager for his firm. The interviewees have tertiary construction educational qualifications, and the length of their construction industry working experience ranged from 5 to 29 years.

In total, 29 interviews were conducted in the two studies and the transcribed data were thematically analysed. Thematic analysis, which involves identifying, interpreting and reporting patterns was used. Working through the interview data helped the analysis to integrate perceptions together with the central research question (Ritchie, Lewis, Nicholls, and Ormston, 2013).

## **RESEARCH FINDINGS**

### **Examples of Site Accidents**

Four accident cases in a particular company were analysed before the start of the interviews in Study A. The cases were provided by a safety manager who gave access to company safety records. The record shows that the four accidents occurred between 2012 and 2015. In Case 1 that took place on the 21 August 2012, a worker was injured while working with a crusher. The accident happened when the foreman wanted to adjust the track on a conveyor while removing a tramp iron from a magnet. When the conveyor started, the worker managed to hold onto the gantry of the magnet while his lower body was pulled under the magnet. Fellow workers raised the alarm and the conveyor was stopped. The employee sustained injuries to his back and leg. In Case 2 that happened on the 24 of April 2014, a worker suffered a head and neck injury in the workplace.

While working next to a structure that was being erected on the site, a 16m piece of roof sheeting was blown off the structure by the wind. The roof sheet landed on the worker's head, and he fell to the ground, unconscious. Luckily, the worker was wearing a hard hat, which protected his head. The worker was taken to hospital where he was treated. After medical treatment, the employee was sent home and returned to work after some days off. In Case 3 (14 October 2014), a worker was injured on site when himself and a fellow worker were busy replacing bin liners on a Komatsu plant. A steel plate that was gouged came loose, popped off the container surface and fell against the employee's left ankle. The accident resulted into instant skin graze, and the worker was rushed to the closest hospital for treatment. The worker returned to work after medical treatments and some days off. In case 4 (6 of February 2015), a worker was injured on site while busy working in an excavation. There was a sudden ground dislodgement, and the employee was almost buried alive. An ambulance was called, and paramedics treated him on the scene. He was after that taken to a clinic where a computerized tomography scan was done. Although there were no internal injuries or broken bones, the doctor booked the injured worker off to resume light duties some days after the accident. These four cases that were extracted from a single company underline the relationship that exists between accidents and physical work in construction.

Besides the four accident cases outlined in Study A, the interviewees in Study B confirmed that minor accidents do occur on their project sites. The Study B interviewees have experienced consistent hand injuries, cuts, and lacerations in construction. Other types of harm cited by the Study B interviewees include eye injuries, body injuries caused by workers trapped between equipment or caught in confined spaces, head injuries caused by falling objects, and electrocution. These examples of accidents recorded in both studies are individual in nature (and not organisational accidents) and they appear to have elements of human constructions, through acts and conditions.

### **Perceptions of Unsafe Working Conditions**

Regarding unsafe working conditions, an interviewee stated that it is a state created by the work environment on a construction site. The interviewees suggest that there is a relationship between accidents and working conditions on project sites. One interviewee said that tight deadlines and the resultant hurried activities could cause accidents. The interviewed safety manager made the comment that the safer the working conditions, the fewer the accidents. He emphasized the importance of providing workers with protective gears, reliable machinery and good haul roads. Another safety officer focused on the importance of daily safety checks. A common concern among the interviewees is working at heights, which often creates a major likelihood of accidents. The interviewees opine that people working at heights should be physically and medically fit. Some of the examples included workers using wrongly erected scaffolding and labourers falling into excavations that were not properly barricaded. Many of the interviewees named 'human error' as the leading cause of most accidents. Two interviewees found that working long hours was a risk factor as people make mistakes when they are fatigued. Another interviewee suggests that alcoholics among working crews constitute 'human-as-hazard.' Also, when asked to discuss the factors that determine the state of working conditions on their project sites, the interviewees agreed that topography and site layout are crucial to safety. They explained that factors such as adequate working space allow people to be safe and orderly. They decided that when a site is congested and chaotic, working conditions will deteriorate. A few interviewees say that the priority that management places on safety management and the way that they enforce it could also determine the working conditions in a site.

Also, an interviewee stated that workers could also cause unsafe conditions. The interviewee says "...not doing proper housekeeping, leaving materials lying around the workplace or leaving equipment or machinery on standby unattended" are conditions created by workers. In contrast, an interviewee stated that sometimes unsafe conditions are caused by management when they are:

...forcing labourers to work in an environment that are not safe, such as expecting labourers to work on the scaffold, which is not safe because of lack of alternative or forcing people to work in poor conditions. Weather is an instance of a poor condition, for example, wind can blow things to labourers' eyes when not wearing safety goggles, or a strong wind, which can blow a person who is at the top of the building down.

Another cited example is the first-hand experience of the students conducting interviews on sites in 2016. The students observed and took pictures of electric wires that were running through stagnated water on a particular site. This is an example of an unsafe condition which is created by workers (but appears to be allowed by management). The site shows that wooden shutter planks are left carelessly on the ground near walkways, which are used as formwork to support a concrete structure. When the shutter planks are removed from hardened concrete, they have protruding nails on them, which could injure people on the site.

### **Perceptions of Unsafe Acts**

According to six interviewees, unsafe acts is what people do that is not safe or how people act towards their work and how they behave towards it when they are not working with standard procedures and methods. An interviewee regarded unsafe acts as the omissions by workers that are not safe. The six interviewees contend that unsafe acts are typical acts observed on construction sites. Some cited acts include working with a grinder without wearing safety goggles and ear plugs, working on scaffolding that is not structurally safe, working on a high scaffold without safety harnesses, not using equipment or tools in a recommended manner, and working under the influence of substances - drugs or alcohol (or both). The interviewees say that unsafe acts are caused by workers through their behaviours and attitudes that are underpinned by ignorance and negligence. Other causes of unsafe acts reported by the interviewees comprise of lack of concentration (inattention), poor knowledge of the implications of acts (whether it is safe or not), and lack of safety information.

In brief, most interviewees perceive that carelessness and complacency pose a serious threat to safety management. For example, one safety officer mentioned that he witnessed workers climbing onto scaffolding they know to be unsafe. The cited incidence is a clear case of violations on sites. Most interviewees also say the negligence of employees regarding the use of allocated protective gears and safety harnesses when working at heights. Another interviewee mentioned that even though barricades are put in place, workers deliberately ignore the risks of falling or tripping. Other interviewees indicated unsafe acts such as not following proper procedures, and using untested work methods.

### **Regulating Unsafe Acts and Working Conditions**

After these cited improper practices, questions regarding compliance were asked in the two studies. In response, most interviewees suggest that regulations positively influence working conditions. For instance, some of them say that regulations 'forced people to pay attention to housekeeping.' Some interviewees were confident that regulations helped with the smooth running of construction sites. Many interviewees contend that toolbox talk is beneficial and when handled correctly, it significantly promotes safe and healthy

working conditions. An interviewee mentioned the need for safety personnel on project sites to understand the work to be done. However, some interviewees were of the opinion that excessive regulations reduced the pace of operations, while others perceive that certain regulations were not applicable to specific construction operations. For instance in Study A, interviewee seven indicated that "...workers are likely to get hand injuries because they use bricks, trowel, grinders, hammers, etc., which are liable to damage or injure their hands". Whereas Interviewee six say "bricklayers always complain that they don't sense the brick when wearing safety gloves, they prefer to use their bare hands as it speeds up their building process."

The nature of work and the preference of workers to follow a particular method is in the spotlight in these comments. When asked about the causes of accidents that they have encountered in the industry, the interviewees were of the opinion that unsafe acts observed through negligence, poor attitude and behaviour of workers, and unsafe conditions are primary origins of accidents. A comment that is indicting the industry was made by an experienced interviewee, who says:

...unsafe acts and unsafe conditions (such as poor housing keeping) cannot be blamed all the time; people have to think about direct causes and indirect causes of accidents.

Study A and Study B recorded divergent views on whether unsafe acts and conditions could be avoided in construction. For example, two interviewees stated that in their opinions, "...unsafe acts cannot be prevented because they are caused by employees' behaviour towards their work, and such acts are difficult to change or modify". However, interviewee 7 in Study A stated that all unsafe acts and conditions could be prevented if a proper safety management system (SMS) is deployed on a site. More importantly, all the interviewees concur that weather is the only unsafe condition that cannot be prevented because it is not subject to human control. In a nutshell, the interviewees were in agreement that training (context specific workshops), education, enhanced safety awareness, and appropriate safety programmes could reduce accidents caused by unsafe acts and conditions. Also worthy of note is the view that management commitment is central to the efficacy of mitigation efforts required for the eradication of unsafe acts and conditions. The reason why management must be involved is rooted in the idea that safety management is an expense that management cannot avoid. As an illustration, an interviewee opines that:

...safety has to start from the top and then cascade to the bottom because if people from the top are not interested in health and safety, so shall the individuals in the workplace because no one is motivating or showing them that safety is a priority.

While noting the veracity of this particular comment, the author of this paper subscribe to the notion that safety is more than a priority. Rather it should be viewed as a value. Furthermore, it is notable that the interviewees perceive that compliance safety may be used to curtail unsafe acts and conditions. One interviewee cited an example. He noted that where workers (such as bricklayers that prefer to lay bricks without protective gloves) are being told to wear appropriate Personal Protective Equipment (PPE), and they refuse; compliance to regulations could be used to modify such behaviours.

So in theory, the interviewees were in support of the notion that regulations will be useful, but in practice, their opinions differ. For example, some of the interviewees noted that regulations have an adverse impact on them regarding the cost of compliance. The interviewees noted that companies have to register all their workers (the author is of the view that this is referring to compensation insurance that is mandated by legislation in South Africa). The concern of the interviewees is based on the premise that the

registration of workers is expensive. The question is, if compliance is expensive, what about the cost of an accident? Another hypothetical example cited by one interviewee is that if there is an incident on site and a fatality is recorded, there is a possibility that the responsible contractor may serve a jail term because of the liability regarding the workers under his/her supervision. An interviewee opines that:

...where H&S is not taken into considerations, the biggest challenge that companies experience is the loss of money, because it is the company's responsibility to pay for labourers' medical bills if they get injured in the workplace and also to pay for damages to the property.

It is also worth noting that an interviewee claimed that a major challenge of compliance enforcement is workers' attitudes and behaviours to safety. The interviewee implied that working with people is difficult:

...because some of them when you tell them what to do, they will inform you that they have been working in the industry for a very long time, and no one will tell them how to do their work.

A relatively common challenge also recorded is that contractors are forced to work with unskilled local workers from host communities of projects. Three interviewees perceive that most contractors complain that strict compliance with safety reduces their onsite production because:

...there are certain tasks that safety inspectors do not allow workers to do. In some cases, where activities are suspended due to working at heights without safety harnesses, safety officers will not let them proceed until they have been supplied.

## DISCUSSION

Study A and Study B link unsafe acts with unsafe working conditions in construction. The two studies highlight the widely reported perception that unsafe acts and poor working conditions are the forerunners to accidents in the construction industry (Shin, Lee, Park, Moon, and Han, 2014). Both Study A and B also highlight human failure types that exist on construction sites. Of the widely reported human failure types, which include slip (commission), lapse (omission), mistake (both rule and knowledge bases), and non-compliances (routine, situational and exceptional) (Reason, 1990), Study A and Study B suggest that routine and situational human failure types are dominant on sites in the region. The implication is that deliberate deviation from rules, regulations, and safe working procedures, which is known as 'violations' are common among construction workers. It, therefore, appears that non-compliance has become the 'norm' so much that the interviewees contend that enforcement of regulations and regular daily inspection is required on sites.

The observations from the two South African studies, however, resonate with the Australian study reported by Lingard et al., (2016). The Australian study shows how safety rule violations in the construction industry have become routine (Lingard et al., 2016). Similar to the opinions of the interviewees in the two South African studies, the violations appear not to be deliberate acts of sabotage by workers in Australia. Rather, violations such as 'the gap between work as imagined and work as done' are routinely undertaken by construction workers (Lingard et al., 2016). Examples of routine deviations are illustrated by the interviewees in Study B, who say that the unsafe acts are seen through negligence, poor attitudes and behaviours of workers, and unsafe conditions are primary origins of accidents in the industry. As an illustration, an interviewee in Study B indicated that:

...bricklayers always complain that they don't sense the brick when wearing safety gloves, they prefer to use their bare hands as it speeds up their building process.

The nature of work and the preference of workers to follow a particular method is in the spotlight. The preference of employees to follow what they perceive to be suitable for them is unintentionally making violations routine in construction operations. Also worthy of note is the situational human failure type reported in both Study A and Study B. Situational failures occur when workers deliberately take shortcuts and fail to follow safe working procedures to fast-track the completion of activities. The situational non-compliance is dictated by context-specific factors such as time pressure, workload, inappropriate tools, and unsuitable equipment (Alper and Karsh, 2009). In effect, work pressures from tight deadlines and rush activities to maintain production in construction reduces levels of compliance with safety rules (Guo, Yiu, and González, 2016), and by so doing, work pressure is promoting situational human failure in construction.

The routine and situational human failure types highlighted in the two South African studies highlight the influence that frontline workers and management have on unsafe acts and conditions. The influence implies critical theories found in the 'person model' and 'system model' of unsafe acts (Reason, 2008). For example, the behaviour of workers in the construction industry is influenced by time pressures, training, experience, risk perception, safety culture, and management (Oswald et al., 2013). The substance abuse incidents cited by interviewees in this paper also emerge as a significant factor in Oswald et al., (2013).

The above discussion suggests that the cursive nature of the causes of unsafe acts and conditions require a better understanding of how to eliminate them in construction.

## CONCLUSIONS

The studies reported upon in this paper reinforce the notion that unsafe acts and conditions could work with resident pathogens to produce accidents. For example, the studies suggest that accidents and working conditions are linked through human contributions (unsafe acts). Such contributions are manifest through attitudes and behaviours of people in construction. Also, the unsafe conditions created by man (both management and their workers) occurs in various ways. By forcing workers to complete tasks on elevated platforms without the use of mandated safety harnesses perpetuate unsafe conditions on sites. The narrative in this paper shows that unsafe conditions can be controlled and it is subject to modification if concerned people are willing to make an effort. Although the interviewees in the reported studies mentioned that enhanced training, education, management commitment and enforcement of regulations would reduce the problem, there is a reason to argue that these measures can only produce marginal improvements until there is a definite shift in the mind-set of the people concerned. The change in the mind-set is what would alter the attitudes and behaviours of workers so that they do not engender unsafe outcomes.

The shift in mind-set is also required to tackle unsafe acts that produce both routine and situational human failures on construction sites. There is a clear indication that no matter how rules are implemented or enforced on sites, with less commitment from concerned parties, accidents caused by unsafe acts and conditions will continue in the industry. Unsafe acts and conditions are therefore of major concern in construction where they have the tendency to transform into practice 'norms'. In effect, people have to learn that safety begins with them, and then, it has to start from people at the management levels where conditions in workplaces are controlled.

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# ANTECEDENTS TO MENTAL HEALTH SYMPTOMS IN THE AUSTRALIAN CONSTRUCTION INDUSTRY

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The construction industry is notorious for its stressful work environments. Excessive stress causes psychological, physiological, and sociological strains that negatively impact on performance. This research identified the stressors for construction professionals based on questionnaire survey responses collected from 289 professionals in the Australian construction industry. Factor analysis of the data found that the stressors can be classified into eight dimensions. Among them work demands, job-related stressors, and organisational stressors are the most frequent stressors experienced by the respondents. Addressing this issue requires the implementation of interventions at three levels: industry, organisation and individual. At the industry level, all influential stakeholders should participate in the effort to change the culture and work norms of the industry. At the organisational level, construction organisations can implement preventive measures by changing the organisational culture, leadership style, and management approaches to address job-related and organisational stressors. Reactive interventions should also be implemented to help those who are suffering mental health issues. At the individual level, problem-focused coping is effective to reduce depression, anxiety, and stress symptoms among construction professionals.

Keywords: industry culture, mental health, organisational culture, stressors

## INTRODUCTION

The construction industry is becoming more and more dynamic and complex, which increases the stress level of construction professionals. Stress is not all bad because optimal good stress is generally transient and can stimulate, enrich, and even sustain performance. On the other hand, the complete absence of stress or severe and prolonged stress affects performance negatively. This relationship between stress and performance is reflected by the inverted-U stress model (Sapolsky, 2015).

Literature indicates that the stress level in the construction industry is excessive and counter-productive. In South Africa, construction professionals experience high levels of stress that cause psychological, physiological, and sociological strain effects (Bowen *et al*, 2014). In the US, the prevalence of mental distress among construction workers is almost twice as high as that in the general population (Jacobsen *et al*, 2013). In Australia, the suicide rate among construction workers are nearly twice the rate of non-construction workers. Statistics show that one construction worker commits suicide every two days (Hon, 2017).

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These cases indicate that stress in the construction industry is beyond its optimum level, thus causing burnout, mental distress, reduced performance, and other personal and social problems. This research aims to identify the stressors most frequently experienced by professionals in the Australian construction industry. By understanding the key stressors, proper interventions can be put in place to reduce their occurrence. Construction professionals also can use coping strategies to alleviate mental health symptoms they may have due to stressors that they experience. This research, therefore, also investigates the relationships between the stressors, coping strategies, and three mental health symptoms: depression, anxiety, and stress. Investigating these relationships is useful to determine coping strategies that can lessen mental health symptoms despite the occurrence of stressors.

### LITERATURE REVIEW

The literature has identified various stressors faced by people working in the construction industry. The physical work environments, such as weather and site conditions, are typical challenges, particularly when working on site (Campbell, 2006). The organisational culture influences the conduct and leadership styles of managers and supervisors, which can affect employees' stress levels, motivation, and commitment to the organisation (Samuel, 2015). The culture also affects work relationships between peers and between managers and employees, conflict management, work norms, and human resource management (Arditi *et al.*, 2013; Campbell, 2006). Other sources of work stress include job pressures, working long hours, masculine industry culture, unclear job roles and responsibilities, and lack of career progression (Campbell, 2006; Lingard *et al.*, 2010; Watts, 2009). The demands in the workplace can spill over and adversely affect family responsibilities and leisure activities. Simultaneously, domestic and personal pressures can also become additional stressors that affect an employee's robustness at work. This creates a vicious cycle in which the stress caused in either area, work or home, makes coping with the other more challenging (Michie, 2002).

These stressors can trigger the occurrence of mental health symptoms, such as depression, anxiety, and stress. Depression is characterised by a loss of self-esteem and incentive, and is associated with a low perceived probability of attaining life goals of significance for an individual as a person. Anxiety is related to fear because of a perceived inability to control or obtain the desired outcomes in upcoming situations. Stress, on the other hand, is a state of persistent arousal and tension with a low threshold for becoming upset or frustrated (Lovibond and Lovibond, 1995).

There are coping strategies that individuals can use to alleviate mental health symptoms. Coping refers to an individual's ongoing efforts in thought and actions to manage specific demands appraised as taxing his/her psychological wellbeing. Coping processes can be classified into two: problem-focused and emotion-focused. The problem-focused coping aims at problem solving or doing something to change the influence of the stressor. The emotion-focused coping aims at changing the way of attending to or interpreting what is happening; i.e. focusing on managing the emotional distress associated with the situation (Carver *et al.*, 1989; Lazarus, 1993).

There are also organisational interventions that can be used to alleviate mental health symptoms. Stress management programs based on cognitive behavioural approach, such as lectures on the perception of mental health issues, measures to cope with them, recording sheets, and counselling, have been found effective to reduce mental health symptoms (Mino *et al.*, 2006). These programs can also be delivered in a computer-presented format where reductions in stress indices have been observed. This computer-

presented format may have higher attrition than the traditional delivery in small, instructor-led groups (Eisen *et al*, 2008). Meta-analysis of various stress management interventions, including cognitive-behavioural, relaxation, organisational, multimodal, and alternative, found that they can reduce the negative impacts of work stress, although cognitive-behavioural interventions tend to be more effective than the other interventions (Richardson and Rothstein, 2008).

## RESEARCH METHOD

A questionnaire survey method was adopted due to the need to collect primary data from many respondents. The questionnaire first collected the background details of the respondents, such as their age range, gender, income level, status, and the size of the organisation that they work for. Second, it sought respondents to indicate the frequency of occurrence of the 38 stressors identified from the literature. The literature suggests that these stressors have the potential to influence the level of stress at work. The third section assessed the coping strategies commonly used by the respondents to alleviate stress. The items in this section are based on the work of Carver *et al*, (1989), who identified 14 coping strategies that can be further classified into problem-focused and emotion-focused coping. Lastly, DASS-21 (21-item Depression Anxiety Stress Scales) was used to evaluate the mental health of the respondents. DASS-21 measures the negative emotional states of depression, anxiety, and stress, and has been widely used in a variety of settings by researchers and clinicians (Lovibond and Lovibond, 1995).

Following the scale used in DASS-21, a four-point Likert scale, comprising never, sometimes, often, and almost always, was also used to assess the frequency of occurrence of the stressors and coping strategies adopted. The questionnaire was distributed randomly to professionals in the Australian construction industry via different channels. Emails containing the link to the online questionnaire were sent to the members of the Australian Institute of Building and the National Association of Women in Construction. Professionals working in construction organisations were also contacted via corporate communications and individual emails. In total, 1085 requests were sent and 289 valid responses were obtained (26.6% response rate).

## ANALYSIS AND DISCUSSION

Table 1 presents the profiles of the respondents. Nearly 60% of the respondents were under 40 years old, aligning with the workforce profile of the Australian construction industry. Most respondents (71%) worked for medium and large organisations (employing 20 or more people), while more than 98% of construction organisations in Australia are small organisations. Furthermore, about 41% of the respondents were women, a higher proportion than the 11% of women representation in the industry. Therefore, research findings should be carefully interpreted within this context. Within those who reported their income levels, about 74% had an annual income of \$80,000 or more, higher than the average Australian earning. This profile is important because individuals with a low income tend to have higher rates of a range of health problems, including disability, mortality, psychological distress, and mental disorder than those in more advantaged socioeconomic positions (Thoits, 2010). Nearly 74% of the respondents were in a relationship or married. Married individuals tend to have better mental health than singles in various aspects, including depression, happiness, life satisfaction, psychological wellbeing, and suicide (Amato, 2015).

Table 1: Profile of respondents

| Participant attribute |                             | Frequency | %    |
|-----------------------|-----------------------------|-----------|------|
| Age                   | 18 - 29 years old           | 86        | 29.8 |
|                       | 30 - 39 years old           | 82        | 28.4 |
|                       | 40 - 49 years old           | 60        | 20.8 |
|                       | 50 - 59 years old           | 47        | 16.3 |
|                       | 60 years and above          | 14        | 4.8  |
| Gender                | Female                      | 119       | 41.2 |
|                       | Male                        | 170       | 58.8 |
| Organisation size     | 1 - 4 employees             | 28        | 9.7  |
|                       | 5 - 19 employees            | 55        | 19.0 |
|                       | 20 - 199 employees          | 128       | 44.3 |
|                       | 200 employees or more       | 78        | 27.0 |
| Income                | Less than \$60,000          | 30        | 10.4 |
|                       | \$60,000 - \$80,000         | 32        | 11.1 |
|                       | \$80,000 - \$100,000        | 48        | 16.6 |
|                       | \$100,000 - \$150,000       | 76        | 26.3 |
|                       | Above \$150,000             | 58        | 20.1 |
|                       | Prefer not to answer        | 45        | 15.6 |
| Status                | Single                      | 61        | 21.1 |
|                       | In a relationship           | 46        | 15.9 |
|                       | Married or de-facto         | 167       | 57.8 |
|                       | Divorced/separated/ widowed | 15        | 5.2  |

Item analysis and factor analysis were conducted on the 38 stressors to ensure that only those items that provide the best representation of the construct were retained. The item analysis was performed to retain only those with the highest item-to-total correlations (0.3 and above) and to remove items that negatively affect the Cronbach's Alpha of the questionnaire. The remaining items were further evaluated to identify those that could not load to any factor or generate loading exceeding 0.35 (Hair *et al*, 1998). Three items, i.e. working night shifts, caring for family members, and previous exposure to traumatic events, were discarded as a result.

In order to determine the factor structure of the remaining 35 items, factor analysis with varimax rotation was performed. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is 0.905 and Bartlett's test of sphericity is significant ( $p < 0.05$ ), indicating that factor analysis is suitable for analysing the data. Based on the eigenvalues (greater than one) and the scree plot, eight dimensions of stressors were extracted, representing 63% of the variance. The eight dimensions were then named based on the items that represent them. Table 2 presents these dimensions along with the stressors in each dimension, the mean of each stressor, and the mean of each dimension.

As presented in Table 2, the most frequent stressors experienced by construction professionals are those related to work demands.

Table 2: Frequency of stressors experienced by construction professionals

| Dimension                     | Item  | Mean | Mean total |
|-------------------------------|---|------|------------|
| Work demands                  | Unpleasant nature of work (high physical/mental demand, meaningless work, high uncertainty/sudden changes)                  | 2.38 | 2.64       |
|                               | Excessive workload  | 2.65 |            |
|                               | High level of time pressure   | 2.80 |            |
|                               | Long work hours   | 2.74 |            |
| Work conditions               | Inflexible work schedule  | 1.84 | 1.63       |
|                               | Unpredictable work hours/shifts   | 1.66 |            |
|                               | Poor work environment (space constraint, extreme weather, excessive noise, poor air/water quality, odours/chemical, unsafe) | 1.56 |            |
|                               | Unfavourable equipment conditions (unsuitable, faulty or inadequate)  | 1.46 |            |
| Organisation                  | Lack of job autonomy (lack of control over workload/content or participation in decision making)                            | 1.83 | 1.81       |
|                               | Low level of support for problem solving  | 1.78 |            |
|                               | Inadequate communications between work colleagues & superiors   | 2.05 |            |
|                               | Social or physical isolation from others  | 1.61 |            |
|                               | Poor relationships with superiors   | 1.57 |            |
|                               | Conflicts with co-workers/colleagues  | 1.66 |            |
|                               | Excessive formalisation/centralisation and rigidity in the organisation   | 1.75 |            |
|                               | Under valuing of your skills/qualifications   | 1.99 |            |
|                               | Lack of appreciation /rewards for efforts   | 2.01 |            |
| Job                           | The tasks you perform do not match your skills (under use of skills or over expectations)                                   | 1.99 | 1.96       |
|                               | Role ambiguity (unclear job roles and responsibilities)   | 2.00 |            |
|                               | Insufficient salary/wage for the work   | 1.96 |            |
|                               | Career stagnation / lack of career development opportunities  | 1.89 |            |
|                               |   |      |            |
| Discrimination and harassment | Differential treatment due to gender, ethnic background, etc.   | 1.54 | 1.38       |
|                               | Sexual harassment at work, e.g. unwelcome / inappropriate comments/ behaviours by colleagues, superiors, clients, etc.      | 1.30 |            |
|                               | Bullying, i.e. slander/humiliation, intimidation, abusive language, aggressive behaviours, etc.                             | 1.53 |            |
|                               | Violence at work, e.g. assault, threat, etc.  | 1.15 |            |
| Family                        | Work-home conflicts, i.e. lack of family time due to work   | 1.98 | 1.63       |
|                               | Low support at home   | 1.40 |            |
|                               | Dual career challenges (working couples struggling to balance family affairs)   | 1.69 |            |
|                               | Poorly functioning home, i.e. tensed relationships between couples /family members  | 1.44 |            |
| Personal                      | Housing/accommodation/living conditions   | 1.23 | 1.54       |
|                               | Financial difficulties  | 1.64 |            |
|                               | Excessive responsibilities in personal life   | 1.81 |            |
|                               | Poor personal health conditions   | 1.48 |            |
| Wellbeing & security          | Job insecurity  | 1.66 | 1.58       |
|                               | Lack of welfare   | 1.50 |            |

Note: 1 = Never; 2 = Sometimes; 3 = Often; 4 = Almost always

Key stressors frequently experienced by construction professionals. The mean of this dimension is 2.64, considerably higher than the other dimensions, and this mean also

indicates that the respondents experienced these stressors often. The construction industry expects its professionals to work long hours and to work non-standard work schedules, including on weekends (Lingard *et al*, 2010). The industry demands the full and flexible availability of its employees and this condition has become more pronounced in today's global competitive environment. Long work hours and visibility hold a symbolic meaning and act as indicators for excellence and commitment. These values are difficult to change, particularly in an industry that has shown itself resistant to change of any kind (Watts, 2009) and have led to all sorts of mental health problems and work-family conflicts (Lingard *et al*, 2010).

The second most frequent stressors are job-related factors, such as poor skills utilisation, role ambiguity, insufficient salary, and lack of career development opportunities. Role ambiguity and role conflict have been suggested as sources of work stress that can lead to reduced performance and low satisfaction (Dahl and Olsen, 2013; Randeree and Chaudhry, 2012). Another job-related factor, a lack of career progression, is a common issue in the construction industry, particularly among women. The construction industry adopts the male career model predominated with expectations of full-time professionals on unbroken career pathways, forcing women to accommodate the life cycle of men whose wives do not have full-time careers. This results in the lack of career progression for women (Dainty and Lingard, 2006). The relatively high proportion of female respondents in this research may be responsible for the frequent occurrence of this stressor. In addition, the long work hours and high-pressure work environments may then create the perceptions among the respondents that their salaries are inadequate even though the average earnings in the industry are higher than the industry average in Australia.

Another dimension that should not be neglected is organisational-related stressors. Most stressors in this dimension are related to poor leadership and ineffective management. Lack of communication and coordination, conflict, and inadequate planning have been repeatedly put forward as factors that cause poor project performance (for example see Gündüz *et al*, 2013). These work conditions adversely affect the stress levels of construction professionals, which can further worsen their work performance and project performance (Leung *et al*, 2015). Poor change management, low skill discretion, lack of support from colleagues and supervisors, distributive justice or perceived fairness of decision outcomes are psychosocial hazards that can cause excessive work stress (Way, 2012).

Construction professionals often experience stressors that are related to the work demands in the construction industry. Because this is essentially about the work norms of the present-day construction industry, any intervention aimed at curtailing psychological issues among construction professionals should first focus on improving these work norms. This cannot be achieved by simply making changes in one or few organisations, but it involves the collective effort of all key players in the industry. Limiting the changes to a few organisations is likely to disadvantage them as they will be compelled to operate against the work norms of the industry. Implementing these changes requires the cooperation and involvement of influential stakeholders of the industry, such as the government, major construction clients, large construction organisations and construction industry associations. These stakeholders should introduce and promote corporate social responsibility, work life balance, and socio-psychological sustainability in the construction industry.

However, there are things that construction organisations can do to alleviate work-related stressors. The job- and organisational-related dimensions are under their control. Top management has a key role to promote organisational culture that offers role clarity, provides adequate development opportunities for all employees, facilitates effective communication, and motivates employees through empowerment and appropriate leadership styles depending on the situations.

### Coping Strategies and Mental Health Symptoms

Besides industry-level and organisation-level interventions, there are coping strategies that construction professionals can adopt to alleviate mental health symptoms. Path analysis was conducted to see the relationship between the dimensions of work stressors, coping strategies, and mental health symptoms (depression, anxiety, and stress). Path analysis aims to estimate the magnitude and significance of causal connections between sets of variables (University of Exeter, 1997). The path analysis as depicted in Figure 1 shows significant relationships between discrimination and harassment dimension and personal dimensions and the use of emotion-focused coping. It should be noted that the relationship between the discrimination and harassment dimension and problem-focused coping is only marginally weaker than the relationship between the same dimension and emotion-focused coping. This indicates that the respondents used both coping strategies to curtail the occurrence of mental health symptoms.

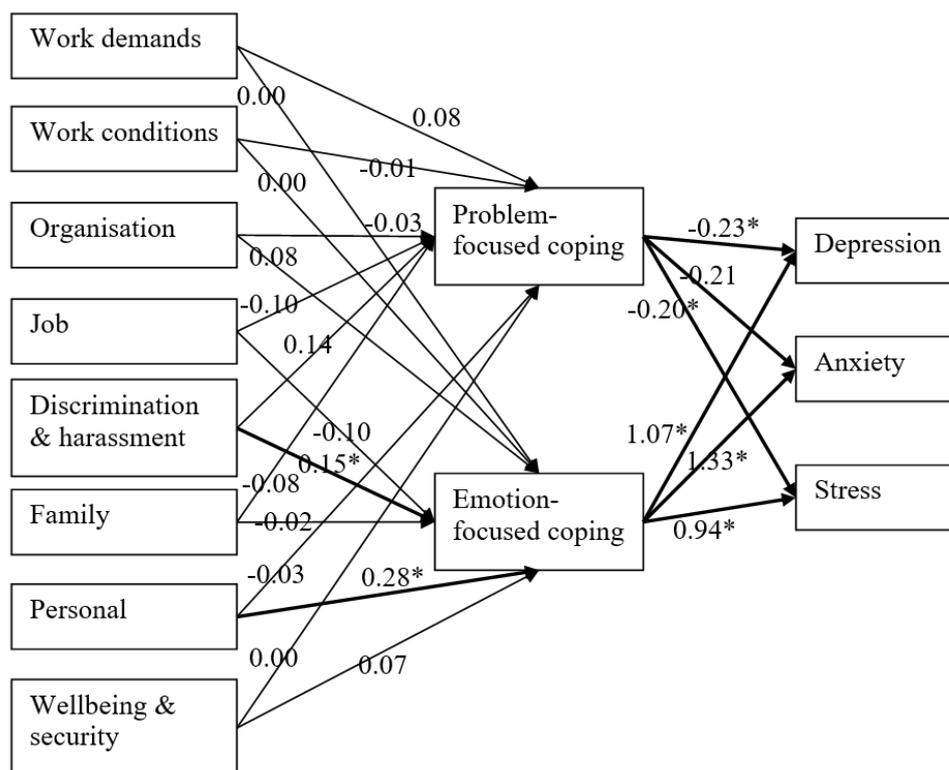


Figure 1: Path analysis

The respondents, however, used emotion-focused coping more frequently than problem-focused coping to manage stressors caused by personal issues. Problem-focused coping is generally used in situations that are controllable, while emotion-focused coping is common to address situations that have to be accepted (Folkman, 2013). In this case, the personal dimension seems to be related to stressors that have become an integral part of

the respondents' daily lives, thus explaining the high use of emotion-focused coping to reduce their negative impacts.

The relationships between emotion-focused coping and mental health symptoms are positive, while the relationships between problem-focused coping and mental health symptoms are negative. This shows that problem-focused coping is effective in alleviating the levels of depression, anxiety, and stress. Construction professionals, therefore, are recommended to adopt problem-focused coping which aims at problem solving or doing something to change the influence of the stressors. These results support previous studies indicating that problem-focused coping is more effective than emotion-focused coping in warding off mental health problems. However, emotion-focused coping can also be effective when the stressors cannot be altered and during the immediate aftermath of the stressors (Carr and Umberson, 2013).

### **CONCLUSION**

Construction professionals operate in stressful work environments. Although an optimum level of stress is beneficial for performance, high levels of stress can be detrimental to mental health and job performance. This research has found that the most frequent stressors experienced by construction professionals are those related to the work demands of the construction industry, job-related stressors, and organisational stressors. The work demands dimension is by far the most frequent stressors experienced by construction professionals. Since these demands are the results of the work norms in the construction industry, interventions to improve the condition should involve all key stakeholders, such as large construction organisations, influential clients, professional bodies, and the government. Implementing the interventions in few organisations may disadvantage the organisations because they are compelled to operate against the norms.

The job-related and organisational stressors are areas under the control of construction organisations. Reducing the occurrence of these stressors mainly falls on the shoulders of top managers who have the authority and power to adjust the culture, leadership styles, and management approaches in respective organisations. These measures are preventive and, therefore, are preferable. There should also be a system in place to help those who are suffering from mental health problems. Workplace interventions, such as cognitive-behaviour programs and relaxation techniques, have been found effective in reducing mental health symptoms.

At the individual level, construction professionals can use coping strategies to reduce their mental distress. Emotion-focused coping is effective to address issues that have to be accepted or to alleviate distress right after the occurrence of the stressors. Problem-focused coping aims to solve the problems or do something to change the negative impacts of the stressors. This research found that problem-focused coping can reduce depression, anxiety, and stress symptoms among construction professionals.

There are limitations in this research. The proportions of female respondents and those working in large organisations are higher than those in the construction industry, thus they may skew the results. Furthermore, despite effort to review existing literature, there may be other stressors that have not been included. Future research should collect more data, particularly from professionals working in small organisations and from blue collar workers to test the factor structure of the stressors. Research has found that female and male respond to stressors differently. Future research can also investigate the impacts of gender on the occurrence of stressors, coping strategies adopted, and mental health conditions.

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# PROFILING RESILIENCE AMONG CONSTRUCTION MANAGEMENT STUDENTS: AN INTERNATIONAL COMPARISON

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Elevated levels of psychological distress are becoming more prevalent for students in higher education. Given this concerning trend, there has been a call to action. Resilience is identified as a capability that can assist students to manage their stress and increase wellbeing. The Resilience at University scale was administered to construction management students in Australia, the United States, Hong Kong, and Singapore. Two hundred and twenty-nine students completed the survey. Principle components analysis identified five resilience factors: finding you're calling/living authentically; managing stress; maintaining perspective, staying healthy; and building networks. Results indicated significant differences between countries on all resilience factors. Of the four countries, Singapore was the most resilient and Hong Kong had the lowest score for all resilience factors. Capacity to maintain perspective was low for all students, irrespective of country. First year students had a lower capacity for finding their calling / living authentically than for other year levels. Final year students had a higher capacity to manage stress than commencing students. The results suggest that demographic characteristics and situational determinants may have a bigger impact on resilience than discipline of study. Findings offer important implications for the development of resilience among university students.

Keywords: education, resilience, university students, wellbeing.

## INTRODUCTION

Academic stress is associated with lower course grades, coping and motivation for students in higher education (Struthers, Perry and Menec, 2000). Of concern are global trends which reveal the increasing prevalence of stress among students undertaking studies in higher education (Robotham and Julian, 2006; Stallman, 2010; Laidlaw, McLellan and Ozakinci, 2016). Stallman (2010) reports that rates of psychological distress among university students are significantly higher when compared with the general population. Consistent with global trends, Larcombe *et al.*, (2016) found that one in four university students experience very high levels of psychological distress, and emphasised the need for targeted mental health promotion and support services. Resilience has been identified as a critical capability that can assist students to succeed.

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Resilience is positively linked to academic engagement and achievement (Martin *et al.*, 2015), and contributes to students' mental health and wellbeing (Munro and Pooley, 2009; Watson and Field, 2011; Hartley, 2013).

Resilience has been defined as an individual's ability to bounce back in the face of stress and adversity (Gerson and Fernandez, 2013; Walker, Gleaves and Grey, 2006). Holdsworth, Turner and Scott-Young (2017, p.12) contend that in an academic setting, resilience extends beyond the concept of bouncing back and is more aptly defined as 'the positive adaptation to situations of stress and adversity within the context of the situated formal or informal learning experience which enables student progress, growth, and learning'. Resilience is acknowledged as a multi-dimensional construct (Wagnild and Young, 1996; Connor and Davidson, 2003) that is contextual and will vary over the life course (Windle, 2011). Assets and resources within the individual, their life and environment facilitate a capacity to adapt in the face of stress and adversity (Windle, 2011).

Research exploring resilience in higher education has applied various methodological designs that have primarily focused on one country. These include multiple universities in one country (e.g. DeRosier, Frank, Schwartz and Leary, 2013), first year students at one university (e.g. Kotzé and Kleynhans, 2013), and one discipline at one university (e.g. Beauvais, Stewart, DeNisco and Beauvais, 2014). Resilience has been studied in disciplines like medicine, social work and nursing, but it is not well understood whether previous studies of resilience can be generalised to the construction management discipline. In recognition of this limitation, empirical research has been undertaken with students of construction management (Turner, Scott-Young and Holdsworth, 2015; Holdsworth *et al.*, 2017) to better understand their resilience profile, with a view to supporting students mental health, academic engagement and achievement as well as preparing them for the imminent stressors associated with the construction industry (Bowen, Govender and Edwards, 2014; Leung, Chan and Cooper, 2015).

Higher education students undertaking studies in construction management have demonstrated strengths in three resilience-building behaviours (building networks/interacting cooperatively, staying healthy, and living authentically), but were less skilled in maintaining perspective (Turner, Scott-Young and Holdsworth, 2015; 2016). This knowledge enables educators to respond to the resilience needs and capabilities of students, and implement strategies to support resilience development (Holdsworth *et al.*, 2017). While this research has served to extend our understanding of the resilience profile of construction management students, the research is limited to one university in Australia. Given that resilience is contextual in nature (Windle, 2011) and may differ across cultures (Ungar *et al.*, 2008), it is not clear whether these findings can be generalised more broadly to students undertaking construction management studies in other countries.

Very few studies of resilience have incorporated students undertaking higher education across more than one country. One exception is Pidgeon *et al.*, (2014), who incorporated university students from Australia, the United States and Hong Kong. In their preliminary analysis, no significant differences were found between the dependent variables (perceived social support, psychological distress, and campus connectedness), therefore the samples were merged to create one large, international sample to explore resilience. Consequently, little is known about student resilience across cultures.

## **AIM**

Although recent research has explored the resilience of students in the construction management discipline, to date, there has been an emphasis on Australian students. It is not known whether students undertaking studies in construction management in other countries share the same resilience profile as Australian students. This study aims to explore the resilience profile of students undertaking construction management across different countries. The research questions framing the research are: (1) Do construction management students share a similar resilience profile across countries? (2) What are the differences between student resilience according to country?

## **METHODS**

### **Sampling Strategy**

A purposive sampling strategy was applied to the research. Construction management students in Australia, the United States, Hong Kong, and Singapore were invited to participate in the research. All students were undertaking an undergraduate construction management program that was delivered in English. The construction management programs in Australia and the United States were delivered on a full time basis and classes were conducted during the day over the course of a semester. Hong Kong and Singapore delivered their program on a part-time basis. Their classes were held in the evening to cater for students who may be working full-time, and delivered according to an intensive mode whereby multiple classes were conducted over a shorter period of time. Participation in the research was voluntary and all data were coded to ensure participant confidentiality and anonymity.

### **Data Instrument and Analysis**

Participants completed a questionnaire that comprised of demographic questions and the Resilience at University (RAU) measure. The RAU (Turner, Holdsworth and Scott-Young, 2017) is a relatively new scale adapted from the Resilience at Work (RAW) measure (Winwood, Colon and McEwen, 2013). The RAU has 20 items and six subscales: (1) finding your calling; (2) interacting cooperatively and living authentically; (3) managing stress; (4) building networks; (5) maintaining perspective; and (6) staying healthy. The six subscales of the RAU closely replicate the seven subscales of the RAW scale as suggested by Winwood *et al.*, (2013), with the grouping of the interacting cooperatively and living authentically subscales. Examples of the RAU items include 'When things go wrong with my university studies, they do not overshadow the other parts of my life', and 'I have friends at university whom I can rely on to support me when I need it'. Instructions given to participants specified that the questions referred to their experience at university, including the time spent at university, as well as the time spent on their studies outside of university. Participants were asked to indicate their agreement with the items on a seven-point Likert scale from 'strongly disagree' (0) to 'strongly agree' (6). The data were subject to principal component analysis (PCA) using varimax rotation. Cronbach's alpha coefficients and confidence intervals were calculated to ascertain the internal consistency reliability of the survey and subscales. Independent-samples t-tests and analysis of variance were applied to the data to enable a finer grained analysis of resilience according to country, gender, and year of study.

## RESULTS

### Participants

Two hundred and twenty-nine students undertaking a Bachelor degree in construction management completed the survey. Fifty-three (23%) participants were from Australia, 45 (20%) were from Hong Kong, 53 (23%) were from Singapore, and 78 (34%) were from the United States. Seventy-five percent ( $n=171$ ) of participants were male and 25% ( $n=58$ ) were female. While the sample included participants from all year levels, just over half were undertaking their first year of study (53%). The mean age of the sample was 23 years ( $SD=3.1$ ). Participants from Singapore (mean=26.5 years,  $SD=4.0$ ) were slightly older than participants from Australia (mean=22.5 years,  $SD=2.7$ ), Hong Kong (mean=22.6 years,  $SD=1.9$ ) and the United States (mean=21.9 years,  $SD=1.7$ ). All participants from Singapore worked (mean hours per week= 44.6,  $SD=7.0$ ), as did the majority (96%) of participants from Hong Kong (mean hours per week= 46.6,  $SD=10.9$ ). Working participants from Hong Kong and Singapore were employed in the construction industry. The majority of participants from Australia also worked (75.5%), but only part-time, with lower average weekly work hours (mean=21.6,  $SD=9.9$ ). In the United States, 25% of participants worked (mean hours per week= 19.4,  $SD=14.3$ ). The Australian (32%) and Singapore (49%) samples had higher numbers of international students when compared with the United States (3.8%) and Hong Kong sample (6.72%).

### Resilience

As 229 participants completed the 20-item scale, the subject-to-item ratio of approximately 11:1 was considered appropriate for factor analysis (Nunnally, 1978). Furthermore, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) value was 0.91, exceeding the recommended value of 0.6 (Kaiser, 1970). The Bartlett's Test of Sphericity (Bartlett, 1954) was significant ( $p=.000$ ), and the correlation matrix revealed the presence of many coefficients of 0.30 and above, therefore verifying that the dataset was suitable for factor analysis.

Principal components analysis (with varimax rotation) yielded a five-factor structure that explained 73.13% of the variance. The five-factor solution closely replicated the six-factor structure of the RAU scale as suggested by Turner *et al.*, (2017). The major difference was the grouping of the items from the finding your calling and living authentically subscales onto one factor, and the exclusion of the two-item interacting cooperatively subscale. The rotated components matrix is shown in Table 1. Factor one had an eigenvalue of 8.41 and explained 46.75% of the variance, and included all items from the finding you're calling and living authentically subscales. Factor two had an eigenvalue of 1.74 and explained 9.69% of the variance, and included all items from the managing stress subscale. Factor three had an eigenvalue of 1.20 and explained 6.69% of the variance, and included all items from the maintaining perspective subscale. Factor four had an eigenvalue of .93 and explained 5.147% of the variance, and included all items from the staying healthy subscale. Factor five had an eigenvalue of .87 and explained 4.85% of the variance, and included all items from the building networks subscale. Worthington and Whittaker (2006) contend that it is possible to retain a two-item factor if the items are highly correlated (i.e.  $r > .70$ ) and relatively uncorrelated with other variables. Factor five met these conditions ( $r=.84$ ), while the two items of factor four had a medium correlation ( $r=.59$ ) however were relatively uncorrelated with other variables. While factor four (staying healthy) did not meet the stringent conditions outlined by Worthington and Whittaker (2006), the factor was retained for further analysis as it signifies a key behaviour associated with resilience capability (Winwood *et*

*al.*, 2013). The two items from the interacting cooperatively subscale were excluded from analysis due to cross loading.

Table 1: Rotated component matrix for the resilience items

| Scale item  | Measure                 | Component |      |      |       |      |
|---|-------------------------|-----------|------|------|-------|------|
|   |                         | 1         | 2    | 3    | 4     | 5    |
| The university work that I do fits well with my personal values and beliefs                               | Finding your calling    | .792      | .188 | .127 | -.017 | .228 |
| My university is somewhere where I feel that I belong.  | Finding your calling    | .732      | .136 | .096 | .080  | .379 |
| Generally I appreciate what I have in my university environment.  | Finding your calling    | .709      | .278 | .222 | -.021 | .162 |
| The university work that I do helps to fulfil my sense of purpose in life.                                | Finding your calling    | .702      | .084 | .143 | .149  | .151 |
| I have important core values that I hold fast to in my university life.                                   | Living authentically    | .681      | .214 | .094 | .280  | .133 |
| I know my personal strengths and I use them regularly at university.                                      | Living authentically    | .670      | .296 | .126 | .314  | .232 |
| I am able to change my mood at university when I need to.   | Living authentically    | .648      | .316 | .314 | .290  | .001 |
| I have developed some reliable ways to relax when I am under pressure at university.                      | Managing stress         | .331      | .821 | .190 | .123  | .091 |
| I have developed some reliable ways to deal with the personal stress of challenging events at university. | Managing stress         | .364      | .737 | .181 | .263  | .172 |
| I make sure I take breaks to maintain my strength and energy when I am working hard at university.        | Managing stress         | .281      | .712 | .298 | .201  | .106 |
| I am careful to ensure that my university work does not dominate my personal life.                        | Managing stress         | .086      | .697 | .292 | .122  | .166 |
| Nothing at university ever really “fazes me” for long.  | Maintaining perspective | .216      | .236 | .816 | .018  | .123 |
| When things go wrong at university, they do not overshadow the other parts of my life.                    | Maintaining perspective | .166      | .265 | .752 | .075  | .093 |
| Negative people at university do not pull me down.  | Maintaining perspective | .143      | .175 | .745 | .228  | .067 |
| I am careful about eating well and healthily.   | Staying healthy         | .148      | .220 | .115 | .836  | .013 |
| I have a good level of physical fitness.  | Staying healthy         | .192      | .165 | .144 | .798  | .211 |
| I have friends at university whom I can rely on to support me when I need it.                             | Building networks       | .387      | .181 | .115 | .128  | .834 |
| I have a strong and reliable network of supportive students at university.                                | Building networks       | .366      | .195 | .167 | .133  | .825 |

Cronbach’s alpha coefficients were calculated to ascertain the internal consistency reliability of the scale and subscales. The internal consistency of the resilience scale (18 items) was very good ( $\alpha = 0.92$ ). All subscales (factors) demonstrated satisfactory internal consistency:  $\alpha = 0.89$  for factor 1,  $\alpha = 0.87$  for factor 2,  $\alpha = 0.78$  for factor 3,  $\alpha = 0.74$  for factor 4,  $\alpha = 0.91$  for factor 5.

The mean score for each of the factors were calculated according to country, as outlined in Table 2. Of the four countries, Hong Kong had the lowest score for all resilience factors. Capacity to maintain perspective was the lowest scoring factor for all students, irrespective of country. A one-way between groups analysis of variance was conducted

to explore differences between countries. There was a significant difference for factor 1 (finding your calling and living authentically) between all countries, with the exception of Singapore and the United States:  $F(3, 215)=46.3, p=.000$ . There was a significant difference for factor 2 (managing stress) between Australia and Singapore, Australia and the United States, Hong Kong and Singapore, and Hong Kong and the United States:  $F(3,216)=12.2, p=.000$ . There was a significant difference for factor 3 (maintaining perspective) between Hong Kong and all three countries:  $F(3,217)=7.0, p=.000$ . There was a significant difference for factor 4 (staying healthy) between Hong Kong and all three countries:  $F(3,218)=9.3, p=.000$ . There was a significant difference for factor 5 (building networks) between Australia and Hong Kong, Australia and the United States, Singapore and Hong Kong, and Hong Kong and the United States:  $F(3,218)=17.7, p=.000$ .

*Table 2: Mean scores of resilience factors according to country*

|               | Factor 1     | Factor 2      | Factor 3      | Factor 4      | Factor 5      |
|---------------|--------------|---------------|---------------|---------------|---------------|
| Australia     | 4.2 (SD=.80) | 4.0 (SD=1.27) | 3.9 (SD=1.11) | 4.0 (SD=1.22) | 4.3 (SD=1.40) |
| Singapore     | 4.7 (SD=.60) | 4.6 (SD=.74)  | 4.2 (SD=1.06) | 4.5 (SD=1.18) | 4.7 (SD=.98)  |
| Hong Kong     | 3.3(SD=.79)  | 3.5 (SD=.94)  | 3.2 (SD=.93)  | 3.3 (SD=1.30) | 3.4 (SD=1.12) |
| United States | 4.9 (SD=.74) | 4.5 (SD=1.04) | 3.9 (SD=1.29) | 4.3 (SD=1.12) | 5.0 (SD=1.08) |

A one-way between groups analysis of variance was conducted to explore differences between year-of-study. There was a significant difference for factor 1 (finding your calling and living authentically) between first year students ( $M=4.0, SD=.97$ ) and other year levels:  $F(4,24)=10.5, p=.000$ . First year students had a lower capacity for their finding their calling and living authentically when compared with other year levels. There was a significant difference for factor 2 (managing stress) between first year ( $M=4.10, SD=1.07$ ) and fourth year ( $M=4.73, SD=.89$ ) students:  $F(4,215)=2.5, p=.03$ . No significant differences were found for factor 3 (maintaining perspective) and factor 4 (staying healthy). For factor 5 (building networks), there was a significance difference between first year students ( $M=4.08, SD=1.28$ ) with second year ( $M=5.16, SD=1.06$ ) and fourth year ( $M=5.13, SD=1.08$ ) students:  $F(4,217)=9.1, p=.000$ .

Independent-samples t-tests were calculated to assess the differences between genders across the sample, however no significant differences were found on the five resilience factors. No significant differences were found for student status according to local or international.

## DISCUSSION

This study aimed to explore the resilience profile of students undertaking construction management across four countries. Results indicated clear differences across countries, with students from Singapore demonstrating the highest level of resilience, followed by the United States, Australia, and Hong Kong. Students from Singapore had the highest level of managing stress (factor 2), maintaining perspective (factor 3), and staying healthy (factor 4). Students from the United States had the highest levels of finding your calling and living authentically (factor 1) and building networks (factor 5). Students from Hong Kong were lowest on all five resilience factors. The results suggest that mode of study (full time or part time), curriculum delivery (12 week semester or intensive), and number of work hours did not appear to moderate levels of resilience. For example, the demographic characteristics of the student sample from Singapore and Hong Kong were similar, with most students working full time in the construction industry while undertaking studies on a part-time basis. The Singapore sample worked 44 hours per

week while the Hong Kong sample worked 46 hours per week. This is in contrast to students from Australia and the United States who both worked on a part time basis while undertaking full time studies. The majority of participants from Australia worked an average of 21.6 hours per week, while 25% of students from the United States worked an average of 19.4 hours per week. The results suggest that demographic characteristics (such as age and year of study) and situational determinants (such as country and culture) may have a bigger impact on resilience than discipline of study.

The variation in resilience across the four countries may have been influenced by cultural differences. The American Psychological Association (2017) identifies that an individual's culture may have an impact on how he or she communicates feelings and deals with adversity, thus shaping resilience. Furthermore, culture may influence whether and how a person connects with significant others, including extended family members and community resources. Ungar (2013) also contends that culture has a critical impact on resilience through the availability and accessibility of resources, and the meaningfulness of the resources provided. This is particularly pertinent, as assets and resources within the individual, their life and environment facilitate a capacity to adapt in the face of stress and adversity (Windle, 2011).

Cultural differences may have impacted on students' capacity to build networks. Building networks is associated with developing and maintaining personal support networks both within and outside of the university, and has been identified as a critical component of resilience (American Psychological Association, 2017; Friberg, Hjemdal, Rosenvinge and Martinussen, 2003; Grant and Kinman, 2012). The results identified that building networks (factor 5) had the biggest variance between lowest and highest mean scores, with students from the United States having the highest level (mean=5.0), followed by Singapore (mean=4.7), Australia (mean=4.3), and Hong Kong (mean=3.4). It is not well understood what cultural factors contributed to building and maintaining support networks for participants across the four countries, and this warrants further research.

Maintaining perspective is described as an individual's capacity to reframe setbacks, maintain a solution focus, and manage negativity (Winwood *et al.*, 2013). In an academic setting, the ability to maintain perspective supports learning and growth and is inherently related to resilience (Holdsworth *et al.*, 2017). Maintaining perspective was the lowest resilience factor for all countries, however students from Singapore (mean=4.2) demonstrated a higher capacity compared with students from Australia and the United States (mean=3.9), and Hong Kong (mean=3.2). This may be an area of resilience development which educators can usefully target through the integration of perspective-building strategies into the curriculum.

Learning from past experiences has been identified as a resilience building strategy (American Psychological Association, 2017; Beyond Blue, 2016), and results of this study suggest that level of resilience improved with age. First year students had a lower capacity for finding your calling and living authentically (factor 1), managing stress (factor 2), and building networks (factor 5) when compared with fourth year students. Furthermore, the sample from Singapore was approximately four years older than the sample from Australia, Hong Kong and the United States. It is possible that age and experience may have contributed towards higher levels of resilience in the Singapore sample when compared with the other countries.

## CONCLUSIONS

This research contributes to our understanding of resilience for students undertaking studies in construction management. Results indicated that there were distinct differences between countries. Further research is required to better understand the factors contributing to these findings. Future research may incorporate student interviews in order to gain a more in-depth understanding of the country-specific situational determinants that shape student resilience. Future research may also usefully identify which resources are considered important for resilience development across cultures, and explore whether these resources are readily available to students.

These findings have implications for educators of the construction management discipline. The results suggest that demographic characteristics and situational determinants may have a bigger impact on resilience than discipline of study. Based on this premise, resilience-building resources and strategies which are culturally nuanced could be usefully implemented in the first year curriculum such as: stress management (such as mindfulness and relaxation training); reframing setbacks and maintaining perspective; and building university support networks that facilitate an earlier adjustment for new students and mitigate the negative impacts of transition stress and anxiety. The continued scaffolding of resilience strengths-based training throughout the curriculum in subsequent years is likely to further consolidate student well-being and establish positive habits which can be transferred by university graduates into their work environment.

The sample of this study was limited to construction management students from four countries. Given that one university from each country participated in the research, the results are not able to be generalised to construction management students of the four participating countries. Furthermore, the focus was on undergraduate students, therefore the results cannot be generalised to postgraduate students. Despite these limitations, the research offers new insights into the resilience of students undertaking studies in higher education and contributes to efforts to support academic success and student wellbeing.

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# THE ROLE OF AFTER-HOURS, WORK-RELATED CONTACT IN WORK-TO-FAMILY CONFLICT AND SLEEP PROBLEMS EXPERIENCED BY CONSTRUCTION PROFESSIONALS

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Advances in communication technology have resulted in boundaries between work and family becoming increasingly blurred, resulting in increased after-hours work contact. Little is known about the relationship between work contact and the work-to-family conflict and sleep problems experienced by construction professionals. Using a survey of 630 architects, engineers, quantity surveyors, and project and construction managers, a conceptual model of work-to-family conflict and sleep problems was proposed and tested using SEM. Demographic characteristics, work experience, job autonomy and control, job pressures, and work contact were hypothesized to explain work-to-family conflict and sleep problems. A tested model was found to be an excellent fit to the data. The results indicate that 1) gender, employment status, work experience, and job pressure are determinants of levels of work contact; 2) work-to-family conflict is predicted by job autonomy and control, job pressure, and work contact, and 3) sleep problems are determined by job pressure, work contact, and work-to-family conflict. Firms and construction professionals need to improved boundary control to limit excessive work contact and/or mitigate its effects on work pressure and work-to family conflict. Intervention strategies by firms should address work contact and employers need to monitor job pressure, and promote job autonomy and control.

Keywords: work-to-family conflict, sleep problems, professional, South Africa.

## INTRODUCTION

Work contact is defined as: ‘the frequency with which workers receive and send work-related communications (e.g. emails, phone calls, text messages) outside of regular working hours’ (Schieman and Young 2013: 244). This definition references and emphasizes the increased role of modern mobile communication technology such as cellphones, laptops and tablets. Madden and Jones (2008) found that 45% of ‘networked workers’ reported working in the evenings and at weekends using such mobile devices, while Boswell and Olson-Buchanan (2007) indicate that such technology-driven contact

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has a profound impact on the nature and character of work; including how, when and where it is carried out; as well as changing the boundaries between work-life and family-life (Derks and Bakker 2014; Ferguson *et al.*, 2016).

After-hours work contact, generally considered a boundary spanning demand, weakens the physical and psychological barriers that separate work and non-work (i.e., beyond work) environments (Voydanoff 2005). Lingard and Francis (2009) found that boundary permeability could influence the presence and extent of work-to-family conflict when the role demands for each of the work and family domains become incompatible. Work-to-family conflict (WFC) is defined as ‘a form of inter-role conflict in which the role pressures from the work and family domains are mutually incompatible in some respect’ (Greenhaus and Beutell 1985: 77). Piszczek (2107) found that boundary control is linked to emotional exhaustion and that after-hours, work-related electronic communication expectations can compel technology-use despite individual preferences in that regard.

WFC has detrimental effects on work capacity and effectiveness (Voydanoff 2005) and is associated with dissatisfaction with family life, impaired domestic partner relationships, and increased family distress (Lingard and Sublet 2002) as well as increased experience of sleep problems and fatigue (Maume *et al.*, 2009). Walsh and Lindblom (2000) suggest that sleep must be sufficiently continuous for it to be restorative. Sleep loss and sleep disturbance lead to increased errors, reductions in performance, fatigue, mood swings, and work injuries (Rogers *et al.*, 2001; Uehli *et al.*, 2013). Sleep problems are under-examined in construction, with the limited literature pertaining to artisans and labourers. For example, Powell and Copping (2010, 2016), utilizing an objective measure of sleep in the form of an actigraph, examined sleep deprivation and its consequences for construction workers, but not for construction professionals. They reported high levels of sleep deprivation and a positive link between inadequate sleep and the risk of accidents.

No previous studies have proposed an integrated explanatory model for the predictive relationship between WFC and sleep problems, and antecedent demographic characteristics, job resources (job autonomy and control), and job demands (work contact and job pressures). The current research proposes such an explanatory model in the context of the South African construction industry, focusing specifically on construction professionals.

## **THEORETICAL FRAMEWORK**

Boundary theory (Nippert-Eng 1996) and the job demands-resources (JD-R) model of workplace stress (Bakker and Demerouti 2007) provide a guiding framework to examine how the work contact experiences of construction professionals relate to WFC and work-related sleep problems (hereinafter termed ‘sleep problems’).

According to Nippert-Eng (1996) people vary in terms of how (and how much) they separate their work and family roles. The boundaries are socially-constructed demarcations between work and family roles, and people vary in the ways and extent to which they individually observe, negotiate, and transition between them in an attempt to achieve some form of balance (Allen *et al.*, 2014). While the two domains are described as ‘work’ and ‘family’, it is important to note that the latter also embraces a person’s social life beyond work and outside of the immediate family environment.

The Bakker and Demerouti (2007) JD-R model of workplace stress provides a useful perspective of the relationship between job demands/resources, and various personal, social and organizational outcomes. In the JD-R model, workplace stress arises from an imbalance between the job demands experienced by a person and the resources available

to deal with them. Such demands may generate work pressure for the person (Schieman and Young 2013) and, if unaddressed, lead *inter alia* to burnout, exhaustion, and sleep problems (Hakanen *et al.*, 2008).

### A Conceptual Framework and Model

The conceptual framework and hypothesised model for this research is depicted in Figure 1. Work experience, gender, domestic situation (relationship status and number of children), and employment position level (hereinafter termed ‘employment position’) are proposed to explain work-related aspects such as job autonomy and control, job pressure, and work contact. Job autonomy and control, job pressure and work contact are theorised to covary and each is hypothesized to predict work-to-family conflict. Finally, work-to-family conflict is hypothesized to explain sleep problems.

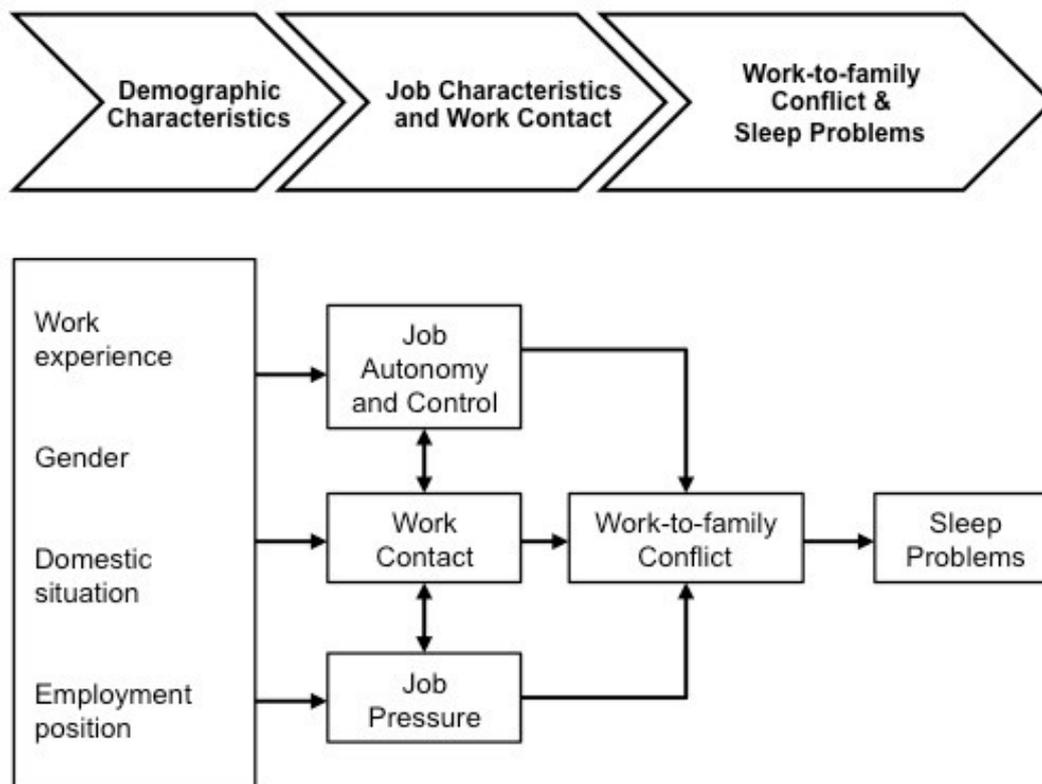


Figure 1: Conceptual framework for work contact, and work-to-family conflict and sleep problems

## RESEARCH METHOD

### Primary data collection

The sample frame comprised architects, engineers, quantity surveyors, and project and construction managers in South Africa registered with their statutory councils. As professional registration is mandatory for these disciplines, registration lists represent full populations. Registered professionals in each discipline were emailed by their respective statutory bodies, requested to participate in the survey, and given a URL for online access.

A 9% ( $n=942$ ) response rate was achieved, leaving a final data set of 630 after the removal of cases with missing values. Missing data analysis indicated that none of the variables of interest had more than 5% missing values. To facilitate the use of

modification indices in the confirmatory factor analysis (CFA) and path analysis, cases with missing values on any of the analysis variables were deleted. The distribution of discipline and gender characteristics in the final dataset was acceptably close to the total population of construction professionals in South Africa, although females are slightly over-represented in all discipline groups.

**Questionnaire items and scale development**

The Schieman and Young telephonic national labour survey (2013) formed the main basis for the questionnaire items. Where necessary, questions were modified for online administration, and were supplemented with questions drawn from Lingard and Francis (2002). Table 1 indicates the relevant items for work contact, WFC, and sleep problems and the scale measures developed for modelling purposes. The variable set was subjected to a confirmatory factor analysis (CFA) using structural equation modelling. Four critical fit indices (see Kline 2011) were applied to determine the degree of fit of the CFA and path models as follows:  $\chi^2/df$  ratio; Comparative Fit Index (CFI); Root Mean Square Error of Approximation (RMSEA); and Hoelter critical N).

No correlated errors were specified in this initial measurement model and the output indices indicated an adequate fit to the data ( $\chi^2 /df$  ratio=2.881; CFI=0.969; RMSEA=0.055; and Hoelter (95%) =274). Factor loadings in this model were all statistically significant ( $p<0.001$ ) and all exceeded 0.50. However, the modification indices indicated the need for correlated error between WFC1 (*insufficient time for family*) and WFC2 (*insufficient energy for family*). With this path specified, the resultant model presented an excellent fit to the data ( $\chi^2 /df$  ratio=2.547; CFI=0.975; RMSEA=0.050; and Hoelter (95%) =310). Factor loadings in this final measurement model were all statistically significant ( $p<0.001$ ) and all loadings exceeded 0.50. Alpha values for individual scales ranged between 0.75 and 0.91, indicating good to excellent internal consistency (see Table 1). Scale scores were created by summing individual item scores (reversed where appropriate) and higher scale scores reflect greater levels of the variable of interest. Additionally, the survey gathered information on respondent demographics, hours worked per week, hours worked at home, desired work-hours, and quality of partner relationship.

Table 1: Questionnaire items, scale measures and Cronbach’s alpha scores (n=630)

| Items and scale measures  | Metric  | $\alpha$ |
|---|---|----------|
| <b>1. Demographic variables</b>                                       |   |          |
| Gender  | Male=1; Female=2  | -        |
| Relationship status   | Divorced, separated, widowed or never married=1; Married or living with a partner=2   | -        |
| Children under 18 years residing at home                              | None=1; 1 Child=2; 2 Children=3; 3 Children=4; 4 Children=5; 5 Children=6; 6 Children=7; 7 Children=8; Exceeding 7 Children=9 | -        |
| Experience in the construction industry                               | 1-5 years=1; 6-10 years=2; 11-15 years=3; 16-20 years=4; Exc. 20 years=5  | -        |
| Employment position   | Salaried employee=1; Associate=2; Director or Partner=3   | -        |
| <b>2. Quality of partner relationship (Scale score range: 3-12)</b>   |   |          |
| PR1. I feel very close to my partner [D6a]                            | Strongly disagree=1; Somewhat disagree=2; Somewhat agree=3; Strongly agree=4  | 0.85     |
| PR2. My partner takes the time to talk over my problems with me [D6b] |   |          |
| PR3. I know that my partner will always be there for me [D6c]         |   |          |
|   |   |          |

|  |   |      |
|--|---|------|
| <b>3. Interaction variable (Scale score range: 1-18)</b>   |   |      |
| Domestic situation (DS)=Relationship status x Number of children under 18 years residing at home                               |   | -    |
| <b>4. Job Autonomy and Control (JAC) (Scale score range: 3-12)</b>   |   | 0.83 |
| JAC1. You have the freedom to decide what you do on your job? [C18a]   | Strongly disagree=1; Somewhat disagree=2; Somewhat agree=3; Strongly agree=4                          |      |
| JAC2. It is your own responsibility to decide how your job gets done? [C18c]   |   |      |
| JAC3. You have a lot to say about what happens on your job? [C18d]   |   |      |
| <b>5. Job pressure (JP) (Scale score range: 3-15)</b>  |   | 0.91 |
| In the last 3 months, how often did (were):  |   |      |
| JP1. You feel overwhelmed by how much you had to do at work? [C19a]  | Never=1; Rarely=2; Sometimes=3; Often=4; Very often=5   |      |
| JP2. You have to work on too many tasks at the same time? [C19b]   |   |      |
| JP3. The demands of your work exceed the time you have to do the work? [C19c]  |   |      |
| <b>6. Work contact (WC) (Scale score range: 3-15)</b>  |   | 0.84 |
| In the past 3 months:  |   |      |
| WC1. How often were you called about work matters outside of normal office hours? [C20a]                                       | Never=1; Rarely=2; Sometimes=3; Often=4; Very often=5   |      |
| WC2. How often did you receive job-related emails or text messages out of normal office hours? [C20b]                          |   |      |
| WC3. How often did you contact people about work matters outside of normal office hours? [C20c]                                |   |      |
| <b>7. Work-to-family conflict (WFC) (Scale score range: 4-20)</b>  |   | 0.91 |
| In the past 3 months:  |   |      |
| WFC1. How often did you not have sufficient time for important people in your life because of your job? [C21a]                 | Never=1; Rarely=2; Sometimes=3; Often=4; Very often=5   |      |
| WFC2. How often did you not have sufficient energy to do things with important people in your life because of your job? [C21b] |   |      |
| WFC3. How often did your work keep you from doing as good a job at home as you could? [C21c]                                   |   |      |
| WFC4. How often did your job keep you from concentrating on important things in your family or personal life? [C21d]           |   |      |
| <b>8. Sleep problems (SP) (Scale score range: 3-15)</b>  |   | 0.75 |
| In the past month how often have you:  |   |      |
| SP1. Had trouble falling or staying asleep? [B6a]  | None of the time=1; A little of the time=2; Some of the time=3; Most of the time=4; All of the time=5 |      |
| SP2. Woke up before you wanted to? [B6b]   |   |      |
| SP3. Woke up feeling refreshed? ( <i>Reverse coded</i> ) [B6c]   |   |      |

Multiple regression analysis (MRA) (not reported here) was used to inform the specification of the path analysis. The variables, applied additively in the MRA, identified significant predictors of job autonomy and control, job pressure, work contact, work-to-family conflict, and sleep problems. The selection of variables entered into the regression models was based on the literature. A path model was then specified and tested to determine the antecedents of work-to-family conflict and sleep problems.

## RESULTS

### Demographic characteristics

The mean and median ages of participants were 45-49 years (range: <25 years to >60 years). Participants were predominantly male (82%), and either married or living with a partner (88%). Just under half (49%) reported children under 18 years old living at home.

Experience in the construction industry yielded a mean of 16-20 years, and a median value of greater than 20 years. Just over half (58%) of respondents were partners or directors in the organisation; 10% were associates; and 32% salaried employees.

Working more than 50 hours per week was reported by 32% of respondents, and 16% reported working 56 hours or more per week. One quarter (26%) reported working more than 10 hours (on average) on job-related work at home on weekdays and weekends, and 8% reported working in excess of 30 hours a week at home outside normal working times. Working fewer hours per week was desired by 57% of respondents, whilst 38% preferred their *status quo* and 5% would rather work more hours per week. Two thirds (67%) reported to be very close to their spouse / partner, and 72% were convinced that their partner would always be there for them. Statistics for the quality of partner relationship scale score were:  $M=10.31$ ,  $SD=2.01$  (range 3-12).

### **Bivariate analysis**

Hours worked per week was significantly related to respondents' desire to work more, less, or unchanged hours per week,  $\chi^2(12, 630)=104.14$ ,  $p<0.001$ , with professionals reporting higher workloads per week desiring to work fewer hours significantly more than did colleagues with lighter loads. Quality of partner relationship was significantly inversely related to hours worked per week ( $r=-0.11$ ,  $p<0.01$ ), job pressure ( $r=-0.093$ ,  $p<0.05$ ), work contact ( $r=-0.11$ ,  $p<0.01$ ), WFC ( $r=-0.21$ ,  $p<0.001$ ), and sleep problems ( $r=-0.18$ ,  $p<0.001$ ). Specifically, poorer quality partner relationships were associated with more hours worked per week and higher levels of job pressure, work contact, WFC, and sleep problems.

### **Path analysis**

Based on the hypothesised conceptual model derived from the literature (see Figure 1) and the multiple regression analyses, a path model specifying the antecedents of sleep problems was specified and tested (Figure 2). The model was an excellent fit to the data ( $\chi^2/df$  ratio=1.439,  $p=0.119$ , CFI=0.994, RMSEA=0.026, and Hoelter (95%) =729). All paths were significant at  $p<0.01$  or more. Model outputs revealed no need for addition of further paths.

Respondents with higher levels of work experience were more likely to experience greater levels of job autonomy and control ( $\beta=0.22$ ,  $p<0.001$ ), but also more extensive work contact ( $\beta=0.11$ ,  $p<0.01$ ). Gender was significant in predicting levels of job pressure ( $\beta=0.12$ ,  $p<0.01$ ) and work contact ( $\beta=-0.11$ ,  $p<0.01$ ), with females reporting higher levels of job pressure than males but lower levels of work contact. Domestic situation was also significant in that greater family requirements result in greater levels of job pressure ( $\beta=0.16$ ,  $p<0.001$ ). Respondents experiencing lower levels of job autonomy and control reported experiencing higher levels of job pressure ( $\beta=-0.13$ ,  $p<0.01$ ), while those reporting greater levels of job pressure were also more likely to experience higher levels of work contact ( $\beta=0.45$ ,  $p<0.001$ ).

Employment position significantly predicted job autonomy and control in that respondents with greater seniority were more likely to enjoy greater levels of job autonomy ( $\beta=0.43$ ,  $p<0.001$ ) but also more extensive work contact ( $\beta=0.16$ ,  $p<0.001$ ).

Higher levels of job autonomy and control were associated with significantly lower levels of WFC ( $\beta=-0.11$ ,  $p<0.001$ ), while greater levels of WFC were associated with higher levels of job pressure ( $\beta=0.50$ ,  $p<0.001$ ) and more work contact ( $\beta=0.22$ ,  $p<0.001$ ). Sleep problems were determined by job pressure ( $\beta=0.16$ ,  $p<0.001$ ), WFC ( $\beta=0.28$ ,

$p < 0.001$ ), and work contact ( $\beta = 0.09$ ,  $p < 0.050$ ). Respondents with higher levels of job pressure, more extensive WFC, and higher levels of work contact were more likely to experience greater levels of sleep problems.

## DISCUSSION

In general, it can be said that, for construction professionals, higher levels of job pressure are likely to lead to increased after-hours work contact. Such contact diminishes or distorts resources and shifts them towards the work domain and away from family life. The resulting imbalance leads to greater WFC. This, along with the job pressure, increases the likelihood of sleep problems for the professional (and possibly for partners). These findings resonate with those of Lingard and Francis (2009) in respect of the construction industry and Schieman and Young (2013) in relation to the general population.

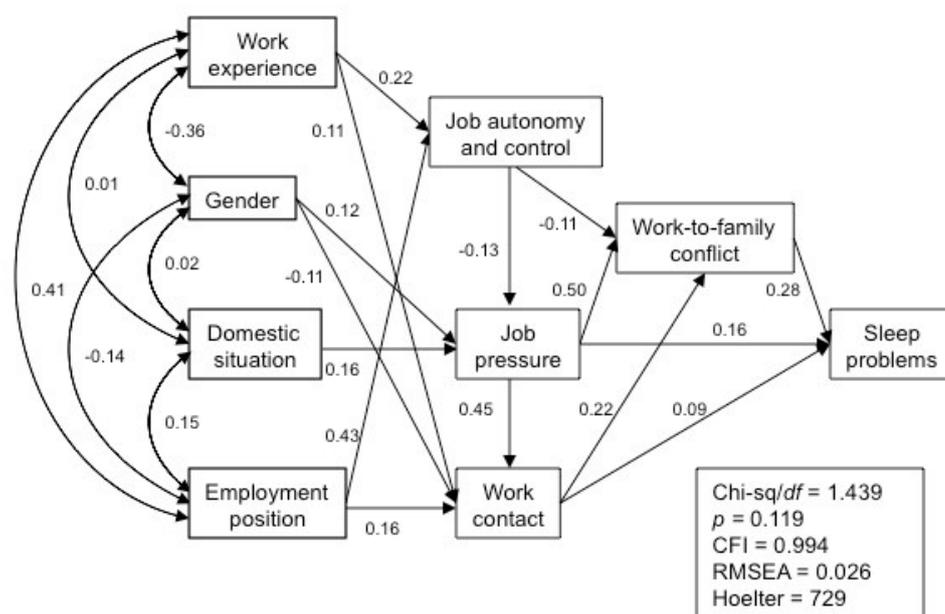


Figure 2: Path diagram of predictors of sleep problems

Previous research (Bellavia and Frone 2005) has pointed to a relationship between employment position and higher levels of work-family interference. This study has reinforced that finding, with more senior professionals reporting more extensive work contact than those of more junior status. Similarly, the findings support the contention that more senior professionals typically enjoy greater job autonomy and control. Job autonomy and control reduces both job pressure and WFC, by virtue of greater flexibility in scheduling work hours. Comparative results drawn from other studies of construction professionals (predominantly working within professional practices) are not available. Work experience, like employment position, proved a determinant of job autonomy and control and work contact - for much the same reasons as outlined above.

Job pressure, WFC, and work contact were found to have the greatest influence on sleep problems experienced by construction professionals. This is not surprising as the stress associated with tight deadlines and heavy workloads is likely to be associated with disturbed and less restorative sleep. Similarly, WFC is associated with psychological distress arising from strained family relationships and resultant sleep problems. These findings resonate strongly with previous research; see, for example, Jacobsen *et al.*, (2014) and Aazami *et al.*, (2016). Work contact, itself a possible source of job pressure

(particularly if initiated by demanding clients and professional team colleagues), may exacerbate the problem.

Research indicates that that long work hours are negatively related to family participation and positively linked to divorce rate (Lingard and Francis 2009; Kravina *et al.*, 2014). Our finding that poorer quality partner relationships are positively associated with more hours worked per week and higher levels of job pressure, work contact, work-to-family conflict, and sleep problems, supports this. Professionals working long hours reported a desire to work fewer hours. How can this be achieved? On the one hand the firm is unlikely to promote stricter boundary control if this negatively impacts productivity. Organisations increasingly push their employees to work harder and longer to remain successful in a globally competitive market (Fry and Cohen 2009). On the other hand, forcing their employees to compromise family relationships and quality of life may lead to increased staff turnover. The dynamic is further complicated by up-and-coming professionals' desire to progress through the ranks of the organisation (to the possible detriment of their families).

More extensive use of home-based approaches to work (working from home) has been advocated (Lingard and Francis 2009) for achieving greater work-family balance. This is *conceivable* within a construction professional context (with the exception of construction managers) provided the necessary computer infrastructure (access to the firm's LAN and proprietary software) is accessible and provided the firm is focused on output delivery rather than (unmonitored) physical hours at work and possible distractions at home (family-work interference). Whether firms enthusiastically embrace this suggestion is doubtful. In many instances, increased WFC and sleep problems may be conditions largely seen as employees' problems rather than organisational issues.

There are limitations to our study. Sleep quality was measured subjectively by self-reporting rather than objectively (see Landry *et al.*, 2015). The existence of more objective measures of sleep quality (e.g. actigraphy) is acknowledged (see Powell and Copping 2010). The survey instrument did not explore the status of the children in terms of the relationship between the parents e.g. situations where separated parents might share housing responsibility for their children. Subtle variations in family situations were thus not explored. Survey bias may exist due to the self-selection online administration process used. Finally, the industry-specific context of the study limits any generalisation of the findings to other sectors and to the general population.

## CONCLUSIONS

There is a significant relationship between the amount of work contact and levels of WFC experienced by construction professionals and reported sleep problems. Our *a priori* hypothesis is therefore upheld. Greater job autonomy and control reduces the impact of increased work contact on work-to-family conflict, but greater job pressure exacerbates it.

There is clearly a need to create greater awareness amongst professionals of the importance of restorative sleep and the relationships between job pressures, work contact, WFC and sleep problems. The inverse relationship between job autonomy and control and job pressure needs to be exploited to potentially reduce levels of work contact and work-to-family conflict and thus help to reduce sleep problems. Trying to manage job pressure more effectively is clearly difficult, but a possible clue may lie in staff empowerment and support, especially for female construction professionals. Professional practices could explore the possible implementation of alternative work arrangements such as flexitime, permanent part-time work, compressed work weeks, job sharing,

'employee choice' rostering, child care support, reduced working hours, and annualised hours (see Lingard and Francis 2009). Given the positive influence of supportive partners, canvassing the attitudes of partners regarding the work organisation and employee job demands would be a useful way of gaining insight into the impact of work contact on employees and families. It could also provide insight into issues such as employee commitment to the organisation and staff turnover intentions.

Work contact effectively extends the working day into time that would typically be devoted to family, social or other activities. Adverse consequences for any of these may be inevitable. However, total exclusion or avoidance of such contact is almost impossible in today's 'connected' world. Inter-generational differences also suggest that younger generations would not even contemplate such drastic solutions. More careful (and disciplined) boundary setting between work and family domains may be the only practical way to address the dilemma, but this cannot be a unilateral approach. Employers (however reluctant) and employees should each play their part. The construction industry, through all its stakeholders and participants, must make appropriate and acceptable work/life plans and sustainably build upon them in terms of human capital.

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# AN INVESTIGATION INTO A HEALTH & SAFETY REWARDS SYSTEM ON A LARGE CONSTRUCTION PROJECT

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Construction companies have widely adopted incentive systems rewarding safe acts and/or low accident rates. Through an ethnographic approach, a reward system used on a large construction project (+£500m) in the UK was investigated. As part of a wider study, the researcher visited a construction project one to three times a week for three years, and utilised participant observation as the main research tool. Data was collected through site walk-arounds, attending meetings, H&S survey results, and informal discussions with employees. H&S survey results revealed that money/vouchers (43%) were the most popular reward choice for construction workers. This was followed by branded clothing (9%), paid leave (8%) and outings (8%), such as golf days; suggesting workers were motivated by financially-based rewards, rather than certificates (6%) or public recognition (4%). An effective reward system required more than an appropriate motivator, as several challenges arose including: a lack of nominations; winners believing they did not deserve an award for 'just doing their job'; variations in prizes from shopping vouchers to iPads which led to feelings of inequality; and operative dissatisfaction when supervisors received awards. The challenges revealed can be used to aid construction companies in creating effective H&S reward programmes.

Keywords: unsafe behaviour, rewards, incentives, awards, H&S

## INTRODUCTION

It has long been understood that there is a link between unsafe acts, unsafe conditions and accidents. Unsafe acts have been identified as more difficult to observe than unsafe conditions (Gould and Joyce, 2009), due to the difficulties in witnessing fluid and momentary acts when compared to static and unchanging conditions (Smith *et al.*, 2017). Within the construction industry it has been argued that there should be further efforts towards understanding and reducing unsafe acts (Shin *et al.*, 2014; Oswald *et al.*, 2015), as there remains little to improve on in terms of physical conditions (Donald and Young, 1996). One of the strategies adopted by large construction companies in an attempt to mitigate unsafe acts is to implement a health and safety (H&S) incentive or reward scheme. Lipscomb *et al.*, (2013) noted that it was clear that both H&S reward and punishment systems were frequently in place in construction, and therefore both should

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warrant careful evaluation. In terms of construction H&S research knowledge, there is uncertainty and limited understanding into H&S incentive approaches. The aim of the research was to explore the H&S reward scheme implemented on a large construction project (+£500m) in the UK. More specifically, two research questions were investigated: 'which awards motivate construction workers?' and 'what challenges are there in designing an effective H&S reward programme?' The findings can be used to help construction companies in developing effective H&S reward programmes.

### **FINANCIAL INCENTIVES AND HEALTH AND SAFETY**

The first question to address is whether financial incentives are an appropriate human motivator within a corporate environment. The use of financial incentives to meet business objectives has been called into question by many authors. Pink (2009), outlined three direct challenges to financial incentives: they ignore human motivations that may be more powerful than economic self-interest; they destroy other motivations; and they create unintended and perverse outcomes. He claims that organisations have not yet been able to understand what really motivates people, and that they need to redesign themselves to take advantage of intrinsic motivation (Ibid.). This can include autonomy (freedom to work in one's own terms and one's own time), mastery (the ability to develop ones skills and ability to apply them to new challenges) and purpose (the possibility of making a contribution to the world) (Ibid.). Hopkins and Maslen (2015) explain that if companies allow the realisation of such intrinsic motivators, there would be no need for additional extrinsic motivators; aside from a reasonable level of fixed pay. It is harder, but not impossible, to implement Pink's (2009) recommendations in industries such as the construction industry, that produce manufactured goods (Hopkins and Maslen, 2015). For such industries his recommendation could be seen as a goal or long term ambition (Ibid.).

Drawing upon Maslow's (1943, 1954) hierarchy of needs there are human motivations that go beyond monetary desires, such as the need for: belonging; approval; making a valuable contribution; self-transcendence; self-esteem; self-respect; and for self-actualisation. Hence human motivation is complex, and it cannot be assumed that financial incentives will determine human behaviour. Yet, in some cases, financial rewards and incentives have been proven to provide temporary compliance and behaviour change (Eriksson, 2011). There is also evidence that the larger the incentive for workers who perform routine tasks that only involve mechanical skill at the bottom of the corporate hierarchy, then the greater the response (Pink, 2009). Hopkins and Maslen (2015) noted that this does not suggest that incentives invariably motivate behaviour, but that in some circumstances, they do. When considering Vroom's expectancy theory, which suggests people will behave in ways that achieves expected results (Druker and White, 1996), individuals may expect potential reward for safe working, and are therefore motivated by the incentive. The fact that human motivation is complex does not in itself undermine the potential of financial bonuses to influence behaviour in corporate settings.

Reward schemes are ways of achieving control in organisations (Kerr and Slocum, 2005) and ways of promoting desired individual and organisational behaviour to achieve the organisation's goals (Lawler, 1995). From an H&S perspective, the aim of rewards, incentives and recognition is to alter the ideas, values and practices carried out in order to achieve H&S behaviours (Vredenburg, 2002). They typically award individuals or groups of employees that achieve certain target levels of injury or accident free working hours (Vecchio-Sadus and Griffiths, 2004). On construction projects, they are commonly used, even though the safest firms are not necessarily the ones that use incentives (Hinze,

2002). Incentives may be effective in reducing workplace injuries, depending on how the rewards are structured (Ibid.), though there is no guarantee that individuals will behave the way the organisation intended (Kerr, 1995; Pink, 2009). Previous research has found mixed conclusions, with some suggestions that safety incentive programmes do positively affect safety performances of construction companies (Goodrum and Gangwar, 2004; Gangwar and Goodrum, 2005; Molenaar *et al.*, 2009); whilst other studies were unable to find a strong link between safety incentives and improved safety performance (Hinze, 2002; Rose and Manley, 2011).

## RESEARCH METHODS

Ethnography is a method of studying a specific group in their natural setting usually through participant observation (Phelps and Horman, 2010). As defined in ‘classic’ approaches to ethnography (see Atkinson *et al.*, 2007), it includes combinations of observing behaviours, participating in activities, writing extensive notes, interviewing and reflecting on one’s own role throughout the research. Ethnography is now emerging as part of the repertoire of approaches to understanding the construction industry, and can offer new routes to knowledge (Pink *et al.*, 2013).

Ethnographers often use participant observation as a main tool for data collection. On this project this included a mixture of: attending site inductions, site offices, canteens, work sites, meetings and having informal interviews with employees throughout the hierarchy from directors to labourers. Information on the setting was also gathered from various project documents. Ethnographic researchers can often benefit from being given access to documents that may not normally have been available to other researchers applying different research methods (Hammersley and Atkinson, 2007). In this study documentary data included site H&S survey responses, safety observation reports and meeting minutes. Such documents have not always been given the attention they deserve within ethnographic work (Hammersley and Atkinson, 2007) despite having the capacity to reveal to the researcher details about the context and social world they were created in (Pole and Morrison, 2003).

Data gathering through conversations and other sources, such as documentary data, can also lead to a form of triangulation, which ethnographers use as a matter of routine (Bryman, 2001). Triangulation involves a comparison of data on the same phenomenon at different phases of the fieldwork, different times and the accounts of different participants (Hammersley and Atkinson, 2007). In social research, relying on one single piece of data can lead to the danger of being exposed to undetected errors (Ibid.), as social reactivity, such as the Hawthorne effect can occur (see Oswald *et al.*, 2014, for a discussion within a construction industry context). Hence different kinds of data reaching the same conclusion can give more confidence in the finding (Hammersley and Atkinson, 2007). A common triangulation method is to compare data produced from different data collection techniques, which can provide a basis for checking interpretations (Ibid.). Triangulation is often a feature of ethnography (Bryman, 2001) and it is possible to triangulate both qualitative and quantitative data. Triangulating quantitative (such as the responses to a site H&S survey in this study) and qualitative data (participant observation) to explore in detail is a pluralism of method, but not a methodological pluralism - a case Pole and Morrison (2003) wish to argue for in what they call inclusive ethnography.

The data were analysed using a thematic approach, which gives the researcher a ‘bird’s-eye view’ of emerging patterns that could be drawn out (Aronson, 1994). This approach identifies patterns across data sets that are relevant in addressing the research aims (Braun

and Clarke, 2006). The thematic analysis consists of six stages: familiarisation with data, generating initial codes, searching for common themes, reviewing them, defining and naming themes and producing a final report (Ibid.).

## ETHNOGRAPHIC FINDINGS AND DISCUSSION

The following two sections present and discuss the research findings. The first part investigates the first research question, 'which awards motivate construction workers?' and second explores 'what challenges are there in designing an effective H&S reward programme?' The quotations used within the text are representative of the typical perceptions on the project, and the data from the site H&S survey is presented in combination with ethnographic insights as appropriate.

### Which awards motivate construction workers?

The project used a combination of awards with financial worth and public recognition to reward winners. The awards consisted of gift vouchers for monthly winners, alongside public recognition through posters and a project-wide congratulatory email. For acts of H&S excellence, iPads were distributed instead of gift vouchers. The project's H&S department asked specific questions relating to the H&S award scheme in an H&S survey undertaken on site. There were 147 responses to a question focused on the prize, with survey respondents asked to complete the sentence: 'I think that the individual rewards for the Award Scheme should be...'

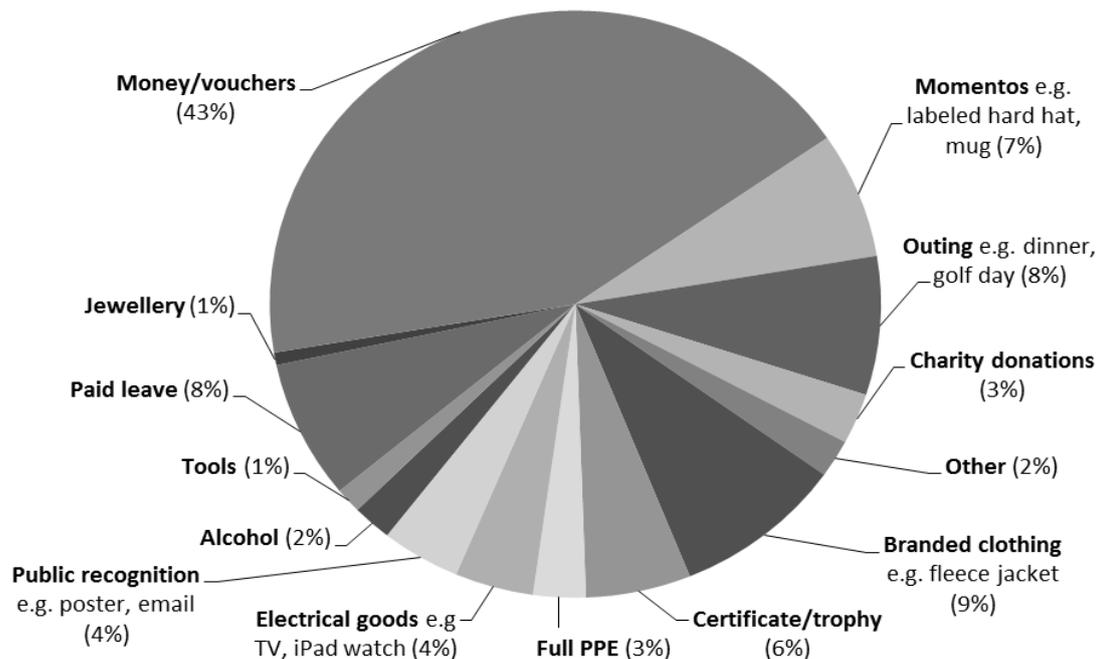


Figure 1: The H&S award prize suggestions from 147 workers

The researchers categorised the answers into fourteen groups. Figure 1 above illustrates the percentage popularity of each category. Almost half of the workers wanted money or gift vouchers (43%) for winning the H&S award. For example, respondents stated: 'bonus'; 'vouchers for major retailers'; 'money'; 'big wedge of cash'. Ethnographic discussions on-site also confirmed that money was a strong motivator for the construction workers:

H&S advisor: 'The guys want to do overtime whenever they can get it. They don't mind doing all the hours, 'cause money is a big driver for them.'

Motivation is a critical factor within an incentive programme (Goodrum and Gangwar, 2004) and therefore it is very important to understand how incentives could motivate workers to be safe. Rose and Manley (2011) noted that financial incentives can enhance motivation at a personal level, and the findings here suggest that financial rewards were indeed a strong motivation for workers. Branded clothing (9%), paid leave (8%), outings (8%), electrical goods (4%), alcohol (2%), tools (1%) and jewellery (1%) were other choices that, while are not legal tender, have financial value. This reinforces the finding that workers were driven by awards with financial worth. It is worth noting that alcoholic prizes could be counterproductive, as they have been previously linked to accidents (see for example Biggs *et al.*, 2012; Oswald *et al.*, 2013; Marques *et al.*, 2014).

Some workers also suggested non-financial rewards in the form of public recognition (4%), certificate/trophies (6%) and mementos (7%), though this was a much less popular choice than financial rewards. Award winners were publically congratulated and photographed receiving the award with the project director. The photograph would be communicated throughout the project via email and posters. Aside from money being a very important driver, ethnographic discussions with employees also highlighted other reasons why non-financial awards, in the form of public recognition, were a less popular choice. A security manager summarised this during a meeting:

...some won't like the stigma of being the safety winner, the limelight of their photo being up on the wall; and it puts pressure on them to not make mistakes, 'cause they are a safety champion. They can't be seen to do anything wrong.

Maintaining one's image is extremely important to individuals in the workplace (Mullen, 2004), and H&S winners may have additional pressure of feeling they are now unable to make a mistake, or break a rule. Considering there are recognised gaps between rules and working practices (Lofquist *et al.*, 2017), and in some cases operatives would break the rules to complete tasks, workers may not want to be a public H&S champion, as they acknowledge they bend the rules on occasion.

Three per cent of workers desired to make a donation to a charity of the winner's choice, while another three per cent stated the prize should be PPE, which should be mandatorily worn on site and provided by employers. It could be interpreted that a small percentage used the survey question to highlight to senior management that they had not received all the appropriate PPE.

Some participants did not offer a suggested prize, and instead used the survey question as an opportunity to communicate that they disagreed with the appropriateness of H&S incentives. For example, workers stated: 'It shouldn't be awards. Work safely is something mandatory.'; 'Going home safely should be reward enough'; 'You don't work safely or make interventions to get an award, you do it so people are safe'. Hence, not all were motivated by the award scheme. This perception represents a challenge of H&S award programmes and their design and is discussed in more detail in the following section.

### **What challenges were there in designing an effective H&S reward programme?**

The design of a reward or incentive programme needs very careful consideration as there can be unexpected and/or undesirable behaviours that are induced by the scheme. For example, Hopkins (2008) noted that bonuses paid to managers for cost-cutting could result in the increased likelihood of major accidents, as managers may take additional risks to save costs. Hence, firms must be careful when implementing incentives or they may not generate the desired result (Hinze, 2002). One of the undesirable behaviours within the reward programme was that there was a lack of nominations:

H&S Manager: 'we only got two nominations again this month.'

A key characteristics of a well-designed incentive programme is that the programme receives a high level of visibility within the organisation (Vredenburg, 2002). In the H&S survey undertaken by the project, 74% agreed that they 'have been told about the Safety Award Scheme', which suggests that while the majority were aware of the scheme, there were still over a quarter that had not been briefed about the programme. Some of those that were aware of the scheme also did not appear to value it. For example, operatives commented:

'let's be honest here, safety awards only matter if you are in R2'; 'Waste of time unless you work for R2; 'Only one department is awarded'

R2 was a department whose members frequently won the H&S award. Operatives in other departments explained that the H&S reward scheme 'didn't matter' to them, and they did not appear to be motivated by the possibility of winning the award. Operatives also thought the award should be targeted for the workers doing the physical construction work, and not their supervisors. They repeatedly questioned:

'Why do supervisors get awarded? We do the work, and they already take the money'

Construction workers were frustrated when a financial award that they thought should be distributed to them, was being awarded to their superiors, who were not doing the high-risk work, and were already receiving higher wages than them. The lack of nominations reduced options for the selectors of the award, which could have influenced the decision to include supervisors in the award. Some of the supervisors themselves even believed they did not deserve it:

Supervisor: 'See the safety award... what are you meant to have to do to get it?'

H&S professional: 'it was meant for those that go above and beyond'

Supervisor: 'well I'm confused... 'cause see I actually won an award... but I had done nothing special, was just doing my job.'

The award was being devalued as it was being distributed for acts perceived as part of the job, and not for surpassing H&S expectations. It is very important that the incentive is awarded to those that undertake behaviours that are perceived as acts of excellence. When awards are distributed for actions that do not go above and beyond what is expected, it is understandable that workers would question the worth of the programme, and that some would have the opinion that there is a moral obligation to stay safe, and so an award for safe behaviour would not change their actions. Hence, it is very important that the criteria for the H&S award scheme is communicated clearly, and is awarded only to acts of excellence where for example, an individual has demonstrated an improvement in the way H&S is performed on site, highlighted a significant latent failing within the system, or has reduced H&S risks to others in one way or another.

The lack of nominations limited the selector's choice every month. If there were no acts of H&S excellence within the candidates, the selectors were still required to choose a winner. This meant there were times when winners were awarded for acts that were perceived as not going above and beyond expectations. Luthan (1992) explained that in such award programmes that have a recurrent award at a specific time, reinforcement is strong immediately before the prize award date, but weak for a considerable period after. If incentives are only to be awarded when individuals consistently go above and beyond H&S expectations, this questions the use of time-intervals (e.g. monthly) in reward systems; and instead distributing an award whenever the reward criteria is met should be considered. This type of award would rely on the fun of participating, as the occurrence

of the reward is unpredictable (Cameron and Duff, 2007). Considering that the evaluation process can be more of a motivator than the money that goes with it (Hopkins and Maslen, 2015), this evaluation aspect of what constitutes a worthy prize should be carefully thought through and communicated. This could increase the likelihood of receiving strong nominations, and avoid the award being distributed for acts not perceived as worthy, which in turn belittles the programme.

Care should also be taken when offering multiple prizes, as this can cause feelings of confusion and inequality. On the project a £50 gift voucher was awarded to the winner of the monthly H&S award. On rare occasions, iPads were awarded instead, and were intended for acts of H&S excellence. However, due to their infrequency this created confusion to whether they existed as a prize. For example, an H&S advisor explained a conversation that occurred within a project meeting:

‘One of the foreman asked a senior manager what happened to the iPads as prizes. The answer he got was like something straight out of a politician’s mouth: he didn’t answer the question, just went in roundabouts. They were being awarded early in the project, when there was still money. Not now.’

The iPad prize was only to be used for acts of H&S excellence, but this devalued the monthly award that consisted of a gift voucher prize. It appeared that it was important to have clear criteria of what types of behaviour deserve reward to avoid such unintended negative reactions to awards. Participants in the programme should be able to understand what the incentive programme is designed to accomplish and how their performance is being measured (Halloran, 1996). When designing the programme it should be planned to continue for the duration of the project, and be independent of the financial stresses on the project during the construction phase. Removal of awards during periods of financial strains on the project can create feelings of injustice within the workforce, thereby potentially reducing positive feelings towards H&S, and H&S management overall.

## CONCLUSIONS

H&S incentive or reward programmes are poorly understood within construction H&S research, despite being widely used in practice. This research sought to understand what incentivised motivated construction workers; and what were the challenges to designing an effective reward programme on a large construction project in the UK. Although only drawing on one large case study project, the transient nature of the workforce and similarities in operating practices amongst large contractors, means that the findings are able to provide insight beyond the case study boundary, as suggested below.

Monetary awards, such as legal tender or gift vouchers, were found to be strong motivators for construction workers. Prizes of financial worth were also found to be a motivation. However, a lack of consistency in the processes through which such rewards and prizes were awarded had, over time, developed it into de-motivator amongst some of the workforce. Indeed, it could be suggested that inconsistencies with the value of H&S awards, alongside other issues such as awards for supervisors which were seen as unwarranted, or a lack of desire for public recognition, led to the problem of a lack of uniform engagement with the programme as a whole. For the HS team this created difficulties in terms of securing nominations, and led to something of a 'vicious circle', whereby those engaged with the programme kept 'winning', whilst those who were initially disengaged simply became more so over time, becoming more de-motivated towards the process as a whole.

It is therefore suggested that H&S reward programmes should be designed with clarity and transparency in mind. Findings from this case study suggest that only one standard

monetary prize would have enhanced the programme overall, and it was found to be essential that the award criteria are clearly communicated to the workforce, such as whether awards are for supervisors or just workers. Non-financial rewards such as mementos or trophies can be used in combination; as long as they do not also involve public recognition. It is also suggested that awards should not be distributed on a set frequency basis (e.g. each month), as there may be a lack of nominations, which can lead to an unworthy winner that belittles the award programme. Instead, awards are better received if they are distributed whenever acts of H&S excellence are performed. Again, this should be clearly communicated and could reflect for example when an individual has demonstrated an improvement in the way H&S is performed on site, highlighted a significant latent failing within the system, or has reduced H&S risks to others in one way or another. Further research should be carried out to investigate this recommendation and determine how the workforce would perceive this process to be most fair in practice.

Whilst there is the potential for H&S reward programmes to be a useful asset for reducing unsafe acts within a wider H&S management system, this research has shown that the process must be carefully managed in practice. While the rewards did not change the behaviours of all individual on the case-study project, they did motivate some workers, and therefore were also likely to have the potential to also motivate others, should the programme be effective. It is therefore important to understand what motivates construction workers and how H&S rewards programmes can be designed to work well in practice. The insights presented within this paper are a step towards comprehending this poorly understood area within construction H&S management.

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# CORPORATE GOVERNANCE, INCENTIVE SCHEMES, AND SAFETY PERFORMANCE IN THE CONSTRUCTION INDUSTRY

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Addressing workplace health and safety has been identified as a dimension of Corporate Social Responsibility (CSR). A socially responsible business is characterised by good corporate governance that provides a healthy and safe work environment. Under the umbrella of CSR, this study examined a specific element of corporate governance, i.e. senior executive incentive schemes, which are the key mechanism used by Boards of Directors to align senior management's interests with organizational interests. The specific focus here is long-term incentive plans (LTIPs). This study investigated what senior management have been incentivized to achieve by LTIPs, and whether, or how, the incentives are aligned with the organizational strategic objective of safety performance. Annual Reports of publicly listed construction companies in Australia were collected and subjected to content analysis. The research found that LTIPs were exclusively related to financial measures with safety indicators not included in any LTIPs. This suggests that the structure of LTIPs may only incentivize senior executives to focus on financial performance thus overlooking safety performance. The design of LTIPs may not contribute to corporate governance capable of producing good safety outcomes. Future research is needed to explore ways to align incentives, senior management motivations and safety performance in the construction industry.

Keywords: Corporate Social Responsibility, governance, incentives, senior executives

## INTRODUCTION

### **Safety and Corporate Social Responsibility (CSR)**

High injury and fatality rates are recorded annually in the construction industry globally (Sawacha *et al.*, 1999). Workplace injuries and fatalities not only incur substantial economic cost (e.g. compensations and reduced productivity), but also have considerable social impact (e.g. pain and suffering to individuals and their families). Improving workplace safety performance is a strategic priority for many construction companies.

In recent years, the notion of corporate social responsibility (CSR) has been increasingly emphasized in the construction industry. Apart from providing effective and efficient building and constructing services, construction companies are also expected to effectively manage their business to be socially responsible (Petrovic-Lazarevic 2008). CSR is concerned with integrating environmental, social and economic considerations into business strategies and practices (Jones *et al.*, 2006). CSR is defined as the

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continuing commitment by business to behave ethically and contribute to economic development while improving the quality of life of the workforce and their families as well as of the local community and society at large (Watts and Holms 2003: 3). Although the focus and meaning of CSR can vary between national and industrial contexts (Carroll and Shabana 2010), generally CSR consists of an internal and an external dimension. The internal dimension primarily relates to employees within an organization and issues such as human resources management, health and safety, and adaptation to change; while the external dimension extends social responsibility beyond the organization to encompass stakeholders such as business partners, suppliers, customers, local communities, and issues such as global environmental concerns (Commission for the European Communities 2001).

Given the inherently dangerous nature of the construction industry, it is not surprising that a strong focus on workplace health and safety (H&S) has been revealed for CSR strategies used by construction organizations. For example, Loosemore and Lim (2017) reported that workplace H&S was ranked as the top CSR focus of companies in the Australian construction industry, with many companies implementing CSR-based strategies to address long-standing issues such as work-life balance, unfair treatment and workplace conditions. Jones *et al.*, (2006) investigated the CSR agendas reported by construction companies in the UK, and identified an explicit and sustained focus on H&S among the companies. In terms of achieving CSR performance, Mackenzie (2007) pointed to the important role of effective corporate governance in attaining CSR objectives by setting CSR related standards and values for companies.

In the following section, a specific element of corporate governance, i.e. executive incentives, will be introduced and the potential role of executive incentives in attaining the CSR objective of H&S in the construction industry will be discussed.

### **Corporate Governance, Executive Incentives and Safety**

Corporate governance provides the structure through which the strategic objectives of a company are set, and the means of attaining those objectives and monitoring performance are determined (OECD 2004 cited in Ferguson 2015). The key group accountable for corporate governance is the Board of Directors, which is responsible, among many other duties, for safeguarding the interests of shareholders, monitoring management, and determining corporate governance strategies (Nicholson and Newton 2010). It is also the Board of Directors that ultimately decides the issues of most importance for the organization, and thus the key priorities that the CEO and other senior executives should focus their attention upon (Ocasio 1997). With the rising importance of CSR, it is not surprising that some Boards are increasingly turning their attention to the objectives encapsulated by CSR and extending their responsibilities beyond the traditionally narrowly defined stakeholder group of shareholders to incorporate a more diverse group of stakeholders such as employees and customers (Mahoney and Thorn 2006).

Incentive schemes for senior executives are a central mechanism used by Boards to emphasize the strategic importance of key priorities (Gupta and Wowak 2017). Boards are bound by fiduciary requirements to design incentive schemes in ways that motivate senior executives to act with organizational interests at heart. Thus, incentive schemes, and senior executive decision-making, are integrally linked to organizational performance (Gupta and Wowak 2017; Nicholson and Newton 2010). Incentive schemes are also important because they are used by Boards of Directors to direct senior executive attention to CSR objectives, including safety performance.

Broadly speaking, incentive schemes consist of a short-term incentive plan (STIP) and a long-term incentive plan (LTIP). The STIP applies to management personnel of different levels (e.g. executives, senior managers, divisional managers, etc.) with payments made annually, although part may be deferred for a period of time (e.g. one year). Payments are granted by measuring individual performance against key performance indicators (KPIs), which are typically linked to organizational strategic objectives such as productivity, financial performance, client satisfaction, and workplace safety performance. In contrast to STIPs, LTIPs are only applicable to the CEO, the Managing Director (MD), and other executive key management personal (KMP). In broad terms, LTIPs generally share common structural features, although with some variations to align with particular organizational objectives. Generally, LTIPs are the largest component of total executive remuneration, with CEOs of major organizations often paid bonuses several times the value of fixed salaries (Shields *et al.*, 2003). This suggests that incentive schemes can provide significant motivation for senior executives to strive for improved organizational performance.

## **RESEARCH AIM**

Under the broad umbrella of CSR, this research examined publicly listed construction companies in Australia to understand how safety is positioned as an organisational objective, and examine the structure of executive incentive schemes, with a particular focus on the structure of LTIPs. The purpose is to explore what metrics are typically included in LTIPs to evaluate the performance of senior executives, and whether LTIPs include any safety related metrics to direct senior executives to focus on the safety performance.

Hopkins and Maslen (2015) examined executive incentives in the resources and energy sector. They identified a poor alignment between incentive schemes and the need to have a senior management focus on safety. Hopkins and Maslen's work provides the basis for exploring what senior management are incentivised to achieve by LTIPs, and whether the incentives are aligned to safety performance as a CSR objective in the construction industry. This is important because the misalignment can possibly result in unintended consequence. For example, the catastrophic accident of 2005 BP Texas City refinery disaster killed 15 workers and injured another 180 people (CSB, 2007), and led to investigations of senior executive incentive structures and major accident risks. Analysis of the Texas City case revealed that incentive structures directed senior management attention towards business and financial objectives rather than safety (Hopkins, 2010). The Texas City case influenced BP as well as other companies involved in hazardous industries to include indicators of major accident risk management in their incentive plans (Maslen and Hopkins, 2014).

## **RESEARCH METHOD**

The research reported here was conducted during 2015-2016 as the first stage of a long-term project investigating senior executive incentive schemes and safety performance in the Australian construction industry. Annual Reports of publicly listed companies in non-domestic construction sector were collected and subjected to a content analysis to examine senior executive incentive schemes and their relationship, if any, with safety performance. Publicly listed construction companies were identified using information available online from the Australian Constructors Association (ACA), the Housing Industry Association's (HIA) HIA-Cordell Construction 100 2013/14 Report and the Australian Securities Exchange (ASX). A limited number of companies are engaged in non-domestic construction in Australia, with even fewer publicly listed. As a result, the

eight Annual Reports discussed here constitute the complete population of publicly listed non-domestic construction companies in Australia.

Publicly listed companies were used because these organizations are required to disclose details about senior executive incentives and the associated KPIs in their Annual Reports, which are freely accessible. The LTIP was chosen because Annual Reports provide detailed information about those plans. In contrast, Annual Reports provide relatively limited information about STIPs because the KPIs used to assess individual performance under these plans are part of confidential work responsibility agreements and are not publicly available. However, Annual Reports have been criticised as a data source because managerial disclosure in these documents tends to be biased and self-laudatory with information selectively disclosed and manipulated to create positive stakeholder perceptions of organizational performance (Deegan and Rankin 1997: 562; Godfrey *et al.*, 2003). A focus on reporting positive results means key hazards or risks are not identified and the efficacy of risk control strategies is not discussed (Jenkins and Yakovleva 2006).

Although these are important points to consider when using Annual Reports as a data source, they are not relevant here. This is because the objective of the research was not to examine the texts as a reflection of reality (Silverman, 2001, p.201), which is also a criticism of content analysis as a research method discussed below. Rather, the aim of the research was to explore the voluntary narrative (Ferguson, 2015, p.64; Leung *et al.*, 2015) provided in Annual Reports, including how organizations position safety, linked to organizational values and objectives and how LTIPs are structured. Thus, the 'voluntary narrative' in Annual Reports provides an organizing, or conceptual, framework for the analysis and a practical way to compare how organizations prioritize safety and structure senior executive incentive plans.

The Annual Reports were interrogated using a content analysis approach, which is a method that has been widely used to investigate Annual Reports in a range of contexts (Fuolo, 2107). Some research has used content analysis to code text into explicit categories that are then subjected to statistical analysis (see for example Dumay and Cai, 2014), often described as the quantitative analysis of qualitative data (Hsieh and Shannon, 2005, p.1278). In contrast, this research examined texts for themes using central concepts or statements, the communicative context in which those statements appear and to assign these to relevant research categories (Flick 2002: 194). In this case, the themes emerged from a close and independent reading of the Annual Reports by the researchers who were guided by the overall research aim, namely to understand how companies positioned safety compared with the structure of senior executive LTIPs.

## **CONTENT ANALYSIS RESULTS**

### **Safety Commitment**

All companies in the sample group expressed a strong commitment to safety in their Annual Reports using terms such as 'Vision,' 'Focus,' 'Priority' and 'Value' to position safety as part of organizational values. For example, organizations described their organizational vision as Injury Free Everyday with safety positioned as their ... number one priority with an uncompromising commitment to operate incident and injury free ... or as ... absolute priority and a core value. There was also an organizational commitment to maintaining and improving safety performance. For example, one company expressed their safety commitment as "...our focus is on continued improvement and keeping our people safe". Safety commitment was also expressed as an integral part of long-term organizational culture and values, as this representative comment shows:

...Pursuit of Excellence is the philosophy that drives the [Company] culture ... at the core of our values system, which embodies the areas of performance, productivity ... and Zero Harm....

The expressions used to discuss safety send a strong message to readers that safety is valued and prioritized as a key organizational operational objective and commitment to improving safety performance to below industry levels or, preferably, to zero. It is not unreasonable to anticipate that LTIPs would include performance indicators, in some form, that reflected such a strongly articulated commitment to safety as a long-term organizational goal.

### Structure of LTIPS

In all companies examined, LTIP participants are restricted to CEOs, Managing Directors (MDs), and Key Management Personnel (KMP). The amount of remuneration available in LTIPs for CEOs and MDs can range from about 67% to as much as 150% of fixed salary. For executive KMP the range can be from 50% to 90% of fixed salary. The LTIPs for six out the eight companies in the sample used performance shares, and the remaining two companies used share options.

#### Performance shares

In LTIPs that use performance shares, senior executives are provisionally granted a certain number of shares that can only vest after a period of time (e.g. between 2 to 4 years) and only if pre-defined vesting conditions have been satisfied. Vesting conditions relate exclusively to financial performance indicators and include both relative and absolute indicators. Normally, 50% of the performance shares are linked to the relative indicator with the other 50% linked to the absolute indicator.

Relative performance indicators compare an organization’s performance against a comparator group, with the most commonly used indicator Relative Total Share Return (TSR). This indicator measures the total amount returned to investors benchmarked against an external comparator group, such as the top 100 ASX listed companies across different industries or the top 200 ASX listed companies from a specific industry. The TSR of the median company in the chosen comparator group (i.e. the 50th percentile) is normally the index against which TSR performance is evaluated. Figure 1(a) illustrates the most typical vesting condition of LTIP linked to relative TSR across the sample group. As Figure 1(a) shows, if TSR performance sits exactly on the 50th percentile at the end of the vesting period, senior executives can be awarded 50% of the performance shares linked to TSR.

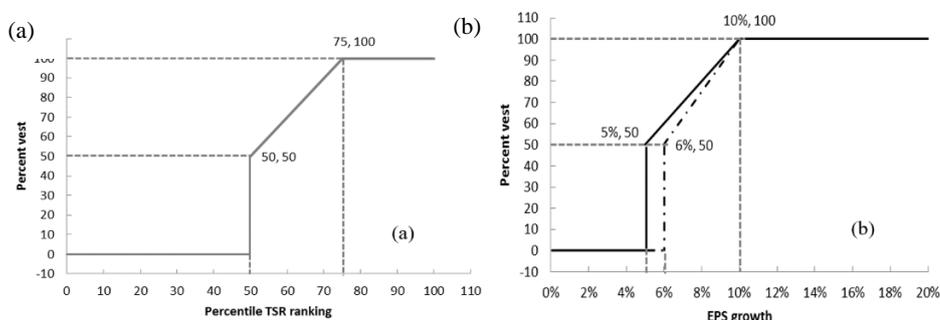


Figure 1: a) Vesting condition of LTIP linked to relative TSR; b) Vesting conditions of LTIPs linked to EPS growth

If TSR performance sits between the 50th and 75th percentile, senior executives can be granted shares pro rata from 50% to 100% on a sliding scale. If the TSR performance sits

at or above the 75th percentile, then 100% of the performance shares linked to TSR can be awarded. However, if the TSR is below the 50th percentile at the end of the vesting period, senior executives will not be awarded the performance shares linked to that indicator. The vesting conditions place significant pressure on executives to achieve the 50th percentile of TSR performance. Absolute performance indicators compare an organizations current performance against its own organizational performance in previous years, reflected as per cent of growth.

The companies in the sample group used three absolute performance indicators, specifically Annualized Earnings per Share (EPS), Annualized Return of Equity (ROE), and Return on Invested Capital (ROIC). All three indicators measure the companies' absolute profitability (i.e. not relative to a comparator group). Figure 1(b) shows two companies in the sample group that used the same vesting conditions in relation to annualized EPS growth as an example to illustrate how LTIP vesting conditions are linked to absolute indicators. Specifically, the threshold for senior executives to be awarded with any performance shares is an EPS growth of 5%, at which point senior executives can obtain 50% of shares linked to EPS growth. After the threshold of 5%, the per cent of shares that can be granted rises pro rata as the EPS growth increases until 100% of shares vest when EPS growth reaches 10%.

#### *Share options*

Two companies in the sample used share options, where senior executive are granted options to buy company-owned shares at a share price that is much lower than the market price. The difference between the market value of the shares and the amount paid to buy the shares is in effect a bonus for the senior executives. However, in order to exercise share options, certain conditions need to be satisfied at the end of the vesting period. For example, the vesting condition for one of the organizations using share options is linked to share price with a specified vesting period of three years. At the end of the second year of the vesting period, if the company's shares hit or exceed the target (described as the hurdle price) and trade with that price continually for at least 10 days, senior executives can exercise 50% of the share options at a much lower exercise price per share. Another 50% of the option can be exercised if the same share performance is achieved at the end of the total three-year vesting period.

## **DISCUSSION**

This study aims to understand how safety is positioned and where safety sits in the LTIPs of publicly listed construction companies in Australia. Analysis of the Annual Reports for the companies examined showed a strongly articulated safety commitment, often described as the 'number one priority,' and linked to organizational values and vision as defined in the respective Annual Reports. Safety was also positioned as a long-term organizational objective, which requires continuing effort to achieve Zero Harm safety goals. However, and notwithstanding expressions of a strong safety commitment, when the LTIPs were examined for performance indicators, organizational safety performance is not considered at all. This reveals a mismatch between stated organizational safety objectives and the operational targets that CEOs and KMPs are being incentivized to achieve in LTIPs.

Similarly to research in the energy sector (Hopkins and Maslen 2015), this research found that irrespective of the type of financial indicator considered, the design of LTIPs places significant pressure on senior executives to prioritize organizational financial performance. Added to that, because even higher rewards are available if financial performance exceeds certain thresholds, there is a significant incentive for senior

executives to push for even higher financial returns for their organization. One consequence of this is that LTIPs may direct the attention of CEOs and KMP to initiatives that focus on share price and earning performance and, as a result, overlook safety performance.

The findings discussed here suggest that the way that the LTIPs are designed influences senior executives to focus on shareholders and organizational financial performance. This seems to be not aligned with the notion of CSR, which requires senior management to attend to broader stakeholders and issues of concern to those groups, including safety. Research has shown that excessive focus on a firm's financial performance can be detrimental to the promotion of social and environmental objectives (Mahoney and Thorn 2006). For example, Wowak *et al.*, (2015) found that incentive schemes, such as those that include stock options in LTIPs with a focus on 'big wins', play a significant role in promoting a lack of caution in CEO decision-making. They note that there can be consequences that are not socially responsible including an impact on public safety, such as when unsafe products are released into the marketplace.

Despite positioning safety as a long-term organizational objective, no safety metrics are included in LTIPs. Rather, safety metrics are only mentioned in STIPs and are typically lagging indicators, e.g. lost time injury frequency rate (LTIFR) and total recordable injury frequency rate (TRIFR). However, these measures are essentially short-term productivity, not safety, measures and, as such, efforts to drive down those measures provide little insight into factors contributing to injuries or fatalities (O'Neill *et al.*, 2016; Safe Work Australia 2013). The ultimate goal of these measures is to reach 'zero harm' or 'injury free' workplaces. However, a commitment to zero harm or injury free as key CSR objectives can be problematic because it can, albeit unintentionally, lead to the development of bureaucratic accountability processes (Dekker 2014: 34). One consequence of such an increasingly bureaucratized approach to safety is that compliance becomes an end in itself, or in other words, safety becomes 'trapped' into rules (Bourrier and Bieder 2013).

The issues noted above raise questions around safety governance, and whether the way that safety policies are developed and the fundamental design of LTIPs really support positive CSR outcomes in terms of safety.

## CONCLUSIONS

The research reported here found that all the companies examined in the group of publicly listed companies in the Australian non-domestic construction sector expressed a strong commitment to safety in their Annual Reports. However, the pattern of LTIPs and their vesting conditions across the group reveals that senior executives are primarily incentivized to improve organizational financial performance. These results are similar to those of Hopkins and Maslen in the energy sector, where LTIPs exclusively depend on financial performance while safety performance is essentially irrelevant (2015: 75). Despite claims prioritizing safety as part of the organizational vision, values, and mission, there were no indicators in the LTIPs relating to strategic organizational safety objectives linked to CSR.

Importantly, the results do not suggest that existing lagging safety performance indicators must or should be part of LTIPs. That type of approach could potentially increase problems such as the manipulation of measurement and underreporting of injuries (see also Safe Work Australia 2013). However, the research findings do suggest that more valid and meaningful safety performance measures should be developed and included in

the LTIPs to align incentives and more effectively manage safety performance in the construction industry from the top down. This would include considerations of alternative frameworks that provide effective KPIs linked to incentives but that also avoid any further bureaucratisation of safety. The ultimate aim is not only to motivate senior executives to consider long term organizational financial growth but also to include ways to ensure that safety performance, as a key CSR objective, can be improved.

This research is a useful starting point in understanding senior executive incentive schemes in the construction industry and how these align executive decision-making with safety performance. It is expected that these research findings will generate substantial interest in the construction management community regarding what senior executives are incentivized to achieve and how safety is relevant to evaluations of their performance linked to incentive payments.

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# THE ROAD TO HELL: WORKER HEALTH, SAFETY AND WELLBEING WITHIN UK CORPORATE SOCIAL RESPONSIBILITY PRACTICES

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Construction work is often unsafe, unhealthy and bad for worker wellbeing. In the UK governments and companies have sought to address this, the former through legislation the latter through their compliance, and more recently through Corporate Social Responsibility (CSR) remit. Yet these developments have brought with them challenges of commodification with worker health enhancement and wellbeing initiatives readily packaged to support the corporate brand. When viewed through a Marxist lens such commodification increases in complexity as the fundamental conflict between capitalism and worker HSW is revealed, suggesting that a ‘business case’ for worker HSW can never truly be made and HSW CSR initiatives remain inevitably superficial, as construction work inevitably exploits its workers and their HSW. Contemporary CSR fails to acknowledge these characteristics of the capitalist system and instead, perhaps more dangerously, is contributing to the illusion that construction worker HSW has never been better taken care of. This paper challenges the ideas of benevolent business practice, decries the notion of CSR within the contemporary neo-liberal doctrine, and questions whether construction should not be doing better in terms of ‘true’ CSR within its hazardous and harmful operations?

Keywords: business case, Corporate Social Responsibility, health, Marxism, wellbeing, CSR

## INTRODUCTION

Construction work is often unsafe, unhealthy and bad for worker wellbeing. In the UK, governments and large construction contractors have sought to address this, the former through legislation the latter through compliance and various management systems. Although there have been considerable improvements in UK construction site safety over recent years, the Health and Safety Executive (HSE 2017) still notes that ‘... a number of serious ill-health issues continue to affect construction workers.’ Available figures from 2014/15 show that construction workers have rates of occupationally related illness that are statistically significantly higher than for workers in any other industry, including many specific illnesses such as work-related musculoskeletal disorders, lung problems and occupational cancers (HSE 2015). Most recently, public health has grown in prominence within the construction industry (Sherratt 2015), with diets, wellbeing and

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lifestyles becoming a new area of focus as large contractors have adopted a ‘partnership’ role with the UK government, taking on responsibilities for their worker’s health beyond the site hoardings and promoting general wellbeing on their sites. This is arguably a positive move, as construction workers are often more unhealthy than most, for example their consumption of drink and illicit drugs is also statistically significantly higher than those working in other comparable high-hazard industries (Tan and Lloyd 2016).

Yet such unhealthy ‘symptoms’ are closely linked to the ‘social determinants of health’; the reasons why people drink or take drugs or eat to excess (Wilkinson and Marmot 2003), which can themselves be associated with more fundamental ‘causes’ including: work related stress (Fardhosseini and Esmaili 2016), 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). That this list is simply a description of ‘normal’ UK construction industry operations is rightly its own cause for concern (Sherratt 2016a), but despite good intentions, worker wellbeing programmes on construction sites all too often follow the template of the vast majority of such benevolent interventions (Sherratt 2016a); focusing on superficial symptoms, rather than seeking to address any more systemic or deep-rooted underlying causes (Conrad 2005).

Indeed, it has been suggested that such superficiality is itself a symptom of the growing influence of Corporate Social Responsibility (CSR) on construction health, safety and wellbeing (HSW). The ways in which this influence has led to challenges of the commodification of worker HSW, health enhancement and wellbeing initiatives readily packaged and used to support the corporate brand and increase organisational attractiveness, has been explored in detail elsewhere (see Rawlinson and Farrell 2010; Sherratt 2015; Sherratt 2016a). The repackaging of HSW in this way, through corporate propaganda, allows companies to present activities or offerings as evidence of benevolence and pastoral care of their workers, whilst fundamental conflicts between construction work and worker HSW remain hidden. This paper draws on history, economics and politics to critically explore CSR, and specifically worker HSW, mobilising Marx to provide a timely reminder of the fundamental conflicts at play within our contemporary contexts. In this way we challenge the ideas of benevolent business practice, decry the very notion of CSR within the contemporary neo-liberal doctrine, and question whether construction should not be doing better in terms of ‘true’ CSR within its hazardous and harmful operations.

## **UNPACKING WORKER HEALTH, SAFETY AND WELLBEING**

To begin this process, due consideration of the way worker HSW ‘works’ within contemporary contexts should be made. Indeed, as history, economics and politics all have their roles to play, a considered archaeology of their influences is first presented here, albeit within the constraints of this paper. Marxist theory has been mobilised to support this archaeological analysis, and to develop a holistic critique of construction worker HSW and the influence of CSR on contemporary practice.

### **Ethics, Morals and God: A Very Brief History of UK HSW Legislation**

One of the most fundamental arguments for the prioritisation of worker HSW in any workplace is grounded in ethics and morality. Such principles are highly personal, although they have also been realised at the corporate level as ‘professional ethics’, one of the key drivers of CSR. This is a relationship with a considerable history, and can readily be traced back to the industrial revolution and the much more prominent role religion then played in UK society. Indeed, the first legislated attempt to improve the

health and safety of the newly-industrialised UK workforce was made through the first 'Factory Act', the Health and Morals of Apprentices Act of 1802 (Putson 2013; Eaves 2014), which sought to set minimum standards for cleanliness, fresh air and care for the apprentices, but also the requirement that apprentices be 'instructed and examined in the Principles of Christian Religion'; their morality, or rather conformity to the dominant doctrine, considered to be of equal value to their health.

It was the raising of awareness by people horrified at the conditions facing those working in the newly industrialised areas of Britain that formed the foundations of corporate pastoral care amongst the nascent industrial capitalists of the time. At its best, such gestures led to developments such as the high-quality housing estate of Bourneville, constructed by the Cadbury brothers (both Quakers) for their chocolate factory workforce. Yet such philanthropy was by no means common practice, and although specific examples remain, these actions remain dwarfed by the acts of indifference displayed by the vast majority of employers to their workforce when one considers the speed and magnitude of industrialisation in the UK at that time. A much more realistic picture of the contemporaneous development of worker HSW can be found in the records of the Houses of Parliaments and Lords, as the 1802 Act and those that followed were furiously debated. Indeed, it is more than a little unsettling to find challenges to worker HSW in the records of over one hundred years ago that still echo loudly today. For despite those who spoke of '... the living testimony which the pallid faces and distorted limbs of the wretched victims of the system, who had been brought before them presented.' (Strickland, HC Deb 28 Feb 1833 Vol 15 cc 1293-9), there were many who argued instead that any such legislation would constrain local and national productivity, and threaten the economic position of the UK on the world stage. Support of worker HSW was therefore often tempered with the caveat that parliament needed to '... take care to adopt no step that may be fatal to commerce and manufactures' (Graham, HC Deb 15 March 1844 Vol 73 cc1073-155). The debates between productivity and worker HSW have very long shadows, and can still be readily identified within the dominant discourses of safety found on the UK construction sites of the twenty first century (Sherratt 2016b).

A significant milestone of the industrial revolution, worthy of mention here, was the presentation of the People's Charter to the House of Commons in 1842. Signed by over 3 million from the 'industrious classes' of the UK, the Charter directly challenged the government to better fulfil its role as the representation of 'the people', its contents arguing that: '... the hours of labour, particularly of the factory workers, are protracted beyond the limits of human endurance, and that the wages earned, after unnatural application to toil in heated and unhealthy workshops, are inadequate to sustain the bodily strength, and supply those comforts which are so imperative after an excessive waste of physical energy.' (HC Deb 02 May 1842 Vol 62 cc1373-81). Production had become valued higher than people, and the unwillingness of parliament to legislate effective controls clearly demonstrated their prioritisation of industrial outputs over worker HSW. Yet despite this intervention, the influential discourses of industrialisation, progress, growth and development had already firmly established themselves in UK parliament by the mid nineteenth century, although profit was less prominent in this particular context, perhaps appearing a less seemly subject for discussion amongst those who were personally benefiting from its creation.

### **Mobilising Marx I**

The historical positioning of worker HSW as a hindrance to the growth of industrialisation and capital within the UK is not all that surprising. Indeed, Marx (1867

[1977:393]) was particularly damning of the developments of early UK HSW legislation, noting how the capitalists were able to 'annul the whole Factory Act, not only in the spirit, but in the letter' in his considerations of how management of the working day and other constraints were readily manipulated to their benefit and worker exploitation.

Indeed, when viewed through a Marxist lens, the construction worker is even more maltreated, even abused, when their HSW is considered. Within the capitalist mode of production, it is the workers' labour that produces not only the final commodity but also the surplus value, or profit, that then enables the capitalist to continue in their operations (Marx 1867 [1977:975]). There is a continued reliance on construction workers as integral to the process of production in the creation of built environment commodities, yet this exchange goes beyond simple labour. As even contemporary statistics of poor HSW still demonstrate, it is evident that worker HSW is also exchanged during construction work, in part for a wage but also in the contribution it inevitably makes to surplus value, or profit. As revealed through the Marxist consideration of dialectical materialism, worker HSW is therefore also commodified through this process, via the commodification of labour, and so also inevitably exploited within this system for others' gain.

Within construction work it is also all too evident that the 'use-value' of this commodity of worker HSW is highly significant, being twofold and affecting both the workers ability to continue to carry out what is often hard and demanding work, but also their own individual ability to employ it for their own benefit and enjoyment in their own time. Construction workers are therefore not only exploited during the process of production itself, but remain so after work has ceased. Their HSW is readily commodified and 'used up' by their employers during this process, but it is they who have to take the consequences of this exploitation home with them each day.

### **The Neoliberal Context**

The emergence of the neoliberal paradigm in the 1980s, a paradigm that believes the needs of society are best met by 'the market' and therefore places market forces at the centre of any discussion of the well-being of society, has inevitable influences on both economic and political practices as well as worker HSW. The relocation of production (globalisation) by large corporations to places where wages are low, working conditions poor and worker unions non-existent, readily reveals the inherent flaws and the internal contradictions found within the capitalist mode of production regarding worker-capitalist interests (Marx 1867[1977:258]).

Within this neoliberal context, the dominant discourses established in the mid c.19 can still be heard; those of progress, development and economic growth as necessary, nay vital, for our continued existence. One clear effect of this agenda on UK construction was its impact on the structure of the workforce. In efforts to reduce costs and maximise surplus value, more 'flexible' ways of working were adopted and companies disposed of their in-house workforce, who were not only expensive but also protected by employment laws requiring such 'luxuries' as sick pay and pensions. Instead the industry turned to sub-contracting, assisted by the 'institutionalised incentivisation' of the workers to become happily self-employed to secure tax breaks (see Green 2009 for a much more detailed discussion of these developments). This shift to supply chains also allowed the industry to take advantage of cheaper migrant labour, something now very familiar to construction work both in the UK and all across the world.

A further consequence of this change to the construction workforce was the significant weakening, if not almost total destruction, of any collective bargaining power of the

workers. It needs to be constantly borne in mind that all of the positive changes in worker conditions from the period of the Industrial Revolution to the present came about through bottom-up pressure in the form of (often illegal) organised worker unions. The policies of neoliberalism have done much to undermine the capacity of workers to combine to fight for better working conditions through outsourcing of jobs along now-familiar subcontracted supply-chains, to sourcing workers from countries where unions are illegal or suppressed and, more subtly, by curtailing through incremental yet impactful changes in industrial relations legislation (Green 2009). The ability of the people to create one unified voice, as they did in the presentation of the People's Charter of 1842, to seek improvements to worker HSW is arguably now little more than a memory.

Yet any increase in subcontracting and 'self-employment' also impacts worker HSW. Consequences include reductions in investment in safety training and equipment, as profits are squeezed at each level of the supply chain, as well as a lack of commitment to safety on sites from a fragmented workforce, resulting in increased problems for safety management (Lingard and Rowlinson 2005) and a barrier to the development of a coherent safety culture (Clarke 2003, cited in Green 2009: 32). Furthermore, the short term and uncertain employment this structuring brings is one of the social determinants of health, negatively impacting worker security and their consequential wellbeing. Whilst the ongoing exploitation of migrant worker HSW is well documented elsewhere (see for example work by the Centre for Corporate Accountability 2009), it remains worthy of note here, not least because of its frequent contraventions of 'professional ethics' in practice (see Amnesty International 2016 for a particularly fine example).

It is within this context, where profits and markets are prioritised over worker HSW, that morals and ethics have made some attempts to regain a foothold. By seeking to harmonise between the two, the 'business case' for worker HSW has often been, or, more specifically, attempted to be made.

## **THE BUSINESS CASE**

### **The Business Case for Worker HSW**

A direct consequence of the dominant 'market' discourses is the need to '... conform [to] the omnipotent 'business case'' (Green 2009:36). Indeed, all corporate and governmental investments, including those for benevolent causes, now require a business case to demonstrate their 'value'. Even academic research is not exempt, and needs to justify itself through 'impact', using essentially the same parameters.

It could be expected that worker HSW should be quite a straightforward business case to make; it can be readily linked to a significant volume of management theory that tells us healthy, and happy workers are more productive (e.g. Sgroi 2015). You certainly cannot build with a workforce that is unwell, injured, maimed or even dead, and, of course, morally and ethically, it is the right thing to do. Consequentially, there has been an ongoing quest to empirically prove the business case for worker HSW, including within construction HSW research. Yet to the best of the authors' knowledge, so far this quest has failed. Although reference is often made to 'the business case' within safety management literature, the evidence is itself lacking. For example although Tymvios and Gambatese (2016) found the 'business case' this to be the best method by which to promote Prevention through Design for clients, the case study they provided as 'business case evidence' was that of improvements in HSW for the completed facility's workers, not for those who constructed it. Indeed, that this research enquired of clients, contractors, architects and engineers would also suggest a familiarity with and therefore

unquestioning conformity to the business case ideal in practice. Others are simply optimistic, indeed Bell *et al.*, (2016) note that '... it is currently difficult to make a convincing business case or plan for the introduction of well-being ... strategies in construction.' Here the discourse is more nuanced, the suggestion made that there certainly will be a time it can be made in the future, just not right now, but as both examples suggest, the business case must eventually be able to be made for worker HSW, not least because it's the right thing to do, right?

### **Mobilising Marx II**

Wrong.

As demonstrated above, worker HSW is necessarily commodified by contemporary construction production practices; it is inevitably used up in the system. Surplus value cannot be generated in the construction industry without such exploitation of workers, and without the generation of surplus value, the capitalist mode of production itself collapses. Therefore, any desire to present 'the business case for worker HSW' immediately hits an internal contradiction in the system (Marx [181867 [1977]]), an inevitable and fundamental conflict between capitalism and worker HSW, and one that cannot be resolved with recourse back to the system itself.

Indeed, there is far more empirical evidence to support this 'conflict argument' that there is for any business case for worker HSW. Most academic HSW research within the construction industry actually finds just two problematic root causes: time and money. Given that within the construction context time also equals money, it is really just all about money, or rather the maximisation of surplus value within this mode of production. Whether it is so baldly stated as such (Sherratt 2016b:184) or couched in more pleasant terms, such as suggestions for additional worker training, better equipment, or better worker welfare (all of which of course also cost money), often depends on who funded the research in the first place.

### **The Business Case against Worker HSW**

As shown, to suggest that there can ever be a 'business case for worker HSW' within the contemporary construction industry context is simply nonsensical. It is a myth that we really want to believe in, because morals and ethics tells us we should, but this bears no relationship to the way the world actually works. Given this analysis, we should not be at all surprised that in the UK construction remains a key focus of the Health and Safety Executive, and perhaps why the notion that it is 'inherently dangerous' perpetuates.

It would actually be far easier to produce a business case against worker HSW, particularly in the construction industry, where the commodity of their HSW plays such a significant role in the maximisation of surplus value. Yet would this inherent contradiction, such blatant exploitation of the workforce, not mean we would inevitably one day run out of workers? Well, the significant skills shortage currently being experienced by UK construction (CITB 2016) certainly agrees with that prediction; the perception of construction work as inherently 'dangerous' frequently cited as a barrier to recruitment in the trades (Chan and Connolly 2006). Yet the neoliberal paradigm had a solution, and for the UK this was in part facilitated by the free movement of labour throughout the European Union, a move that further undermined the worker's ability to organise whilst strengthening the power of organised capital. The EU was readily able to provide the UK with another workforce all too willing to sacrifice their HSW to the construction of commodities within a country with the money, or perhaps more accurately with the mechanisms to create the money through a debt fuelled bubble to pay for them.

Indeed, with the BREXIT referendum of 2016 that this 'Band-Aid' workforce may no longer be a viable solution, and UK construction industry capitalists were only too quick to clearly state their Pro-Remain position, arguing that 'free movement is the cornerstone of the UK construction industry's success' (Builder and Engineer 2016). Which when you are continually exploiting workers and their commodified HSW to the point of their inability to participate in the process altogether, could actually be considered something of an understatement.

## **CORPORATE SOCIAL RESPONSIBILITY**

However, a solution has emerged to help smooth over these wrinkles, stutters and other unpleasant problems inherent in the capitalist mode of production with relation to construction workers HSW, and that solution is CSR. CSR enables us to cling firmly to morals and ethics, or the ideas of them at least, because at its very heart is the idea of 'doing good to do good' which will in turn help companies 'do good to do well' (Brès and Gond 2014). It fits beautifully within the neoliberal paradigm, transforming organisations from '... perceived evil empires to 'partners' (Whitehouse 2003:303), keen to demonstrate that they are committed to behaving ethically and improving the quality of life for the workforce (Baptiste 2008).

For many years construction worker HSW was a clear priority in the industry, yet in the last decade it has been readily subsumed into the realm of CSR (Rawlinson and Farrell 2010). Such an approach could perhaps be considered 'progress', to draw on an appropriate discourse, as where else could doing the right thing go? What is construction worker HSW if not the responsibility of the construction capitalists? Indeed, improvements in worker HSW have been linked to CSR, although the empirical evidence for this remains as elusive and ethereal as that provided for the business case. Indeed, the CSR approach to worker HSW within the construction industry has met with robust challenge, corporate activities to promote worker HSW found to focus on superficial prizes, awards and events rather than any fundamental changes to work practices or structuring (Sherratt 2016a).

### **Mobilising Marx III**

The final consideration of Marx's thinking is here made by mobilising his aphorism of tragedy and farce (Marx 1852); it has already been demonstrated that worker HSW is the tragedy, their exploitation within the capitalist mode of production augmented by the commodification of their HSW. It is now suggested that CSR is the farce; that there could ever be any kind of business case for worker HSW has already been shown to be paradoxical, and so has resulted in governments and companies turning instead to superficial worker HSW initiatives and programmes under the CSR umbrella in attempts to address the inherent inequalities within the system. Ironically, this creates yet a further manipulation of the workers; the rebranding and reuse of their already commodified HSW through CSR, utilised as a corporate enhancement, rather than the evident exploitation that it is.

### **The Road to Hell is paved with CSR**

The nature of this farce becomes even more pronounced when the medium of the message is considered in any depth. Contemporary CSR is arguably a product of the technological developments and trends in society (Pedersen 2015), and as CSR activities are placed in the public eye under the management of PR staff (Ennals 2011:146) it is again unsurprising that they have become focused on superficial ventures (Conrad 2005) which are in turn readily commodified, photographed and tweeted (Sherratt 2016a).

But such a highly visible approach is all the more concerning, even dangerous, in the way it seemingly convinces the world that for UK construction workers, their HSW has never been better taken care of. It creates good intentions writ large, but without any depth or substance, instead presenting a colourful and convenient misdirection from the fundamental causes of poor worker HSW within our industry, that go deep into history, economics and politics, altogether much more serious, complicated and difficult issues than can be solved by the photogenic offerings of healthy apples, oranges and bananas for breakfast in the site canteen. Indeed, the growth of public health initiatives for construction workers is something of a road to hell, as their HSW, both occupational and public, is happily exploited by the very same industry setting out with such good intentions to save them.

## CONCLUSIONS

The capitalist mode of production is by necessity a system that is complicit in the exploitation of those it needs to create our contemporary built environments. The philosophy of neoliberalism lends a veneer of respectability to this exploitation by valorising the market (profit) and placing it at the centre of society. That this philosophy has led to increased (and increasing) disparities between rich and poor is not an unforeseen outcome but a predictable consequence of placing gain (for some) at the heart of society. The words of Mary Ellen Lease, speaking in 1890, 'Wall Street owns the country. It is no longer a government of the people, by the people and for the people, but a government of Wall Street, by Wall Street and for Wall Street' (Zinn 1980:288) could just have easily been addressed to protesters of the 'Occupy Movement' of 2011, and reveal that the contradictions addressed above between profit and worker HSW are not new issues, but as Marx propounded they are systemic contradictions contained within the capitalist system.

Yet these problems have in part been mitigated by the emergence of CSR, a ready and willing tool of neoliberalism. For construction worker HSW, CSR has been able to photogenically obfuscate the systemic issues that surround worker HSW, replacing them instead with superficiality. Construction is an industry that exploits workers on many different levels: from their fundamental contribution to surplus value through the capitalist mode of production, to the further commodification of their HSW, to the way work is structured to the detriment of their social determinants of health, to the final indignity of having CSR approaches to HSW ignore all of this and instead set about packaging and once again commodifying superficial attempts of benevolence towards them, as if they make any real difference to worker HSW at all.

But can we really do no better than this? Can we not consider the true position of construction worker HSW within industry operations, within legislation and government bodies, or within academia? Can we not start to develop some notion of 'true' CSR that has effective impact on the systemic problems highlighted above? Perhaps not, given the current contexts as revealed through this analysis, but perhaps there is change afoot. Perhaps the capitalist mode of production is approaching its final stutter, and then we may be able to move on from a system that is so fully complicit in the exploitation of those it needs to create the built environments in which we all live, work and play.

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# **HUMAN RESOURCE MANAGEMENT**

# ATTRACTING AND RETAINING WOMEN PROFESSIONALS IN CONSTRUCTION: A WORK-STRESS MANAGEMENT PERSPECTIVE

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Construction is one of the most male-dominated industries and excessive work stress is blamed for its failure to attract and retain women professionals. This research investigates the causes of excessive work stress experienced by women construction professionals and their impacts on the psychological wellbeing of women professionals. An online questionnaire survey was conducted in the Australian construction industry, in which 119 responses were obtained from female construction professionals. Descriptive statistics were first computed to rank causes of work stress for women construction professionals, which revealed that the topmost causes are: time pressure, excessive workload and long work hours. The t-test analyses were then conducted to compare the psychological wellbeing of this cohort with the Australian general population and it was found that female construction professionals suffer significantly higher depression, anxiety and acute stress. Finally, correlation analyses were performed to investigate the associations between the stressors and psychological health issues among female construction professionals; 10 out of 38 stressors studied showed significant correlations with the psychological health issues. The findings inform construction organisations of management and employment aspects that they need to revisit for creating more conducive work environments and cultures that support attracting and retaining women professionals.

Keywords: gender diversity, women professionals, wellbeing, work stress

## INTRODUCTION

Gender diversity has the potential to bring about many business benefits to organisations by improving corporate social responsibility (Soares *et al*, 2011), fostering novel solutions leading to radical innovation (Díaz-García *et al*, 2013), increasing productivity (Sahoo and Lenka, 2016) and improving financial performance (Campbell and Mínguez-Vera, 2008). Furthermore, an increase of female participation has the potential to reduce the occurrence of conflicts (Loosemore and Galea, 2008) and alleviate skill shortages prevalent in the construction industry. Despite these benefits, the construction industry is still a male-dominated industry. In Australia, for instance, women account for only 11% of the workforce and they leave the industry at a much higher rate than men (Turnbull, 2016).

The National Association of Women in Construction (NAWIC, 2013) proposed that the construction industry must promote itself to women at an early stage to help them make an informed decision about pursuing a career in construction. The industry should also

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promote female role models who can dispel negative perceptions about the industry. Support programs, such as mentorship, sponsorship, career development, flexible hours and diverse forms of networking, should be introduced and then strengthened by genuine commitment from the top management. In a similar vein, the Australian Human Rights Commission (2013) developed a toolkit of strategies to increase women's representation in male-dominated industries, including the construction industry. The toolkit recommends implementing an integrated gender diversity strategy led by the top management; attracting women by addressing the negative perceptions of and promoting the opportunities offered by the industry; diverse recruitment strategies using merit-based processes; organisational culture that embraces diversity and flexibility; and career development based on a transparent and merit-based approach. Despite all these efforts, the construction industry still fails to attract and retain women in the workforce.

Research has indicated that women in construction experience high levels of work stress due to unique challenges they face (Bowen *et al*, 2014), which lead to low job satisfaction, poor health and wellbeing and high turnover intentions (Sang *et al*, 2007). Therefore, the construction industry should understand and address the unique work stress challenges faced by women if they want to attract and retain them. To this end, this research addressed two research questions: (1) Do female construction professionals suffer more severe work-related psychological symptoms than the general population? (2) What are the critical work stressors that impact on the psychological wellbeing of female construction professionals?

### **Literature Review**

Nearly 70% of construction professionals suffer from psychological injuries such as anxiety, depression and stress-induced burnout/acute stress as a direct consequence of working in the construction industry (Campbell, 2006). The work stressors in the construction industry can be classified into four factors: physical, organisational, job demand and job role.

The physical factors are mainly related to the physical work environment and conditions. People working in construction projects are exposed to the external environment when working on site, such as exposure to the sun, humidity levels, high or low temperature, rain, snow, etc. In addition, there are poor workplace conditions that increase work stress, such as inadequate ventilation, poor lighting, excessive noise and unsafe work conditions.

There are organisational factors that can promote the occurrence of work-related stress. Work culture, or the system of shared belief and values that develops within an organisation, is a significant factor that influences attitudes, directs behaviours and establishes performance expectations and the motivation to fulfil them (Schermerhorn *et al*, 2014). Reflected in the leadership style and the conduct of managers and supervisors, this culture can affect employees' stress levels and their commitment to the organisation (Samuel, 2015). Work culture also affects the norms in the workplace and can unconsciously nurture negative norms, such as discrimination and harassment. Women and ethnic minorities in the construction industry have suffered from workplace discrimination, particularly in relation to a lack of career progression (Arditi *et al*, 2013; Dainty and Lingard, 2006), while sexual harassment is also an entrenched feature of life on construction sites (Watts, 2007). Furthermore, the involvement of various stakeholders who have differing agendas is a fertile ground for conflicts. Coupled with competitive tendering that can worsen the already tense work environments, it is easy for the blaming game to begin when mistakes happen, which will bring additional pressure

for construction professionals (Zou and Sunindijo, 2015). Other organisational factors that should be considered are inadequate staffing, poor planning, lack of training and lack of feedback (Campbell, 2006).

Job demand factors, such as too much work, working long hours, high job pressure and unrealistic deadlines, are common work stressors in construction (Campbell, 2006). The construction industry expects its professionals to work long hours even though this practice has adverse impacts on productivity and performance. They are also expected to work non-standard work schedules, including on weekends (Lingard *et al.*, 2010). Long work hours and presenteeism have become symbols of excellence and commitment. These values are difficult to change, particularly in the construction industry that has shown itself resistant to change of any kind (Watts, 2009) and have led to all sorts of psychological injuries and work- family conflicts (Lingard *et al.*, 2010).

The job role factors that cause psychological injuries include: unclear job role and responsibility, conflicting demands, inadequate management support, lack of career progression, job insecurity and poor remuneration as compared to job demands (Campbell, 2006). These challenges make women less satisfied with the job (Dabke *et al.*, 2008). Moreover, the traditional male career model in the construction industry is predominated with expectations of full-time professionals on unbroken career pathways. This indirect form of discrimination rooted in the traditional male career model causes lack of career progression for women in the construction industry (Dainty and Lingard, 2006). As such, women are obliged to either conform to the existing masculine culture or become marginalised (Arditi *et al.*, 2013; Loosemore and Galea, 2008). Trying to prove themselves in the male-dominated work environment and continuously confirming to a less fit career model result in stress and burnout among women who eventually leave the construction industry (Department of Employment, 2016).

## **Research Method**

An online questionnaire survey approach was adopted to collect primary data, which were then analysed using statistical techniques for deriving insights. The questionnaire consisted three sections. The first section requested demographic and professional background information of respondents. The second section captured the severity of mental illness suffered by the respondents, using Depression, Anxiety and Stress Scales (DASS) 21, developed by Lovibond and Lovibond (1995), which has been widely used in a variety of settings by researchers and clinicians. It is a list of 21 statements that assess the levels of depression, anxiety and acute stress present in an individual's mind. The prevalence of symptoms is assessed by a four-point ordinal scale comprising never, sometimes, often and almost always. The final section sought respondents to indicate their experience as to what degree they encounter each of the 38 listed stressors at work on a four-point ordinal scale comprising never, sometimes, often and almost always. The list of stressors was derived from a comprehensive literature review. The same four-point ordinal scale of the DASS questions was used to collect data on stressors to maintain consistency across questions in the questionnaire and to reduce confusion. Although the ordinal responses were collected using textual descriptors, they were assigned numerical values, such as 1 = never, 2 = sometimes, 3 = often and 4 = almost always, to facilitate quantitative analyses.

Random sampling technique was used to achieve a representative sample whereby professionals in construction organisations in Australia were approached through different channels to participate in the survey. Email requests with the link to the online survey were sent to members of The Australian Institute of Building and The National

Association of Women in Construction who are professionals in the construction industry. Additionally, employees in individual construction organisations were sent the requests via corporate communications. In total 1019 requests were sent and 286 valid responses were received, yielding a response rate of 28%. Out of the respondents, 167 were male and 119 were female. To achieve the aim of this paper, responses from female professionals were separated and statistically analysed. Nearly 60% of them were aged between 18 and 39 years old and 92% worked in medium and large-sized organisations. This does not reflect the proportion of organisations in the Australian construction industry where more than 95% of organisations are small, employing fewer than 20 people. Fifty-four percent of them had an annual salary of \$100,000 or more, confirming the typical high salaries in the construction industry and 50% were married or in a de-facto relationship.

## DATA ANALYSIS AND FINDINGS

The first part of data analysis concerned answering the first research question of "Do female construction professionals suffer more severe work-related psychological symptoms than the general population?" and Table 1 presents the analysis results. Column 2 of Table 1 shows the magnitude of psychological issues suffered by the surveyed women professional in the construction industry. Depression scored 3.74 and anxiety yielded 3.67 while acute stress that is responsible for burnout scored 6.55. Column 3 shows the respective values for the Australian general population. T-tests were conducted to check if the differences in values between the two groups are statistically significant and the p-values are shown in column 4 of Table 1. It is evident that female construction professionals experience significantly higher levels of depression, anxiety and acute stress symptoms than the Australian general population does. According to the well-known inverted-U theory that plots the relationship between work stress and performance, there is an optimum level of stress/arousal that causes the best performance; higher or lower stress than this level results in steadily decreasing performance (Yerkes and Dodson, 1908).

*Table 1: Mental wellbeing of construction professionals*

*Table 1: Mental wellbeing of construction professionals*

| Rank       | Female construction professionals | Australian general population (Crawford et al., 2011) | Significance |
|------------|-----------------------------------|---|--------------|
| Depression | 3.74                              | 2.57  | 0.000        |
| Anxiety    | 3.67                              | 1.74  | 0.000        |
| Stress     | 6.55                              | 3.99  | 0.000        |

It is not known what the optimum level of stress is among the working population in Australia. Assuming the levels among Australian general adult population found by Crawford *et al*, (2011) as the standard, the construction industry should be aware of the relatively high mental health issues suffered by female professionals, which may be causing lower performance.

Table 2: Stressors at work and psychological issues among female construction professionals

| Rank | Stressor  | Descriptive statistics |        | Correlation |         |              |
|------|---|------------------------|--------|-------------|---------|--------------|
|      |   | Mean                   | SD     | Depression  | Anxiety | Acute stress |
| 1    | High level of time pressure   | 2.7227                 | .86283 | .272**      | .301**  | .468**       |
| 2    | Excessive workload  | 2.6891                 | .79987 | .206*       | .299**  | .394**       |
| 3    | Long work hours   | 2.6807                 | .93820 | .252**      | .331**  | .329**       |
| 4    | Unpleasant nature of work (high physical/mental demand, meaningless work, high uncertainty/sudden changes)                  | 2.3529                 | .75451 | .281**      | .261**  | .447**       |
| 5    | Inadequate communications between work colleagues & superiors   | 2.1345                 | .86283 | .250**      | .230*   | .299**       |
| 6    | Lack of appreciation /rewards for efforts   | 2.1092                 | .90000 | .369**      | .369**  | .465**       |
| 7    | Role ambiguity (unclear job roles and responsibilities)   | 2.0924                 | .82330 | .182*       | .178    | .129         |
| 8    | The tasks you perform do not match your skills (under use of skills or over expectations)                                   | 2.0504                 | .69926 | .317**      | .307**  | .233*        |
| 9    | Differential treatment due to gender, ethnic background, etc.   | 1.9496                 | .97293 | .231*       | .263**  | .309**       |
| 10   | Under valuing of your skills/qualifications   | 1.9412                 | .85662 | .317**      | .308**  | .372**       |
| 11   | Work-home conflicts, i.e., lack of family time due to work  | 1.9328                 | .82061 | .219*       | .208*   | .315**       |
| 12   | Insufficient salary/wage for the work   | 1.9328                 | .91810 | .219*       | .268**  | .279**       |
| 13   | Career stagnation / lack of career development opportunities  | 1.8992                 | .91499 | .264**      | .256**  | .234*        |
| 14   | Lack of job autonomy (lack of control over workload/content or participation in decision making)                            | 1.8403                 | .77002 | .297**      | .307**  | .294**       |
| 15   | Dual career challenges (working couples struggling to balance family affairs)   | 1.7899                 | .88177 | -.005       | .053    | .131         |
| 16   | Inflexible work schedule  | 1.7647                 | .80996 | .192*       | .336**  | .395**       |
| 17   | Low level of support for problem solving  | 1.7647                 | .69752 | .346**      | .335**  | .338**       |
| 18   | Excessive responsibilities in personal life   | 1.7395                 | .82813 | .169        | .366**  | .347**       |
| 19   | Excessive formalisation/centralisation and rigidity in the organisation   | 1.7395                 | .84835 | .263**      | .325**  | .359**       |
| 20   | Social or physical isolation from others  | 1.6723                 | .80369 | .260**      | .236**  | .127         |
| 21   | Bullying, i.e. slander/humiliation, intimidation, abusive language, aggressive behaviours, etc.                             | 1.6723                 | .83473 | .344**      | .334**  | .330**       |
| 22   | Poor relationships with superiors   | 1.6639                 | .80546 | .226*       | .235*   | .187*        |
| 23   | Conflicts with co-workers/colleagues  | 1.6387                 | .60690 | .367**      | .302**  | .284**       |
| 24   | Job insecurity  | 1.6303                 | .83225 | .225*       | .213*   | .107         |
| 25   | Previous exposure to traumatic events or depression episodes, e.g., death of relatives/friends, assault, depression, etc.   | 1.5882                 | .62993 | .308**      | .314**  | .259**       |
| 26   | Sexual harassment at work, e.g., unwelcome / inappropriate comments/ behaviours by colleagues, superiors, clients, etc.     | 1.5546                 | .77784 | .218*       | .246**  | .181*        |
| 27   | Poor work environment (space constraint, extreme weather, excessive noise, poor air/water quality, odours/chemical, unsafe) | 1.5042                 | .73501 | .240**      | .173    | .213*        |
| 28   | Unpredictable work hours/shifts   | 1.4874                 | .63600 | .288**      | .158    | .173         |
| 29   | Lack of welfare   | 1.4706                 | .73443 | .167        | .248**  | .170         |
| 30   | Financial difficulties  | 1.4622                 | .66115 | .123        | .228*   | .146         |
| 31   | Poorly functioning home, i.e., tensed relationships between couples /family members   | 1.4622                 | .67384 | .101        | .219*   | .261**       |
| 32   | Poor personal health conditions   | 1.4370                 | .57694 | .296**      | .372**  | .445**       |
| 33   | Low support at home   | 1.4202                 | .58939 | -.009       | .115    | .154         |
| 34   | Unfavourable equipment conditions (unsuitable, faulty or inadequate)  | 1.3782                 | .58210 | .211*       | .238**  | .168         |
| 35   | Extra care needs for family members, e.g., caring for disabled family members, elderly parents, etc.                        | 1.3697                 | .63600 | -.019       | .124    | .058         |
| 36   | Working night shifts  | 1.3445                 | .68193 | .184*       | .059    | .053         |
| 37   | Housing/accommodation/living conditions   | 1.1849                 | .46880 | .056        | .316**  | .153         |
| 38   | Violence at work, e.g., assault, threat, etc.   | 1.1345                 | .41013 | .093        | .300**  | .147         |

\*\* . Correlation is significant at the 0.01 level (2-tailed).

\* . Correlation is significant at the 0.05 level (2-tailed).

The second part of the analysis sought to answer to the research question of "what are the critical work stressors that impact on the psychological wellbeing of female construction professionals? The survey sought respondents to rate as to what degree they experience

the 38 stressors at work. Mean and standard deviation values of the ratings were calculated and the stressors were then ranked based on them. Table 2 shows the analysis results. Attention is paid to the top ten stressors to optimise solutions, following the 80:20 principle.

Job demand factor related issues such as high level of time pressure, excessive workload and long work hours were ranked as the top three most frequent causes of work stress. While this confirms with previous research by Savery and Luks (2000), Campbell (2006) and Watts (2009) who identified working long hours, unrealistic deadlines and high job pressure as causes of work stress in construction, this research categorises them as the top stressors. Unfortunately, these have become the norms of the present-day construction industry. The second group of stressors within the top 10 concerns the job role factor and suggests that women face challenges more frequently in dealing with issues related to their role. Stress due to gender discrimination appears to be less frequent than job demand and role induced stress.

Surprisingly, work-home conflict was ranked 11. Moreover, stressors that are related to family life/personal life appear at the bottom of the list, indicating these are not of major concern for female professionals. This may be due to the presence of a high proportion of unmarried/ single female professionals in the respondents, which might as well be the reflection of the actual situation in the construction industry. This also prompts that less number of married women continue to stay in the industry.

Bullying and sexual harassment, which are often highlighted issues for women, were rated low in this research. On the other hand, factors related to career progression (career stagnation, low salary and job autonomy) are more of a concern than harassment for women professionals. Collins *et al.*, (1997) claimed that sexual harassment at work, traditional work culture tailored towards the male career model and discrimination in hiring and assessing performance contribute to mental health issues faced by women. While this study found the prevalence of these issues, sexual harassment is ranked lower than career progression issues.

### **Associations between Stressors and Psychological Injuries**

Pearson correlation analyses were performed to investigate the associations between the stressors and the different DASS subscales of psychological injuries. The results are shown in columns 5, 6 and 7 of Table 2. Stressors are simultaneously associated with depression, anxiety and acute stress were extracted and depicted in Table 3. Fifteen out of 38 stressors have strong correlations with all three DASS subclasses of psychological injuries. Eight out of the 19 appear in the top 10 stressors shown in Table 2, suggesting that the top 10 stressors need to be managed seriously to ensure wellbeing of women professionals in the construction industry. Moreover, four stressors out of the 19 appear to be of serious concern, which have stronger correlations with depression, anxiety and acute stress than the other 15 stressors. These are: lack of appreciation/ rewards for the efforts, under valuing of skills/qualifications, low support for problem solving and bullying. These are largely interpersonal challenges facing women professional in construction and have significant implications for their wellbeing.

Table 3: Correlations analysis

| Rank | Stressor  | Descriptive statistics |        | Correlation |         |              |
|------|---|------------------------|--------|-------------|---------|--------------|
|      |   | Mean                   | SD     | Depression  | Anxiety | Acute stress |
| 1    | High level of time pressure   | 2.7227                 | .86283 | .272**      | .301**  | .468**       |
| 2    | Excessive workload  | 2.6891                 | .79987 | .206*       | .299**  | .394**       |
| 3    | Long work hours   | 2.6807                 | .93820 | .252**      | .331**  | .329**       |
| 4    | Unpleasant nature of work (high physical/mental demand, meaningless work, high uncertainty/sudden changes)                | 2.3529                 | .75451 | .281**      | .261**  | .447**       |
| 5    | Inadequate communications between work colleagues & superiors   | 2.1345                 | .86283 | .250**      | .230*   | .299**       |
| 6    | Lack of appreciation /rewards for efforts   | 2.1092                 | .90000 | .369**      | .369**  | .465**       |
| 8    | The tasks you perform do not match your skills (under use of skills or over expectations)                                 | 2.0504                 | .69926 | .317**      | .307**  | .233*        |
| 9    | Differential treatment due to gender, ethnic background, etc.   | 1.9496                 | .97293 | .231*       | .263**  | .309**       |
| 10   | Under valuing of your skills/qualifications   | 1.9412                 | .85662 | .317**      | .308**  | .372**       |
| 11   | Work-home conflicts, i.e., lack of family time due to work  | 1.9328                 | .82061 | .219*       | .208*   | .315**       |
| 12   | Insufficient salary/wage for the work   | 1.9328                 | .91810 | .219*       | .268**  | .279**       |
| 13   | Career stagnation / lack of career development opportunities  | 1.8992                 | .91499 | .264**      | .256**  | .234*        |
| 14   | Lack of job autonomy (lack of control over workload/content or participation in decision making)                          | 1.8403                 | .77002 | .297**      | .307**  | .294**       |
| 17   | Low level of support for problem solving  | 1.7647                 | .69752 | .346**      | .335**  | .338**       |
| 19   | Excessive formalisation/centralisation and rigidity in the organisation   | 1.7395                 | .84835 | .263**      | .325**  | .359**       |
| 21   | Bullying, i.e. slander/humiliation, intimidation, abusive language, aggressive behaviours, etc.                           | 1.6723                 | .83473 | .344**      | .334**  | .330**       |
| 23   | Conflicts with co-workers/colleagues  | 1.6387                 | .60690 | .367**      | .302**  | .284**       |
| 25   | Previous exposure to traumatic events or depression episodes, e.g., death of relatives/friends, assault, depression, etc. | 1.5882                 | .62993 | .308**      | .314**  | .259**       |
| 32   | Poor personal health conditions   | 1.4370                 | .57694 | .296**      | .372**  | .445**       |

\*\* . Correlation is significant at the 0.01 level (2-tailed).

\*. Correlation is significant at the 0.05 level (2-tailed).

## DISCUSSION

The construction industry is making efforts to increase gender diversity through various mechanisms. It is critical the industry makes the work environment more favourable and appealing to women's nature to achieve the social target. Women are generally more susceptible to emotional stress symptoms than men. This can be seen, for example, from those who experienced mental disorders in the past 12 months in Australia, women had higher rates than men (22% vs. 18%) (Australian Bureau of Statistics, 2008) and epidemiologic studies found that women develop anxiety disorders at twice the rate of men (Kessler *et al.*, 2005). This may be due to their different biological mechanisms; Felmingham *et al.* (2012) found that there is an enhanced consolidation of negative images under stress in women that may be a potential mechanism for the greater female prevalence for developing anxiety disorders. These conditions are also reflected in workers' compensation data, where women were more likely than men to file stress claims and suffer depression.

This research has found that the degrees of anxiety, acute stress and depression suffered by female construction professionals are even higher than the levels of the Australian general population. Hence, managing work stress to curb the onset of psychological

injuries is a critical requirement for attracting and retaining women in construction. The top three stressors at work that are most frequently experienced by female construction professionals are: high level of time pressure, excessive workload and long work hours. These are the work norms of the present-day construction industry. There is a wider believe that sexual harassment and discrimination are the most important stressors for female construction professionals. This research has found that these are not the most critical stressors though they appear later in the list. The main stressors are the industry norms mentioned above. Thus, any intervention aimed at attracting and retaining female construction professionals should first focus on improving these norms. Additionally, uplifting inclusiveness and ethical conduct within the industry by introducing measures to eradicate discrimination, bullying and sexual harassment is also important to attract and retain female construction professionals. All these, however, cannot be achieved by making changes in one or few organizations; rather through a collective effort of the entire industry. The change also requires the cooperation and involvement of influential stakeholders of the industry, such as the government, major construction clients, large construction organisations and construction industry associations.

### **CONCLUSION**

Work stress appears to be a threat to gender diversity in the construction industry and as such the industry is missing out on numerous performance gains derived from gender diversity. Its reputation for excessive work stress, resulting in poor psychological health, is among the reasons for women not entering the industry or for them leaving the industry prematurely. Based on the findings of this research, it is suggested that the construction industry and relevant stakeholders endeavour to reform/ improve three aspects through policies and procedures to make the industry attractive to women workforce, which are: (1) industry norms on acceptable work practices and hours, (2) fair recognition of efforts and talents and fair rewards across genders and (3) interpersonal relations protocols. These, when implemented, would pave the way for a gender diverse construction industry. The present research investigated that the work stressors frequently experienced by female construction professionals and their impact on their psychological wellbeing. Another study can be conducted to study male professionals and then conduct comparisons. The research can be further extended to develop complete causation model of work stress and psychological wellbeing in construction, which accounts for the mediating influences of the gender.

The research has two limitations that are common to questionnaire surveys and should be acknowledged. First, the data collected through the questionnaire survey were self-reported and subjective, thus response bias might have occurred. For instance, respondents might have different interpretations concerning the levels of mental health issues or work stressors that they experienced. Thus, the same level of stress and mental health issues confronted by two different people might have been rated differently on the measurement scale. Second, they survey might have been responded by only professionals who are motivated to complete it or had strong opinions on the subject matter, thus violating a representative sample and thereby causing response bias. There is no information about the attitude and motivation of the respondents and there is no guarantee that they make a representative sample of the industry. It is hard to control or judge these aspects in a random survey. Nevertheless, it can be equally assumed/argued that they do make a representative sample.

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# CAN CORPORATE VOLUNTEERING HELP ADDRESS THE UK CONSTRUCTION SKILLS SHORTAGE?

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The UK is facing a construction skills shortage and is struggling to attract youngsters to the industry. This paper explores the potential value of corporate volunteering as a mechanism to address this problem. Despite volunteering being one of the most common forms of corporate social responsibility strategy employed by construction companies, there has been no research in this area in construction. To address this gap in knowledge, a single in-depth case study of a national UK corporate volunteering program which focusses on students in disadvantaged schools is presented. This research contributes new empirical evidence to understanding the potential impact of such programmes on recruitment. The results show that by engaging construction professionals and students in a problem-based learning environment, students emerge more knowledgeable about the construction industry, more motivated to engage and clearer about potential career paths. This is particularly the case for students whose style of learning does not suit traditional classroom based education and for female students. In particular, such programs appear to be effective at developing intrinsic attributes and soft skills which are valued by employers as crucial to future career success. Based on these results we conclude that there is some evidence that corporate volunteering could make a contribution to addressing a looming skills crisis in the UK construction industry.

Keywords: corporate volunteering, Corporate Social Responsibility, skills shortage

## INTRODUCTION

While the exact definition of corporate volunteering is contested, it is widely accepted to mean a non-monetary, formally planned and strategic commitment by a commercial organisation to encourage and support its employees to contribute their time, skills and knowledge to support community groups and not-for-profit organisations working in the community (Allen 2012, Roza *et al.*, 2013). A significant increase in business interest in corporate volunteering in recent years has been noted by Rodell *et al.*, (2016) and Zappalà (2003) put this down to three main drivers. First, is the growing trend towards corporate social responsibility (CSR) and social reporting and the need for businesses to be seen as good corporate citizens. Secondly there are increasing expectations by employees for their employers to provide them with opportunities to give back to the communities in which they operate. Third, there is growing interest in corporate volunteering from the community and not-for-profit sectors as they experience a shift towards more enterprising business models in response to trends in New Public Governance which place more

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emphasis on the business, government and not-for-profit partnerships in the delivery of welfare to the community.

Such trends are also evident in the construction industry and while there is a growing body of CSR research in construction over the last decade (Murray and Dainty 2008, Loosemore and Phua 2011, Barnes and Croker 2013), there has been no empirical research into corporate volunteering in the sector. The aim of this paper is to address the gap in knowledge through a single case study of a major UK school-based corporate volunteering program involving construction companies. More specifically, focussing on the school student as the unit of analysis, the aim of this paper is to capture the impact on potential recruitment through the mobilisation of qualitative research methods. This focus on youth recruitment is important given the looming skills crisis facing the UK due to its long-term under-investment in training and apprenticeships, its reducing and ageing workforce, its poor public image, its low attraction rate to youngsters and potential shortfalls in skilled labour brought about by Brexit (Farmer 2016, Martin 2017). More broadly, our focus on the recipients of volunteering is novel and important since most research into corporate volunteering identifies volunteers as the unit of analysis and considers the business case for volunteering initiatives (see for example, Hamilton and Fenzel 1988, Pajo and Lee 2011, Rodell 2013, Ockenden and Stuart 2014, Walsh and Black 2015 and Rodell and Lynch 2016).

### **The Impact of Schools-Based Corporate Volunteering**

As Walsh and Black (2015:8) point out “Volunteering has a wider set of benefits for individuals and communities that have economic, social, cultural and political dimensions”. While there has been research, albeit limited, into the broader community benefits of general volunteering, there has been very little research into schools-based volunteering programs. However, the relatively limited research that has been conducted has identified numerous potential benefits for the students involved, particularly those from socioeconomically disadvantaged backgrounds. These potential benefits include: better school attendance; greater confidence; higher work output and efficiency; higher grades; better work-readiness; better matriculation; less poor behaviour; improved social skills; improved literacy and numeracy; greater employability; improvement in critical thinking, analytical reasoning and logical abilities; and better progression to work and university (Henderson and Mapp 2002, Stanton *et al.*, 2011, Walsh and Black 2015). Other documented benefits include: broadening student learning experiences; building confidence in interacting with people from the world of work; becoming more work-ready by building understanding of work demands, expectations and environments; and exposure to different educational and job experiences and ways of learning for those pupils whose learning styles do not suit traditional classroom environments. In particular, research by Polidano and Domenico (2013) shows that by integrating work-based learning experience into the upper-secondary curriculum significant benefits can be derived from improving the educational engagement and post school pathways of less academically inclined students.

Other studies such as Boeck *et al.*, (2009) and Wu (2011) have shown how the individual benefits from volunteering programs discussed above can also spill-over into students’ families and communities producing multiplier benefits such as: local economic development; building community social capital and cohesion; breaking down negative stereotypes of different social groups; fostering better understanding of other cultures and religions; solving social problems; making communities safer; bringing people together from different backgrounds; and helping other be more active in their community by

going on to volunteer themselves which, in-turn, brings a whole set of additional benefits. Holroyd and Silver (2001) and Roza (2013) also show that volunteering programs give young people access to inspiring tutors and mentors who can act as role models which are often missing from their lives.

Importantly, schools can also benefit greatly from corporate volunteering programs. For example, school education can be enlivened and made relevant, difficult students can be engaged, curriculum and learning facilities can be enhanced, staff resources can be released, new knowledge can be delivered to students and school/community relationships can be strengthened (PC 2010, Roza 2013, The Centre for Mental Health in Schools 2016). More generally, corporate volunteering programs can provide schools with access to low cost and pro bono commercial services; to private sector management skills; to innovations and business mentors; to better relationships with business; and even financial and in-kind assistance with basic backbone infrastructure such as learning materials, equipment; computers, office space and administration support. Allen (2012) indicates that through these benefits schools can attract new talent and energy to their cause and bring new innovations and fresh perspectives to their operations, thereby enhancing their legitimacy in the eyes of external stakeholders.

It is important to note that in addition to the many claimed benefits of corporate schools-based volunteering there are also a number of potential downsides which have been identified. For example, Daparle (1997), Martiniuk and Negin (2012) and Bartlett (2013) show that volunteerism, is a double-edged sword with many risks, as well as opportunities, which if not effectively managed can be more harmful than good. For example, while most volunteers are well meaning, they may lack the skills to interact effectively with beneficiaries and there are also significant costs for receiving organisations in selecting, monitoring, inducting, training and managing them, especially when they are only present for short periods of time, as many volunteers are. Short-term volunteerism is often not the best use of limited financial and human resources and it is also very important to be clear about what volunteers can and cannot do. Many for instance will not have the training, skills, personality and stamina to work with children with special needs and as well as there being consequences for the students it may also burn out volunteers emotionally. Bad mentors or uncaring volunteers who volunteer for compliance or selfish reasons, can have a particularly negative effect on vulnerable teenagers, reinforcing negative experiences of uncaring and failed relationships from their past.

## **METHOD**

The focus of our research was an accredited schools-based corporate volunteering and engagement programme called Budding Brunels run by a major not-for-profit (Construction Youth Trust). The Budding Brunels programme, which uses a work-based learning model, has been running since 2004 and has engaged with 1,156 students over that period. The program focusses on engaging with young male and female students from disadvantaged backgrounds in schools, academies and further education colleges in deprived areas of the UK. The aim of the programme is to develop industry awareness and employability skills, creating opportunities for school students to feed into construction company apprenticeship and graduate schemes.

While we recognise that there are limitations with single case study research, the advantage of our approach was the depth of insight which multiple case study research could not provide (Yin 2009). Furthermore, there are common lessons to be learnt across all types of corporate volunteering programs which means that our results, while not

generalizable in a statistical sense, may hold important insights in other contexts (Allen 2012). Finally, as Flyvbjerg (2006) notes, it is not always desirable to generalise research results and that good quality single case studies are of enormous in-depth value as highly valid narratives in their own right. Indeed, in support of our approach, single case study research has been widely and successfully used in a number of volunteering research projects (see for example Pajo and Lee 2011).

In line with the traditions of single case study research, data about the impact of the Budding Brunels programme was collected using a range of methods. These included: a post-program survey; a pre and post outcomes measurement tool called a progress web; reflective diaries and student workbooks completed by students who were given industry placements. Data was collected across five runs of the program which took place in 8 Schools, 5 Academies, 1 College of Further Education with five different construction industry firms as partners. This mix of quantitative and qualitative methods is discussed in more detail below and the purpose of the data collection was to help the students articulate, in their own words, the affective (feelings and emotions), cognitive (knowledge and learning) and behavioural (career plans) aspects of what they gained from the volunteering experience (Eagly and Chaiken 1993). The data collection process was also designed to identify intrinsic (happiness, self-esteem and confidence etc.) and extrinsic (educational achievement, literacy and numeracy etc.) outcomes associated with the volunteering program (McNeil *et al.*, 2012, Robles 2012).

Narrative analysis was used to analyse our qualitative data, an approach which has evolved from what has been described as the narrative turn in social science research. In adopting Reissman's (2008) approach to narrative analysis we employed three approaches: thematic analysis, structural analysis, dialogic/performance analysis, and visual analysis. The thematic analysis involved keeping the respondent stories intact and emphasising the words, phrases and themes used in the narrative over its structure, content and form. The structural analysis looked into the ways in which these narratives were structured, categorizing aspects of the respondent accounts guided by the research cited above which identified a range of motivations, cost and benefits associated with volunteering for each stakeholder group. In effect, these costs and benefits became our initial coding strategy. Dialogic/performance analysis focuses on performed accounts and asks questions around when and why, viewing stories as social artefacts which say as much about the organisation, society and culture as it does about the individual respondents. In line with narrative analysis research, the results of this analysis are presented below in a narrative style. The response rate to the survey was 100% giving a sample of 103 useable responses and the final sample structure is shown in Table 1.

The results of our progress web analysis showed significant increases in all measured categories, particularly in cognitive outcomes (147%) and extrinsic outcomes (147%). The largest single variable change was in 'knowledge of the construction industry' (particularly for the female candidates). Of all the candidates that went through the program 87% said they wanted to pursue a career in construction compared to an estimated 50% at the start of the program. Interestingly, our results showed that female students entered the volunteering the program with a generally lower score than the male students and while this self-confidence increased to a comparable level by the end of the program. The results also show significant diversion between male and female responses in many outcomes and that the main benefit for the female students who attended the program, compared to their male counterparts, was the work experience and increased knowledge about career paths in the construction industry.

These findings are perhaps not surprising given evidence that most young women see the construction industry as a male dominated domain and are often discouraged by their families, parents and teachers to enter the industry and not given the same opportunity to learn about it in schools and at home (Powell *et al.*, 2010).

*Table 1: Sample details*

| Students (number, gender, ethnicity)                               | School, Academy and Sixth Form College Details   |
|--|--|
| 8 total - 2 Female, 6 Male, 6 BAME, 2 white British                | School - Serves an area with high levels of social deprivation from a diverse community.   |
| 19 total - 1 Female, 18 Male, 15 BAME, 4 white British             | School - The proportion of disabled students and those with special educational needs is higher than average.<br>Academy - A well above average proportion of students receive support through the pupil premium, which is additional government funding for specific groups including children who are looked after and students known to be eligible for free school meals.                                  |
| 18 total - 4 Female, 14 Male, 18 white British                     | School - Most pupils are of White British heritage, with only a few from minority ethnic backgrounds. There is no data on free school meals for the school.  |
| 21 total - 3 Female, 18 Male, 18 BAME, 3 white British             | Academy - The proportion of students who are from minority ethnic heritages is above average, as is that of the students who speak English as an additional language.<br>School - The school population is mainly White Male with a lower-than-average proportion of students from ethnic groups.<br>School - An above average-size high school serving an area of considerable ethnic and cultural diversity. |
| 17 total - 7 Female, 10 Male, 15 BAME, 2 white British             | School - One of the largest sixth form colleges in London. The very large majority of students at the college are from a minority ethnic heritage.<br>School - The proportion of disadvantaged students known to be eligible for the pupil premium (additional funding for children who are looked after and pupils known to be eligible for free school meals) is above average.                              |
| 20 total - 8 Female, 12 Male, 10 BAME, 10 white British            | Sixth Form College - The college population is mainly White British with a lower-than-average proportion of students from other ethnic groups.   |
| 103 students total - 25 Female, 78 Male, 64 BAME, 39 white British | 8 Schools, 5 Academies, 1 College of Further Education   |

*Key: BAME: British, Black, Asian, and minority ethnic*

It was also notable that while the female students started from a lower average score in every category, they also had the highest gains in all categories and especially in the ‘cognitive’ and ‘extrinsic’ components which indicates that they learnt a significant amount of new factual knowledge about the construction industry. Despite these encouraging responses and the significant increase in knowledge of the industry (191%), the relative lack of increase in knowledge of career paths and behavioural intention to pursue a career in the construction industry among the female cohort was disappointing. Our results suggest that for young women, increased knowledge of the construction industry may not produce an incentive to engage and that other strategies need to be put in place alongside such programs to overcome this potential risk. For example, recent research suggests that lack of female role models are a critical aspect of encouraging more young women into the construction industry and keeping them there (Lockwood 2006).

Analysis of student diaries and workbooks showed that most of the cited benefits (56%) were affective and intrinsic in nature (fun/enjoyable/interesting/eye-opening/exciting/inspiring/social/collaborative/teamwork). This supports work-based learning research (Adams 2014) that the emotional benefits of such programs are significant and important in terms of motivation. In further support of the extensive literature on work-based learning, the results also indicate that many students found the experience a new and engaging way of learning which contrasted with traditional school-based learning (Cunningham *et al.*, 2004). In particular, the qualitative data showed that the activity-based learning (field trips/site visits, model building competitions) were an important part of enriching the learning experience for the students and provided insights into the world of work and their place in that world, which many of the students had never visualised or experienced before. Of the students, 38% said that the site visits were the most enjoyable part of the volunteering programme. This supports research by Kisida *et al.*, (2015) who argue that field trips provide students with a living laboratory, enabling learning through hands-on active engagement and experience to expand beyond the classroom into the wider community, providing experiences that cannot be achieved in school, but which are an integral part of school instruction.

I liked visiting the construction site because I learned more and [this] pushed me more into working to my role

There were also clearly benefits for the students in building team work skills and appreciating the importance of collaboration in work.

I enjoyed working in a group as I met new people and learnt new things about them and how to work - improving my team working skills

The volunteering program also changed the students' view of what construction professionals do. In particular, the stories of the professionals they met, shadowed and interviewed during the program motivated the students and changed their view of what they could do in their own lives and what they needed to do to become such a professional. This supports Binder's (2011) research into the importance of stories in education which shows they are important for deepening student learning experiences and creating opportunities for pedagogical change by enabling teachers and students to explore and reflect on personal practical knowledge and position their own lives and future paths.

The interviewing of the professionals because it helped me find out what is involved in becoming [part of] that trade/profession and enlighten me on different jobs with construction

The interactions with the industry professionals also appeared to clear common misconceptions about the construction sector which tends to be seen as a low innovation, traditional and labour-intensive industry in the public's eye (Loosemore 2014).

Initially I thought construction is not innovative and does not involve the technical nature of engineering. However, I have discovered construction is a diverse industry which is constantly innovating via engineering

The program also opened the students' minds to future career paths they had not envisaged before, supporting research by Change the Equation (2015:15) which shows that opportunities to interact with professional mentors encourage students to become more interested in STEM (Science Technology Engineering and Maths) careers and the types of skills required for success in this field and the workplace more broadly.

...yes it definitely changed my view, it shows me there are so many different roles within the industry

When asked what it would take to get to a similar position as the professionals they met, every student was able to articulate at least three strategies which included gaining work experience (36%), going to university (45%) or acquiring particular skills which they saw had been important to their mentor's career success.

...reliability, communication, teamwork (inspiration), research and interpreting data" - mentor performance improvement manager

...passion, communication between different strata of the industry, time management, building rapport" - mentor asset manager

What is striking is the similarity between the core attributes which the students saw in their mentors, regardless of profession and role. It is also interesting that while the number of attributes was diverse, the vast majority (91%) of the attributes listed were soft skills rather than hard skills. This supports findings of Change the Equation (2015) that students engaged in work-based programs gain an understanding of workplace norms, including the soft skills that can influence career success. It is particularly interesting that the results align so closely to the attributes which Robles (2012) identified, from a survey of senior business executives to be the most important ten skills for business success: integrity, communication, courtesy, responsibility, social skills, positive attitude, professionalism, flexibility, teamwork, and work ethic.

These results above are very positive. The only negative comments from students revolved around logistical issues such as time taken to travel to sites, location and facilities and their desire that there be more field work and that the program should be longer to capitalise on potential learning opportunities. Other issues included a lack of skills brought to the course from school in making presentations and in completing the paperwork necessary to complete the course. This is a typical reflection of the different skills needed by students in work-based and traditional learning environments (Change the Equation 2015).

## CONCLUSIONS

The aim of this paper was to address the lack of research into corporate volunteering in the construction sector by addressing the question of whether such programs could help to alleviate the predicted labour shortage in the UK construction industry by recruiting more school students into the industry. Results from an in-depth single case study of one of the UK's longest lasting and successful schools-based volunteering programs show that volunteering programmes can have a significant impact on the career choices, aspirations and employability of adolescent students who are about to enter the world of work. By enabling new connections between construction professionals and students who might not have thought about working in the industry, the results show that students appear to emerge more motivated and clear about potential careers and career paths and what is required of them to succeed. This is particularly the case for female students, although our results indicate that they may need extra support in the form of more female role models and mentors during the program to prevent negative gender stereotypes being reinforced.

Last and not least, the results show the importance of active team-based and goal-directed exercises in building these skills and of work-place learning as an alternative and enjoyable blended learning experience for students who might not be academically strong or suited to learning in the classroom environment. In particular, the imparting of appreciation of intrinsic attributes and soft skills as key to future career success developed through this alternative pedagogical model contrasts strongly with the academic messages around knowledge acquisition imparted by traditional classroom based education. More

research is needed into corporate volunteering in construction and in particular into the potential risks for beneficiaries, volunteers and organisations involved in supplying and receiving volunteers. We are aware that the results are largely positive and suggest that more research is undertaken into the potential downsides of these programs. However, based on these results we conclude that there is some evidence that corporate volunteering could make a contribution to addressing a looming skills crisis in the UK construction industry.

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# TOWARDS THE USE OF KNOTWORKING FOR INCREASING INNOVATION IN CONSTRUCTION PROJECTS

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Knotworking is an emerging collaboration form in the built environment, which promises to encourage innovation at Construction project level. This study of knotworking processes is part of a larger research program about collaboration in the built environment. In this study of Knotworking, the focus has been on how the participating organizations and professionals can learn how to participate in knotworking. A facilitator was introduced to establish how facilitators can assist the participating organizations in a construction project to learn to produce knowledge and innovation through knotworking. The theoretical foundation is Activity Theory, the data collection method derives from applied ethnomethodology using a blend of video recording and participant observation. The data has been collected in a series of planning meetings and one workshop about building a new kindergarten. The analysis of data shows that the open-endedness of the process was difficult to handle for the participants, as they wanted to return to old norms and routine that overrule the knotworking process. The major result is that the use of a facilitator can function as a catalyst helping the participant exploiting the openings for knotworking by encouraging people to bring in their resources and tools in new ways and in this way increase innovation.

Keywords: activity theory, construction industry, facilitation, knotworking.

## INTRODUCTION

A wish to develop new methods, tools and production for facilitating efficient buildings is the background for the EU project called Green Building A-Z. The collaboration form 'knotworking' has been chosen as a method to develop this. The desirable type of innovation is pragmatically and analytically categorized as "product innovation (changes in the things (products or services) that an organization offers) and process innovation (changes in the ways in which they are created and delivered)" (Tidd and Bessant 2009: 21). Much of the innovation in the construction industry is co-developed at project level, found Xue *et al.*, (2014) in their review on innovation in the construction industry. They continue to recommend more research into how innovation is managed at project level. Research into innovation in project-based organization has so far been little (Taylor *et al.*, 2004). Knotworking is a collaboration form, which combines the use of Activity Theory's way of understanding human behaviour with the concept of Expansive Learning.

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Expansive Learning happens, when “learners learn something that is not there yet” (Engeström and Sannino 2010: 2). In this way, they learn something new, i.e., some knowledge that was not there, when they started their collaboration. Knotworking allows for an understanding of how to “sketch the contours of [how to perform] knowledge- and innovation-driven production” (Engeström 2008: 20). It is a “core activity” in order to promote learning and innovation when different “kinds of knowledge are combined” (Wegener 2014: 249). On this background, the choice of knotworking as a collaboration form becomes appropriate for situations where innovation is the aim.

Knotworking allows for participation of many experts to cope with emerging situational challenges. The participating experts form what is called ‘a knot’ and will be working towards an object. The members of the knot do not remain stable, but are changed as the knot works towards its object. An object can be defined as ‘the raw material’ or ‘problem space’ at which “activity is directed” (Engeström and Sannino 2010: 6). This process has typical no clear deadline or fixed endpoint (Engeström 2008). Collaboration between the organizations in the knot is of “vital importance, yet it takes shape without rigid, predetermined rules or a fixed central authority” (Engeström 2008: 20). This was exemplified in Finland where a lack of common goal was an issue that questioned the prevailing way of collaborating and motivated the initiation of knotworking (Kerosuo 2015). Similarly, the use of knotworking in a Danish case showed that the exploitation of digital technology such as information exchange between disciplines/domains and the underlying data models and interfaces, in some cases, challenged the provision of data. The Client ended up being unable to compromise company procedures and demanded the deliverables in predefined formats, which caused a relapse into known methods and procedures instead of supporting new ways of collaboration and documentation (Buhl *et al.*, 2017).

There are hindrances to successful Knotworking. Kerosuo (2015) discovered that simultaneous membership in a knot and a firm might restrict performance in the knot. A similar point is observed by Scaratti *et al.*, (2017), who report on troubles with the power dynamics in the knot related to mandate, coordination and work methodology. These barriers may be due to the structure of the inter-organizational networks, an organization form we often see in construction projects. The interorganizational network encounters difficulties in facilitating expansive learning while working on goal-fixed projects, Klitgaard *et al.* (2016) showed that a strong focus on a specific goal by a project’s activity system hinders expansive learning. A construction project requires the involvement of a broad range of actors with different competences and specialties (Eriksson 2013). The participating organizations are used to networking which is fundamentally different from Knotworking. Knotworking encourages “upsetting traditional boundaries and improvising new co-configurations of work and object of activity”, argue Scaratti *et al.*, (2017: 18) and differs from the traditional way of looking at a network with “focus on maintaining and nurturing existing relations. Knotworking is very different to the traditional collaboration in the construction industry.”

The construction industry with its project-based nature with a goal specific nature and networking practices may seem to contrast with the knotworking collaboration form. In order to meet opportunities and increase innovations at project level, we have chosen to work with Knotworking in the "Nordic project, Green Building A-Z". However, knotworking is still a new collaboration form for the construction industry, so to spread knowledge about knotworking as well as how to facilitate change with knotworking the role of a facilitator is being tested and researched.

The focus of a facilitator can be to move the project forward. He will adjust the need for assistance and enablement depending on the contingencies (Freytag and Storvang, 2016). However, as Rasmussen (2011:398) describes the use of interactive methods and facilitation for change, where “the primary objective of facilitation is to support participants to transcend ‘business as usual’ conventions and help them to think in terms of new modes of behaviour and perspectives...The facilitators enable groups to be creative and to collaborate more effectively”. The focus of the facilitator depends on the purpose of the facilitated.

A knotworking facilitator seems like a contradictory function. Knots are expected to form when collaboration between organizations is needed. They should perform “without rigid, predetermined rules or a fixed central authority” (Engeström 2008: 20), which contrasts with giving the facilitator the function to set up rules and authority. On this backdrop, we decided to investigate the role of the facilitator in a Knotworking process and pose the question: "How can a facilitator assist the participating organisations in a construction project in their efforts towards producing knowledge and innovation through knotworking?"

## **KNOTWORKING - THEORETICAL FRAMEWORK**

The theoretical perspective of this research is AT and Expansive Learning. This analytic combination allows the research to examine what the participants learn together (Engeström and Kerosuo 2007). Activity Theory (AT hereafter) brings an understanding of human activity, which is often depicted as an activity system that entails the relations between subjects, objects, and instruments involved in production as well as the social aspects of an activity such as rules, division of labour and community. Expansive learning is initiated by a questioning stage which happens when subjects in an activity system are “questioning, criticizing or rejecting some aspects of the accepted practice and existing wisdom” (Engeström and Sannino 2010: 7). Analytically and pragmatically this question stage is followed by analyzing the historical development into the present situation, as well as the analysis of the actual situation, modelling of a new solution, examining the new model, implementing the new model, reflecting on the process and consolidating the new practice in what is called the expansive learning cycle (Engeström 2000: 970). All stages may not be completed, and it shouldn’t be considered a linear process. In this way, the questioning of the accepted practice can be developed through expansive learning into new models and practices. Therefore, expansive learning can be used to analyze the processes whereby new knowledge and new mediating objects of activity are collaboratively created (Paavola *et al.*, 2004: 573). The work practice of ‘knotworking’ in the construction industry finds its origins in this approach. Five analytic principles have been derived from AT. These five principles have been adapted and re-interpreted from AT which form the foundation of knotworking within the activity system and issues concerning the intervention and facilitation of knotworking processes (Kerosuo 2015):

The first principle of Knotworking, performing actions in groups as human activity, is the object-orientation. Objects of activity are both material and cognitive constructions that entail directionality, purpose, and meaning to collective activity (Engeström 2008). The collective activity system determines how the subjects decide and react while performing actions designed to reach the object (Foot 2002). In this way, the object becomes a representation of the collective motive of the activity systems’ subjects (Toiviainen 2007). As the subjects learn more about their object, it will change (as subjects’ accommodate their motivation to changes of purpose). In this way, learning is not “manifested as changes in the subject” but as “changes in the object of the collective

activity” (Engeström and Sannino 2010: 8). The object will create meaning and motive for all the subjects in the knot. The flexibility of who is participating in the knot may deal with Young’s (2001) concerns about Expansive Learning; motivation and power. He argues that not all subjects will have the same motivation to enter the Expansive Learning cycle and that power issues may deter some subjects to participate. An awareness of how object changes may be signs of learning, and not signs of not sticking to the agenda, is needed for the facilitator of the knotworking process.

The concept of mediation in human actions and activity is the second principle of Knotworking; the elements of an activity system mediate human activity. For instance, various instruments such as manual and software tools, building plans, building schedules, and meeting procedures mediate a building project. New tools may be developed and adapted to reach an object. A new tool changes the subjects' views of the object concluded Virkkunen and Newnham (2013), and it affects the inter-action between the subject and object as well as the subject's role, self-understanding, and identity. Facilitating knotworking gives subjects the freedom to work with their tools because it is through the use and development of the tools learning and innovation is happening. This may seem contradictory to the traditional facilitator's role of ensuring the right tools are available.

The mutual constitution of actions and activity is the third principle. Expansive Learning can happen, if the activity system is directed its’ activities against a durable object. (Engeström 2000: 961). However, if the Activity System is pursuing a short-lived goal the Expansive Learning cycle may never be entered into. An object may not be clearly defined from the beginning but, through cycles of Expansive Learning, it will be transformed into a result. It is the intention of Knotworking to work on abstract objects and through Expansive Learning enter into a process of product and/or process innovation. It is not the intention to solve concrete problems or specific goals. Facilitation of knotworking should support activities directed towards abstract object, although it may seem contradictory to the traditional facilitator's role of assisting with contingencies.

Examining contradictions as sources of change is the fourth principle of Knotworking. Contradictions are historically accumulated tensions between and within different activities that manifest in disturbances, gaps as well as innovative solutions (Engeström 2008). For instance, a contradiction may emerge between the adoptions of new digital technologies such as BIM and organizational structures developed during a prior technological paradigm (Kerosuo *et al.*, 2015). Tensions in a knot can be turned into the Expansive Learning cycle. Engeström (2008: 36) observed a team which stagnated and resisted change and innovation. This happened because they did not react to tension by "attempting or completing an innovation". Facilitation ensures that openings for innovation is kept open, although the subjects of the knot may attempt to solve the tensions by other methods than innovation.

The historicity of human activity is the fifth principle of Knotworking. Engeström connects Knotworking to the emerging historical type of work called co-configuration. The features of co-configuration involve: Integrated product and/or service combinations; Continuous relationships and mutual exchanges between customers; Producers and products and/or service combinations; The customization of products and/or services over a lengthy period of time; Multiple collaborative producers operating in networks within and between organizations (Engeström 2008: 195-196). Co-configuration requires input from different participants and so the facilitator should have some focus on that everyone’s opinion is important, not just the traditional experts.

A facilitator with knowledge of the five knotworking principles may be able to assist the participants in their knotworking.

## **METHODS, DATA, AND ANALYSIS**

The method of the study is applied ethnography, which is a practice-oriented approach to contribute to change processes (Chambers 2000). Applied ethnography is often used in action research projects that serve public good and/or decision-making, and can involve analysts as facilitators. It emphasizes collaboration with the participants of the change projects and those involved as subjects in fieldwork. Applied ethnography resembles developmental approaches drawing from the methodology of expansive learning with regard to its orientation to practice and participation in change processes. The focus of developmental approaches on tensions and disturbances is also similar to applied ethnography. The idea of both these methods is that researchers make the tensions and disturbances of the work practice visible (Kerosuo 2006).

The method of the data collection was participant observation (Hammersley and Atkinson 1983). Five dimensions when performing participant observation must be considered according to Patton, stresses Warming (2009); while she adds a further three dimensions. Dimension (1) regards the level of researcher's level of participation. The research team decided that the researchers should engage in the knot if they thought it could be beneficial. Dimension (2) and (3) concern the participant's awareness of the research. It was decided, that the participants should know about the research and that its' focus was the facilitator's role. Duration of the observation (4) was decided to be during all meetings and the focus to be the facilitator (5). The researchers have to be present to sense and feel the observed (6) so the recordings will be used to recall the experience. The researchers will observe both the spoken words as well as body language (7) and finally by carefully describing the observed (8) the researchers give their readers the opportunity to evaluate the objectiveness of the observed.

The use of applied ethnography allows for a study into how processes are changing from traditional routines to knotworking. In reading the data, episodes of these occurrences need to be identified. We call this kind of unit of analysis a transitional learning episode or in our case "change process episodes" where we are analysing how the facilitator assists the participants in knotworking. Our definition of an episode resembles the way Kerosuo's (2011) study of critical episodes of successful change, the transition from individually experienced contradictions to collaborative change, drawing on theoretical concepts, models, and methods from AT (Engeström 2008; Virkkunen 2013) to study the critical transition in meeting and workshops.

The data is collected from one of the Green Building A-Z's pilot project, a kindergarten. The client/developer is a Danish council, so first of all the research team had a meeting with staff from the building department to introduce the general idea of knotworking. This was followed by a meeting, where it was discussed, which theme/object the council wanted to have in centre of a later workshop. A meeting with participants from the Green Building A-Z project followed where the framing of the later workshop was discussed. Finally, the knotworking workshop was held, see figure 1 for a timeline.

A member of the research team was chosen as facilitator for the knotworking workshop as a sound understanding of the knotworking principles are required to facilitate the process. This facilitator also needs to have a sound knowledge of the construction industry.

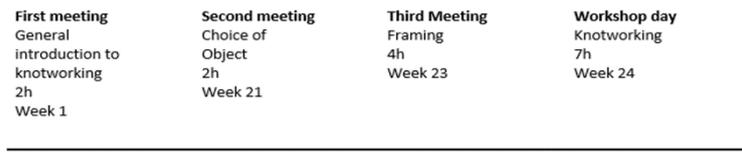


Figure 1: Timeline for meetings

Video recordings of the meetings three and four took place as it was during the meetings participants from different organizations within the industry was present. The purpose of the framing meeting (meeting no. 3) was to set up the conditions for the later workshop. The participants were asked to further discuss the object for the workshop, the rules for the workshop, how they would allow for different disciplinary communities' presence at the workshop, the division of labor during the workshop as well as which tools they wanted to have present and use during the workshop. These questions are inspired by the categories in the activity system. Nine participants were present at the meeting which took four hours. A week later, the workshop day took place, which was video recorded. Eleven participants from 6 different organizations participated. They were representatives from the client, the client consultant, the user, the commissioning consultant, project management and half of the day a contractor was present. The workshop lasted 6 hours and 45 minutes. During the day, the participants split up in 3 smaller discussion groups for 45 min. Members of the research team observed these group discussion, although they were not recorded. 534 minutes of video recording on 2 different cameras were made, along with 552 minutes of voice recording, also on 2 different recording devices. Selected episodes of analytic interest were transcribed.

## FINDINGS AND ANALYSIS

The first meeting with between the council staff members and the research team was an exchange of information. The research team was informed of the progress of the pilot project, the kindergarten and the council staff was introduced to the knotworking collaboration form. The second meeting between the client and the research team, the object of the later workshop was discussed. The leader of the council's building division expressed a wish to develop some sort of procedures for good collaboration between participants in a construction project. He had found on previous occasion that once a contract had been signed between the client (himself) and the design and build contractors, all intentions of good collaboration seemed to dissolve. The facilitator agreed that this was an appropriate object for knotworking as it based on a historic contradiction in how to designing a good project (use value for the client) for as little money as possible (exchange value; as the project is build using design and build procurement, the chosen contractor will have a huge interest in keeping costs low and so maximizing his profits). During the framing meeting (no. 3), the participants for the later workshop were called in to discuss the conditions for the later workshop. They agreed on the object. However, they wanted to be able specify it to a degree that it could be used in the coming tender material. A list of tools for the workshop was decided including actions to minimize the presence of different disciplinary communities. It was decided, who was going to be the moderator of the day as well as who was to write down the day's results.

The workshop day was held a week later. In the beginning of the day, the participants discussed the topic good collaboration. The discussions were very loose and moved back and forward across the themes; time, resources, expectation, demands and more. Later in the day, the participants had to turn these discussions into specific criteria for a tender material. This caused some change processes. The figure in the table shows sequences of disturbance and their influence changing between "present project routines" (rules and

norms) and knotworking (co-configuration). Reported in table 1 below. In this way, the participant did knotwork and by entering into questioning stages; they did in the end come up with a specific tender criterion for collaboration. The content of this criterion was new for them and so they did display the knotworking learning process during the workshop. However, the research team has been informed that this criterion was not included in the tender material after all. The reason for this is at present unknown.

Table 1: The findings

*Timeline of the "transitional episodes"*

| Sequence   | Quotes and analytic remarks  |
|--|--|
| A:<br>Returning to known routines and procedures | <p><i>I just need to make sure. We create a catalogue of ideas now, and then later we find out, what specifically we should include in our tender material - or should we discuss that now too? - client advisor</i></p> <p><i>So, now we really will begin to discuss what should be included in the tender material? - client advisor</i></p> <p>As it became clear that the participants were to discuss the tender material, they switched away from the previous open discussion and wanted to go back to negotiation the present routines. One of the participants want to read aloud some tender material he had prepared before the workshop. The facilitator attempted to stop this:</p>  |
| B:<br>No effect of the facilitator's question    | <p><i>I am very sorry to disturb...but I have noticed that you have focused a lot about collaboration today but is a bit unclear what you mean. I would really like if you [...] discussed this and found, what it is specifically you want to write" - facilitator</i></p> <p>However, the participants do not want to follow the facilitator's advice. They want to hear what had been prepared before the workshop. It is an example on how the participants react to knotworking and how easily they revert to old routines and norms.</p> <p>The participants heard the pre-prepared tender criteria about collaboration between tradesmen on site (no representatives from these were present) and agreed that it seems "existing" and "makes sense". This is followed by silence. The participants seem unsure what to do. At this stage, the intended manager of the kindergarten says:</p>  |
| C:<br>Switch to knot-working                     | <p><i>But, I understand [that collaboration between actors on the building site is important] but I am also becoming interested, when we are speaking about collaboration, then I am also interested in collaboration, in what could be called the process as a whole. What, you describe now. All that is when the project is planned ... maybe we [participants in the room] should have defined our collaboration, I think [...] Can you follow my idea? And that collaboration will become very important? And I think that is what you write into the material. What does that collaboration build on?- the council's pedagogical leader for all kindergarten in the council</i></p> <p>This input from an outsider of the construction industry is questioning the collaboration between the client, client advisor, commissioning manager and project manager as well as their collaboration with the tradesmen onsite. It is questioning the existing division of labor.</p> <p>They start negotiating the need for being able to evaluate collaboration with contractors.</p> |

|  |  |
|--|--|
| <p>D: Switch to knot-working</p>                         | <p>At a point, the facilitator suggest that they may need a new tool and perhaps it would assist them to see some tender material. In response to this, the intended leader of the kindergarten replies:</p> <p><i>"I think, that we are beginning to get there [...]I do think, that we begin to have a fair understanding, Right? Don't we? I have. - the council's pedagogical leader for all kindergarten in the council</i></p> <p>The participants seem to react to this. They question the object of the day, which might not have been clear for them until now.</p>   |
| <p>E: Staying with knot-working</p>                      | <p><i>" I am wondering....is this just something we do for fun....this knotworking discussion should, in a way help us, or?" - sustainability manager</i></p> <p><i>"I think we can learn from this process, but we should hopefully be able to take something with us..." -project manager</i></p> <p><i>"Yes, something concrete." - client advisor</i></p> <p>This willingness to have an outcome of the day is interrupted by the discovery, that a prequalification advertisement for a design and build contractor has already been published. A discussion about the possibility for working on tender material for describing the kindergarten project begins:</p>   |
| <p>F &amp; G:<br/>Switch to present project routines</p> | <p><i>"It need to be done by tomorrow at nine" - client advisor</i></p> <p><i>"I would like to write the prototype, but not for tomorrow."- commissioning manager</i></p> <p><i>"...after Friday, it will only be details I will take into the project or I simply can't make it" - client advisor</i></p> <p>The participants accept the time constraint and switch away from the willingness to develop further on the criteria.</p> <p><i>"Today we are doing a lot of things, which we can also use in the future...Nothing is wasted, even if we don't get it into the tender material" - project manager</i></p> <p><i>"It won't come in this time,...it is the beginning of a process" - client advisor</i></p>   |
| <p>H:<br/>Switch to knot-working</p>                     | <p>The facilitator steps in and asks:</p> <p><i>But, let's pretend you had the time for it. Then that is closed. If you had to find criteria. We need to get something on paper..." - facilitator</i></p> <p>This prompted co-configuration. Criteria for the upcoming tender material was created in spite of the close deadline. It is not clear at what point the participants discovered that it was feasible. They say:</p> <p><i>"...we have actually reached our goal. Then we just need to remember to look at all the rest [more discussion on the foundation for good collaboration]..it became very specific there..." - the council's sustainability manager</i></p> <p><i>""Don't you agree, that we reach the goal? Ready for tender material?"- commissioning manager</i></p> <p><i>"Yes, I just need to copy and paste" - client advisor</i></p> |

On reading the above data, it can be seen that the facilitator did assist the participants in their effort to knotwork. Interestingly, it seems as though the pedagogical leader responded more to the facilitator than the construction professionals, as two of her questions seem to be reflections of a previous question by the facilitator. It could be due to her educational training, or because she does not have the same project routines to switch back to as the rest of the participants.

The facilitator first demonstrated knowledge of knotworking, when the object of the workshop was decided. It was based on a historic contradiction in how to design a good project (use value for the client) for as little money as possible (exchange value; as the project is build using design and build procurement, the chosen contractor will have a huge interest in keeping costs low and so maximizing his profits). The facilitator did initiate the beginning of some questioning stages, which prompted the participants to switch into knotworking with the possibility for the occurrence of expansive learning. The first question about collaboration is based upon the tension in dividing task and responsibility (division of work) in the construction industry. It refers to the fourth principle of knotworking. The question if they wanted to see some tender material was made based on the second principle relating to mediation. The third principle of actions and activity was used by the facilitator when attempting to eliminate the focus on a tight deadline.

## CONCLUDING REMARKS

It is possible to innovate and create new requirements and expectations to the collaboration in a construction project as the above episode of a transitional learning process shows. It was achieved by creating a workshop, which allowed for knotworking. By combining workshops with the use of a facilitator with focus on knotworking, it may become possible to perform knotworking in the construction industry even if it seems contradictory to the nature of knotworking to introduce a facilitator. Facilitation as suggested in this paper is far from completed and stabilized. The challenge for the facilitator is to manage their functions so that they are catalysts.

The findings indicate that it is possible to facilitate knotworking processes, seeking to build collaboration in knot-like ways, beyond the models of stable, well-bounded institutions and project norms and rules. New ways of working shall emerge and by facilitating construction processes it is possible to innovate, so participants from the build environment leave old routines within construction project - roles and assignments - and engage in knotworking (co-configuration), creating new solutions to old problems and conflicts. The implementation of the knotworking process is an innovative method of collaboration in the construction industry, which entails the disruption of the present norms, practices and rules. The use of a facilitator functions as a catalyst helping the participant exploiting the openings for knotworking by encouraging people to bring in their resources and tools in new ways and in this way increase innovation.

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# A HUMAN TOUCH: EXAMINING THE ROLES OF MIDDLE MANAGERS FOR INNOVATION IN CONTRACTORS

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Innovation in construction is becoming increasingly important. Many studies on construction innovation focus either on the project level or on top management. In doing so, the in between group of midlevel managers risks to be neglected. If studied, middle managers are often narrowly defined to fit the mechanistic implementation of top management ideas. This does injustice to the importance of middle managers and the variety of their roles in innovation. In this paper, we address the different roles that middle managers may adopt in relation to innovation. A literature review and a case study were conducted at a regional housing division of a large Swedish contractor. In 10 semi-structured interviews and a vision seminar the middle managers were asked to voice their perceptions about innovation in the division and about their own role. Systematisation of working practices, employee development, and health, safety and sustainability measures were perceived to be the most important innovations. Four different roles of the middle manager have been examined: implementer of change, networker, sensemaker and enabler. Most middle managers identified with different mixtures of these ideal types. On this background, we discuss how middle managers may advance these roles to contribute to innovation in housing construction.

Keywords: contractor, expertise, innovation, middle manager, roles

## INTRODUCTION

The construction sector has a somewhat difficult relationship to innovation. Innovation is perceived to be important as can be seen from discussions on Lean production, Building Information Models (BIM) and 3D printing. Simultaneously, there is a widespread perception that construction companies are conservative and slow to adopt innovations. Like in many other industries, innovation in construction is hindered by a discrepancy between long-term collective benefits of innovation and a limited pay-off for individuals that innovate (Orstavik 2015). Additional barriers to innovation are said to be caused by the project-based nature and complexity of construction (Author reference, Orstavik 2015, Winch 1998).

In this context, we address the role of the middle manager which is an undervalued professional group in construction innovation. From the perspective of a hierarchical organisation, the middle manager has traditionally been viewed as responsible for implementing top management strategies at the operational level. With the emergence of a trend towards flatter and project-oriented organisations, the middle manager risks to be

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seen as a symbol of slow action in the organisation (Floyd and Wooldridge 1994). It may seem as if the middle manager is an additional barrier to innovation that should be removed, instead of a resource to be used. Against this argument, a body of research has emerged that pleads for the middle manager position to be re-evaluated instead of abolished (e.g. Balogun and Johnson 2004, 2005, Floyd and Wooldridge 1994, Koch *et al.*, 2015). This paper takes up the quest and further explores the roles that middle manager may take in construction innovation. This paper addresses the following question: How do middle managers perceive their own role regarding innovation in construction?

Innovation is defined here in a pluralistic perspective as "changes in established ways of value creation" (Orstavik *et al.*, 2015:4). This means that related concepts such as development, strategy, and learning are also included. Using an open definition of innovation leaves room for a more contextual understanding, where innovation means different things to different people at different times and places. This benefits the middle managers that speak in this study, as they are not restrained to commit to any predefined understanding of innovation.

### **METHODOLOGY**

A conceptual exploration of different middle manager roles in innovation was performed through a literature review. Sources were selected using a snowballing technique based on four articles identified in the beginning of the research was used as basis of the review (i.e. Floyd and Wooldridge 1994, Kissi *et al.*, 2013, Koch *et al.*, 2015, Rouleau and Balogun 2011). Furthermore, a search was conducted in the Fall of 2015 using the Google scholar search engine and combinations of the following key words: middle management, middle manager, change, innovation, organisational change, construction sector, construction, built environment, and contractor.

The empirical context of the study is set by a case that was studied: middle managers in a regional housing division in a large Swedish contractor. The firm is structured around different product groups and different geographical regions. The regional housing division is itself structured in a production, support, and sales unit. The study focusses primarily on innovation perspectives from the production unit. Empirical data was collected through semi-structured interviews with ten middle managers and a non-obligatory vision seminar prior to the interviews. Eight out of ten middle managers that participated in the study were working in the production unit. The other two interviewees were working in the support unit.

At the end of each interview, the interviewees were introduced to four roles identified in the literature review. They were then asked to select the role they felt to be most appropriate for themselves. The concept of roles is used as a means to enable a description of behaviour and activities that managers are doing. Along with Wilson's (2004) critique of Mintzberg's role theory, we do not pretend that the role concept can deliver more than just that, descriptions. The interviews were tape recorded, and transcribed by one of the authors. The transcripts were analysed using middle manager tasks and responsibilities, innovation in the Construction Company, and roles of the middle manager as analytical themes. Secondly, the four specific roles identified in the literature review were separately selected as themes for the analysis.

## CONCEPTUALISING THE MIDDLE MANAGER

### **Middle Manager Position, Responsibilities and Roles**

The reviewed literature presents different conceptualisations of middle managers. Here, understandings based on the position, responsibilities, and roles in innovation are discussed, with an emphasis on the latter. A position-based understanding of middle managers emphasises an organisational understanding. There appears to be a tendency to use a negative definition of the middle manager position: i.e. middle managers are defined by what they are not. Middle managers are neither top-level strategic managers nor lower-level operational managers (Balogun 2003). A positive positional definition of the middle manager relies on the formal position in an organisation to describe middle managers. There is a wide variety of formal positions attributed to middle management, ranging from division directors to site managers (Kissi *et al.*, 2012, Styhre and Josephson 2006).

A responsibility-based understanding of middle managers tends to stress the diversity of tasks that middle managers do. Styhre and Josephson (2006) portray the middle managers as a 'jack of all trades' being responsible for technical site work, administrative and financial matters, legal issues, human resource management, and conflict management. Kissi *et al.*, (2012) distinguish between a supervision of lower-level managers and financial responsibilities for a financial profit. These two examples reflect a characteristic split between fulfilling operational responsibilities and more aggregate organisational responsibilities. A role based understanding of middle managers is provided by Buss and Kuyvenhoven (2011). They distinguish between three discourses on middle manager roles: implementing top management strategy, networking between different levels and domains in an organisation, and sensemaking of needs, plans and actions. A fourth theme that is added includes middle managers as enablers of change. Next, we expand the conceptualisation of these four different roles.

### **Specifying Middle Manager Roles on Innovation**

#### *Middle manager as implementer of change*

The implementer of change role focusses on the middle manager as an implementer of top management defined strategic themes for innovation. It centres on a 'plan and control' view of the organisation and the role of the middle manager is to implement the strategy of the top management on the work floor (Floyd and Wooldridge 1994).

Criticism towards this role is mainly directed to the top down mechanistic view of innovation and organisation that this approach assumes. Accounts of demand-driven innovation and of innovation as a solution to practical problems at the construction site are poorly accounted for in this role description (Kissi *et al.*, 2012, Loosemore 2015). Furthermore, the middle manager self may also be perceived to have strategic agency and be knowledgeable (Mantere 2008). The focus on planned linear notions of change also disregards more emergent understandings of change and the unexpected consequences that always appear to result when planning change (Balogun and Johnson 2005, Toms *et al.*, 2011, Weick 2000).

#### *Middle manager as networker*

When middle managers adopt a networker role they position themselves in between different units in the organisation and the construction project. This role assumes that middle managers can draw benefit from their position 'in between' and develop relations that can be used in innovation. Because middle managers are likely to have a closer relationship to the client than top-level managers, they are believed to be well placed to

support demand-driven innovations and suggest strategic alternatives (Kissi *et al.*, 2012, e Cunha *et al.*, 2011).

In a networker role, middle managers recognise the value of information from diverse sources regarding costs, functionality, risks, market needs, and so on. Middle managers may act as an initial screen to ideas coming up in the organisation and select those ideas they want to bring to the attention of the top management (Floyd and Wooldridge 1994). A close relation to the operational level allows middle managers to use informal work networks and relationships to sustain long-term change efforts (Toms *et al.*, 2011). A middle manager can build social capital and develop unique interfirm networks (Loosemore 2015). Next to vertical networks between the office and the work site, middle managers may also build horizontal networks comprising of other middle managers in the organisation.

#### *Middle manager as sensemaker*

The sensemaker role focusses very much on the interpretive qualities of the middle manager. Differences in understanding between partners hinder collaboration and are particularly relevant in innovation because work practices change. Unable to rely on established modes of doing things, differences in context and understanding between parties may easily lead to misalignment and conflict. Through sensemaking, middle managers mediate between the strategic intentions and the realities of different groups within the organisation (Balogun and Johnson 2004, 2005, Jarzabkowski and Spee 2009, Sage *et al.*, 2012).

Sensemaking requires the translation of intention from the different parties through negotiation and buffering practices (Balogun and Johnson 2004, 2005, Koch *et al.*, 2015). Crucially, success of sensemaking requires an understanding of different motives and realities of the parties involved, and an ability to translate intentions, mediate, negotiate and buffer. This is difficult to achieve, and may be more difficult to formalise.

#### *Middle manager as enabler*

Middle managers can be enablers for change when they enable others to innovate. Typically, this role is more closely related to bottom up innovation. To enable innovation requires middle managers to adopt a supportive role towards project managers to help them overcome barriers to innovation. This can be done by fostering an innovative business culture or by developing capacities to innovate in the organisation (Kissi *et al.*, 2012, Loosemore 2015, Löwstedt and Räisänen 2012).

An enabler role can be practiced by providing resources, allowing autonomy and freedom, asking questions, creating visions, attracting and developing new ideas (Kissi *et al.*, 2012, Loosemore 2015, Toms *et al.*, 2011). At the same time, it can be questioned to what extent the middle manager can provide resources to support innovations (Kissi *et al.*, 2012: 14). Similarly, fostering an innovative organisational culture may be a difficult goal to aim for as individual middle manager.

Summarising, different conceptualisations of the middle manager have been explored in this section. A discussion of position and responsibilities of middle managers was followed by a focus on middle manager roles. Four different roles were discussed: implementer, networker, sensemaker and enabler of innovation.

## **DESCRIPTIONS OF MIDDLE MANAGERS AND INNOVATION**

### **Middle Manager Positions and Responsibilities**

In the case study, the two positions above the site manager were commonly perceived to be part of the middle management. Most interviewees defined their position as middle manager in relation to the organisational hierarchy. Simply said, a middle manager has managers above and below in the organisation. Two levels of middle managers were identified: a first layer middle manager directly above the site manager, and a second layer that sits above the first level middle manager and below the division manager. The middle managers emphasised that while they sit in an office, they are still in close contact with the operational aspects of the projects, something which higher level managers are no longer. Two first-layer middle managers insisted that they spend nearly all their time at the building site.

The middle managers described to have two main responsibilities: a group of people and several construction projects. Personnel responsibilities range from three to a dozen people. Middle managers recruit new personnel, hold performance reviews, salary negotiations, and monitor individual development of the employees. They make sure that their employees have the right conditions to feel good and be productive. Middle managers said to keep regular contact with their employees to learn how things are going, act as a soundboard for ideas and concerns, and allow employees to develop. In case of urgent problems, they had to give full personal attention.

Responsibility for construction projects is connected to an annual target revenue. As an indication, a first-level middle manager has responsibility for one to four building projects with a total annual revenue of 100-200 million SEK (approximately €10-20 million). A second-layer middle manager has responsibility for the portfolio of about four first-layer middle managers and a target revenue of 400-800 million SEK. Middle managers take responsibility to ensure that the different areas of the project are successful. This includes involvement in activities such as planning, control and problem solving, staffing, time management, financial planning, purchasing, contracts, and termination of the project.

### **Experienced Innovations in the Organisation**

Middle managers express to be part of both a sector that is prone to be conservative and an organisation that strives to be innovate. This situation gives problems because many innovations are perceived to require industry coordination. Innovative solutions are mostly characterised as those that are new to the firm or the division, or that deviate from established ways of working.

Three overarching themes for innovation were identified in the organisation: i.e. systematisation and harmonisation, employee development, and adjustment to wider societal changes related to health, safety and sustainability.

Systematisation and harmonisation is the dominant narrative of change in the company. The goal is to create unity to handle the complexity and uniqueness of the construction projects. Indirectly, an increased systematisation is contributing to increasing information flows in the construction project and organisation. While systematisation of production is generally perceived as positive by the middle managers, the increase in information flows is not. Several systems have been introduced that harmonise and steer the way the organisation works. These include systems that structure activities such as time and staff planning, budgeting, quality management, technology choice, document management,

and purchasing. They are not just about information gathering but actively prescribe certain ways of working. With the introduction of more information streams and systems also come a perceived increase of specialist roles in the organisation such as the BIM specialist and the sustainability specialist. While there is much focus on development and implementation of different systems, it seems that less attention is being paid to how people actually work with these systems and what the quality of the information flows is.

A second narrative of change is related to the development and treatment of the employees. Many middle managers consider development and training of personnel an important theme when discussing innovate and change. This includes leadership programmes and educational packages which the contractor supports. It is important to emphasise that many middle managers have worked their way up in the organisation. The educational programmes can be seen as a way to allow others to achieve a similar personal change and growth as the middle managers themselves have witnessed. At the same time, the development of employees enables the organisation to make best use of the available personnel resources.

A third narrative of change in the organisation was related to wider changes in society. Increased attention to health and safety measures in the organisation was noted by most interviewees. A recurring practical example is the obligation to wear safety glasses at work and the introduction of an incident reporting system. Increased attention to sustainability in society has also made its impact on the organisation. The middle managers pointed to the appointment of a sustainability manager and introduction of BREEAM as a sustainability assessment and certification tool in their company. In a few projects that reached a very good environmental performance it led to the introduction of innovative solutions such as solar cells.

**Middle Manager Roles in Innovation**

The middle managers were asked to select the role they identified most with (See table 1). The table shows that all roles have relevance. Furthermore, most middle managers chose a combination of roles.

*Table 1: Middle management roles of innovation chosen by the interviewees*

| Middle manager | Implementer | Networker | Sensemaker | Enabler |
|----------------|-------------|-----------|------------|---------|
| #1             |             | X         | X          |         |
| #2             | X           |           |            |         |
| #3             | X           | X         |            |         |
| #4             | (X)         | X         | X          | (X)     |
| #5             | X           |           |            |         |
| #6             | X           | (X)       | (X)        | X       |
| #7             |             | X         |            | X       |
| #8             | X           |           |            |         |
| #9             |             |           | X          | X       |
| #10            | (X)         | (X)       | (X)        | (X)     |
| Total          | 5 (7)       | 4 (6)     | 3 (5)      | 3 (5)   |

*Note: 'X' represent roles specifically identified by the interviewees, (X)' represents roles identified under the answer 'a bit of all.'*

This would indicate an awareness of flexibility in the adoption of roles by the middle managers. IT also gives an indication that use of a specific role may be context

dependent. Next, a more detailed description of the different middle manager roles in innovation is presented.

*Middle manager as implementer of change*

When middle managers talked about implementing innovations they spoke about implementing rules, systems and tools diffused from higher management levels to the project level. The introduction of safety glasses and other safety measures was used as an example where top management intended the middle manager to implement change at the project level. Middle managers spoke of a responsibility to ensure that work at the project level is done in similar ways between projects and units of the organisations.

The middle managers can fulfil this role using different actions. Some suggestions include: breaking down action plans into smaller sub-plans, leading by example, showing how useful a certain tool can be or getting others to do so, setting goals together with the group, rewarding adherence to a changed rule or system, sanctioning the breaking of rules, ensuring that measures are well communicated and implemented at different parts of the organisation.

*Middle manager as networker*

The networking role of the middle manager was described to be very much about getting things done by finding the right people. Most middle managers claimed to spend a lot of time at the different projects and in all kinds of meetings. These moments are opportunities for middle managers to build and maintain their network with sub-contractors, specialist functions, clients and so on. These networks can be of use later on in innovation related behaviour.

Most often one tries to find the right person and ask if they can develop or change a system in a certain way because it does not work right [...] You call someone and ask if they have tested this solution, or what experience they have with it, what the risks are. [#4]

Vertical networks were said to facilitate bottom up change. The middle manager is in the position to communicate the opinions and insights of different people at the project level back up in the organisation. Incidental participation in reference groups may work as a short cut to allow the middle manager to spread input from people working in the projects directly central in the organisation. Horizontal networks were explained to allow middle managers to learn from each other. Dedicated forums for site managers and middle managers were identified as instruments to help develop such a horizontal network.

*Middle manager as sensemaker*

The role as sensemaker became most obvious when interviewees discussed the introduction of different information and working systems. From the management perspective, more information and more similar ways of working increase the control of the quality of the projects. This conflicts with the logics of a construction project with its own goals and problems.

You have a very nice system or time plan, but nobody really knows how long it takes to do the different activities, or what they contain, or in which way you should do things out there, then it is no good [#2]

The sensemaker role was also relevant when the interaction between production and specialist oriented parts of the organisation was discussed. Specialist functions were experienced to expand together with the complexity of construction and organisation. Even though middle managers recognise that specialist functions are there to support the production and the projects, they blamed specialists for promoting their own interests. Here, sensemaking could be initiated.

In this light, we may see the strong emphasis many interviewees placed on their extensive background within the organisation, industry and construction site. The dominant narrative is that of a carpenter who has been promoted to a work supervisor and a site manager before taking up a middle management position in the organisation.

I started one day as a carpenter myself, so then you have a bit of an understanding for everything, then I believe that one is quite good placed as a middle manager, because one can do the operational ... and can take the top managements ... guidelines and visions, it becomes possible to transform it, so that they understand what our task really is. [#1]

A good understanding of routines and work processes can give middle managers the ability and legitimacy to translate between different worlds of construction.

### *Middle manager as enabler of change*

From the interviews, it became clear that there are no real resources at disposal to the middle managers to develop and test innovations independently. This hinders the enabler role. A strategic intent to improve efficiency and similarity within and among projects lends itself poorly to independent experimentation. Experienced resources pressure, efficiency, and systematisation goals make it unappealing for the middle manager to do so.

Instead, middle managers perform the role as enabler of change through enabling employees to develop themselves personally through training and courses. Even though it is not directly related to changes at the operational or strategic level, education is a mechanism for employees to grow into other positions within the company. By giving access to educational programmes, middle managers allow employees to achieve a personal growth that they themselves have witnessed. Education and personal growth of employees was claimed to help the company retain capable employees, but do not in itself lead to the exploration and exploitation of change in the organisation and the construction project. Furthermore, the middle manager could enable innovation by creating a culture that promotes change.

## **DISCUSSION**

The exploration of different middle manager roles has provided insight into the different valuable contributions that this professional group may have for construction innovation. Simultaneously, some lessons can be drawn that allow individual middle managers to develop these roles further and positively use them where and when it is likely to foster innovation.

As an implementer of change, the middle manager in the studied organisation acts most in line with the strategic intentions of the top management. It is the implementer role that provide legitimacy for the interviewed middle managers to enforce changes when needed. Care is needed to avoid simplistic mechanical implementation of strategic decisions as they expect to meet resistance to change and simultaneously risk a poor fit between the measure and the realities at the project level.

Middle managers can use their personal network to find out what experiences others have had with a new solution and to judge the functionality of a novelty. The value of learning from others is especially important in an environment where key drivers for change have been identified to lie mostly outside of the own unit - i.e. construction site, clients, suppliers, top management, specialist units in the organisation, and government regulation.

For the role of a sensemaker, having experience in several different parts or units in the organisation can be considered an asset. A good knowledge of the routines and processes

of construction allows the middle manager to translate between different worlds of construction. Additionally, it may give the middle manager the legitimacy to do so.

A potential mechanism for developing the role of the middle manager as an enabler could be to set aside part of the efficiency gains. These could be used as resources to - temporary - dedicate themselves or other employees specifically to innovation and development purposes. An increased focus on the solutions and questions that come up in the individual construction projects could be a potential source of innovations for the organisation.

## CONCLUSION

This paper has explored the roles of middle managers in innovation in construction. It has done so through reviewing existing literature in the field and conceptualising the middle manager according to position, task and role. Four roles of the middle manager were identified - implementer of change, networker, sensemaker and enabler. Furthermore, they were explored using the perceptions and experiences of selected middle managers at a regional housing division of a large Scandinavian construction company.

The diversity in the roles that middle managers may be engaged with gives us an insight in the world of the middle manager. Middle managers act in a larger heterogeneous network of innovation. For this reason, roles and innovation are not linked in a simple manner. Instead, the role of the middle manager is context dependent, varying over time and place. Far from the much-romanticised innovation champion, the middle manager opts for more subtle forms of agency. At times, the middle manager can act as an implementer of change, using top management backup and accompanying narratives of the organisation as an efficient machine. At other times, the middle manager may rely on one of the other roles. Networking, sensemaking, and enabling roles equip the middle manager with the subtle forms of agency useful for those who work in the middle.

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# SIZWE BANZI IS DEAD: THE ABERRANT CASE OF CONSTRUCTION SECTOR IDENTITY

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The death of Sizwe explores themes of adopted identity and aspects of migrant work-seeking, and may also be seen as the triumph of human agency over institutionalised racism. In the South African context historically, identity was statutorily assigned by racial category, and occupational identity development was stunted by restriction on permanent urban residence, and exclusion from formal qualification or artisan status. In *post-apartheid* South Africa, skills development is a key strategic instrument in the workplace, supporting acquisition of formal qualifications. The construction sector is identified as a readily accessible form of employment, particularly in developing countries. Occupational identity derives from acquisition of skills related to an identifiable occupational role. However, construction employment is characterised by short-term contracts. How do these transient work relationships, use of migrant labour and attendant labelling, affect the acquisition of skills and occupational identity? Concepts of self and identity draw upon social interactionist perspectives, Goffman's concept of performance in social interaction, and occupational science literature. This background frames a desktop review of international research into aspects of identity in the construction sector, and occupational identity as the lens to evaluate implementation of skills development in the South African construction sector, which is broadly defined to include the policy makers and industry institutions. The conclusion reached is that the sector has neither responded positively to the new dispensation, nor supported dignified development of occupational identity through implementation of skills development. The conclusion motivates for further research on the implications for occupational identity development of transient employment.

Keywords: labelling, migrant, occupational identity, skills, transient employment

## INTRODUCTION

Significant consensus exists identifying the construction sector as an easily accessible source of employment and the sector has been seen as a generator of economic development, particularly in developing countries (Wells 1986, 2007; Giang and Pheng 2011; Lopes 2012; Ofori 2012). In the South African (SA) *post-apartheid* context, the workplace is envisaged as key to implementation of skills development. The sector is perfectly placed to achieve a positive contribution to skills development. Effective implementation of the skills strategy should influence development of occupational identity and significantly contribute to the promotion of an inclusive economy, in sharp contrast to the *apartheid*-era statutorily assigned exclusion based upon racial identity. As Berger and Luckmann (1967: 194) note, historical context is critical: *[s]ocieties have histories in the course of which specific identities emerge....* The SA context is portrayed

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in the Athol Fugard play *Sizwe Bansi is Dead*. The play explores twin themes: personal identity assigned by the SA *apartheid*-era identity document, which all persons designated as ‘black’ were required to carry, and which specified where the person may live and work; and secondly, the pattern of migration of mainly men, who left their families in the designated rural homeland areas, and travelled to urban areas and mines in search of work (Marino 2010). Central character Sizwe has not been able to find employment in town, but the opportunity arises to assume the identity of someone else by taking their documents. However, Sizwe will lose his identity, and with it-his extended family connections. Sizwe and his friend discuss burning Sizwe’s identity document - Sizwe will be dead, but he will be able to remain in Port Elizabeth, to live, and work. Human agency triumphs - Sizwe and his friend Bantu have developed a strategy to subvert the *apartheid*-era restrictions. Currently, in addition to national rural-urban migration, migrants-both legal and illegal-from surrounding countries continue to seek work in the SA construction sector.

Nisbet (1966: 9) suggests the: ... *ideas we are concerned with are incomprehensible save in terms of the ideological contexts in which they first arose*. The allegorical *sizwe* - translating directly as *the nation*, illustrates the demeaning loss of personal identity and human dignity engendered by *apartheid* legislative exclusion. Consequently, one of the foundational values of the new SA Constitution is human dignity. *Everyone has inherent dignity and the right to have their dignity respected and protected* (Republic of South Africa 1996: s1 & s10). The previous economic exclusion was reinforced by poor quality education, which specifically excluded mathematics and science, and restricted advancement to tertiary education and formal qualification. Skills development is now a strategic intervention in the workplace, and the acquisition of formal qualifications a key pillar of redress. The questions addressed in this paper are: has the SA construction sector supported implementation of skills development and acquisition of formal qualifications, thereby supporting development of occupational identity? What further research on identity may enhance the construction sector performance in this regard?

## **METHOD AND PROCESS**

*Aberrant* is defined as *deviating from morality* (Collins 1994: 2). The review builds upon Hammond et al.’s (2016) study of roadside work-seekers, and considers the response to the skills development intervention of the SA construction industry, which is broadly defined to include the policy-makers, industry institutions, and contracting organisations. Occupational identity provides an investigative lens to identify progress. A literature review traces the social-interactionist foundations of identity theory, links to occupation as an aspect of identity, and the relationship to the socio-cultural context of work (Christiansen 1999; Unruh 2004). This insight frames the desk study of occupational identity as conceptualised by researchers examining the construction sector, and the SA implementation of Vocational Education and Training (VET) as a strategic developmental intervention. The review contextualises migration, and issues of labelling and identity.

## **A LITERATURE REVIEW - CONCEPTUALISING IDENTITY**

Seeking the roots of a socially derived conceptualisation of identity leads to the American symbolic interactionist tradition, initially proposed by Mead (1934), and furthered by Blumer (1954). The centrality of communication and inter-personal verbal and non-verbal communication provides the individual’s means of developing her/his sense of self; and is also the individual’s means of reflecting upon and attributing meaning to the interaction (Blumer 1954, 1962, 1969). The identity develops in a combination between information gained from the social environment, and personal reflection. For Goffman

(1959) the presentation of self is a performance; roles are conveyed as presentations, and the means of informing others about oneself. This description is relevant to the method of displaying skills acquired, the display of competence in an occupational identity, and suggests agency in the management of the performance. These two strands of identity theory, namely: the relationship of identity to social structure, and the focus on how the individual reflexively verifies identity in social interaction, were initially developed individually by Stryker and Burke, respectively. Subsequently Stryker and Burke (2000) collaborated to motivate a reconciliation of the self-verification of identity with interaction in social structures, compatible with Mead's original principles.

The works quoted above mainly reflect the sociology and social psychology disciplines. However, separate developments of occupational identity have evolved via Human Resource Development (HRD), VET, and the work of occupational scientists, which are all more closely related to skills development and the acquisition of occupation-related skills. Brown (1997) motivated that HRD and those involved in VET should pay attention to the development of occupational competence and of occupational identity, offering a model, which incorporates the development of occupational identity over time. The importance of work, and the relationship of work to the personal aspects of relationship development integral to occupational identity, is identified by Christiansen (1999). This integration is confirmed by Unruh (2004), who also considers the private as well as public aspects of occupational identity. Subsequently, a series of authors explore the development of occupational identity. Phelan and Kinsella (2009) credit Kielhofner (2002) with coining the term 'occupational identity'. These contributions acknowledge the relevance of socio-cultural influences, as well as a future orientation-personal motivation (Laliberte-Rudman 2002; Laliberte-Rudman and Dennhardt 2008). This conceptualisation frames an exploration of identity in construction management research.

### **Identity in construction - management and apprenticeship**

Two broad categories may be distinguished, namely: reviews of roles and identity of construction management, and the inculcation of skills and cultural behaviours into apprentices; both categories recognise the relevance of organisational culture to the development of identity. Brown and Starkey (2000) identify a collective organisational identity of defensiveness, and a resistance to accept organisation change. The authors suggest that this may be addressed by organisational learning. This view that organisational culture may be influenced and managed, and new entrants may be incorporated into the culture forms the foundation of employer induction programmes, and part of apprenticeship programmes. Following this logic, Phua and Rowlinson (2004: 913) adopt a positivistic approach to social identity to consider how to operationalise *culture*. The authors list a number of previous articles indicating the importance of creating cultures of partnership, in order to improve the performance of projects. The rationale here is that social identity theory may be utilised to explore how socio-psychological factors can directly affect the working relationships between project participants (Phua and Rowlinson 2004: 914). They conclude that the relationship between culture and individual behaviour is more complex than previously envisaged. Subsequently, also seeking to improve project performance, Brown and Phua (2011) investigate the activities of construction management. Their findings identify the relevance of the relationship to organisational structure, specifically in terms of managerial activities and the exercise of power, as contributing to personal identity. The emphasis is on *self*: ...*what construction managers do is grounded in their conceptions of self...* (Brown and Phua 2011:92). The motivation of the authors is to improve project management outcomes, concluding again the need for further research into the

relationship between identity and performance. At this point, it is necessary to define what constitutes an organisation. In the context of project management, it is probable that there would be a continuity of core complement, with additional professional, skilled, and unskilled persons joining intermittently as required to conclude a specific project. In such an environment, too strong a core complement culture and identity may constitute an obstacle to effective performance. In a study of social identity of managers within a large organisation in Sweden, the effect of organisational culture and the collective identity of belonging emerges from participants' life stories. The self-defining identity is consistent for: ... *the majority of managers ... regardless of their different roles, functions or responsibilities.* (Löwstedt and Räsänen 2014: 1102). A central conclusion notes the risk of rejection by the strong collective culture, for those from other contexts, or professions. The authors propose the benefit of further exploration of construction-specific practices - and how these may be linked to change (Löwstedt and Räsänen 2014).

This differentiation between core and project staff is relevant to the second category of construction research, which was identified above - that of apprenticeship and traineeship. Hauschildt and Heinemann (2013) develop the relationship between identity development and interrelated fields of commitment, which they characterise as: occupational, organisational, and personal work orientation (Hauschildt and Heinemann 2013: 177-178). In researching apprentices, the authors acknowledge the importance of the actual apprenticeship and organisational context to development of commitment and identity. Brown (2004: 266) defines occupational identity as ... *formation processes and patterns of strategic action relate to a number of issues at the level of the individual, the organisation and society as a whole.* These levels resonate with the original social-psychological concepts of identity (Huot and Rudman 2010). Of relevance to development of an occupational identity, the research specifically covers employed apprentices; traditionally apprentices serve their time as employees, but may not necessarily remain within the organisation once qualified. Therefore, it may be of relevance to consider how occupational identity factors continue after qualifying, where employment ends, and potentially where artisans may commence contracting. The formulation Brown (2004) proposes may hold where the artisan remains employed, but what is the strength of the craft occupational identity, when the individual is required to serve short periods on a variety of projects in transient employment relationships? The nature and format of the training experience may have relevance. Smith (2013) utilises occupational identity in an exploration of negative perceptions of traineeships in Australia. Although not exclusively related to the construction sector, occupational identity emerges as less robust in traineeships compared to traditional apprenticeships. A key aspect relevant to the construction sector and VET, is the inability to transfer from traineeship into apprenticeship. Exclusion of such articulation is pertinent to the SA experience in that similar reservations are expressed about Learnerships and the National Certificate Vocational (NCV). Comparable to traineeships, they are generally shorter than apprenticeships, but do not carry the status of the artisan Red Seal certification.

In summary, socio-cultural factors influence the development of personal identity, and occupational identity may be influenced by occupational, organisational, and social factors. Within the construction sector, complexity may be added depending upon whether the individual forms part of a core organisational complement, or regularly participates in project work, and whether at a professional or artisan level. For labourers and less skilled workers, and within developing countries, additional influences upon occupational identity are informality, and migration. In such impermanent situations of multiple casual work relationships, what influences occupational identity?

## THE SOUTH AFRICAN CONSTRUCTION SECTOR

Twin discoveries of diamonds (1867), and gold (1886), provided the impetus for international, intra-continental, and national rural-urban migration to SA. Racial conflict had previously existed, but the formalisation of these industries introduced recognition of formal qualifications, indirectly related to race. Construction constitutes a substantial portion of the mining operation and the international migrants brought formal artisan craft qualifications, from which African migrants were excluded. The strikes of 1913, 1914, and 1922 concerned wages, with qualified artisans concerned to ensure their privileged status and wage rates (Wilson 1972; Hyslop 1999). Davenport (1969) documents the State response, a concern to prevent any sense of permanence, or urban residence for the African migrants. This introduction of racial identity as the criterion for exclusion from craft qualification, and permanent urban residence, laid the groundwork for the *apartheid* formalisation of job reservation, and residential racial segregation.

### The skills development infrastructure - concept and actuality

In the new skills development landscape, the Construction Education and Training Authority (CETA) (RSA 2016b) is responsible for sector skills planning. The CETA receives eighty percent of the sector Skills Development Levy (SDL), which is one percent of annual company payrolls over R500 000. The CETA is charged with preparing a Sector Skills Plan, and facilitates the development of relevant VET qualifications via the Quality Council for Trades and Occupations (QCTO) for registration on the National Qualifications Framework (NQF) (RSA 2008). Levy-paying employers may obtain a percentage refund for submitting an annual Workplace Skills Plan (WSP) and Annual Training Report (ATR). Participating employers may qualify for additional discretionary funding to implement programmes leading to professional, vocational, and technical qualifications or part qualifications, (PIVOTAL) programmes (RSA 2012, 2013, 2016a). Under the workplace-based format, employees require a workplace experience component in addition to the knowledge and skills components to qualify, requiring a participating company to ensure employment, and registration for the appropriate formative and summative assessment – or artisan trade test.

Companies with a payroll of less than R500 000 per annum are exempt from paying the SDL, which encourages a limitation on permanent staff numbers, and excludes the small enterprises from participation, other than when they are able to participate in strategic projects funded via the National Skills Fund, provincial or metropolitan funded projects, or initiatives such as those of the Master Builders Association. Secondly, the CETA statistics indicate very low levels of sector employer participation: of 49,161 registered companies, 2,281 are levy-paying, and of those, 2,094 submit WSPs and ATRs (Nethengwe 2017). Although large employers participate in skills development, they represent a small proportion of the CETA sector. Thirdly, the informal sector appears to constitute an unknown but considerable component of the sector activity, as indicated by Statistics South Africa (CETA 2017: 9). This conclusion is supported by the recently launched Afrimat Construction Sector Index (ACI), which measures use of building materials and indicates greater activity within the sector than previously formally reported (Afrimat 2017). Collectively, these points raise questions for policy-makers on skills development, but also suggest unaccounted for levels of informal skills acquisition, and potential attendant identity development.

As part of a comprehensive post-school education and training strategy, the Department of Higher Education and Training (DHET) has invested significantly in Technical Vocational Education and Training (TVET) colleges to provide formal VET

qualifications. Monitoring and evaluation of progress is conducted against strategic objectives (DHET 2015). Recent reports (PMG 2017) do indicate high drop-out or failure rates, bringing into question the return on investment of TVET colleges. Powell and McGrath (2014) and McGrath and Powell (2016) criticise the predominantly quantitative evaluation methods used to measure VET college performance, suggesting a better evaluation method would be the UNESCO human development focus, which considers ...*individual well-being*... and what people actually do (Powell and McGrath 2014: 136). One conclusion may be that the emphasis on qualified workers is unnecessary in a sector where formal qualifications are not requested as a matter of course (Cattell 1994). There has been limited implementation of recognition of prior learning (Blom *et al.*, 2007). Here, the SA context is key. The Presidential Commission on Labour Market Policy (1996:41-43,109) established that quality-assured, credit-bearing, portable qualifications were an essential transformation requirement. Consequently, the DHET will continue to pursue achievement of formal qualifications. It would be informative to ascertain from those who have dropped-out, or failed, how they utilise what they have learnt.

A significant element in unequal or volatile societies is the limitation of career choice occasioned by survival pressures (Powell and McGrath 2014). In the construction sector, multiple factors confound acquisition of skills, and development of occupational identity, such as: informal and transient employment relationships; persistently high levels of unemployment; intra-continental economic migrants; and a rejection of recognition for informally acquired skills. Additional limiting factors are: the low levels of mathematics and science of school-leavers, which restricts access to apprenticeships; and an extremely high youth (defined as under 35 years of age) unemployment level, which encourages young people to sign up for any programme providing a stipend. Economic pressure on youth to take what is available appears to hamper any sense of development of occupational identity. The extent to which policy-makers, State departments, and industry institutions have collectively co-ordinated regulatory frameworks to achieve transformation within the sector is also questionable. Finally, a significant constraint remains inadequate participation by employers in skills development structures.

### **Migration - identity and labelling**

In addition to the conceptualisation of identity developed through social interaction, sociological interpretation has moved from a static or fixed concept, to that of a continually evolving concept, which has significance for migration and transient work circumstances (Huot and Rudman 2010). In this context, the behaviour of the SA migrant roadside work-seekers demonstrates human agency in affecting their surroundings and social circumstances. Having travelled to the country, both legally and illegally, and despite the constraints and restrictions, individual occupational identity is claimed and owned by the display of craft tools, or display of handheld signs by roadside work-seekers (Hammond *et al.*, 2016). As established, in some cases the claim is based upon formal vocational training, such as by the Zimbabwean work-seekers, but in other cases skills have been acquired from observation and experience, and the coaching of fellow workers, or socially responsible and interested employers. How society envisages and labels the work-seeker constitutes an important element. Examples of such societal influences are the descriptions of roadside work-seekers (Hammond *et al.*, 2016), where men with a wide range of construction-related skills are defined in research as: *day labourers* (Blaauw *et al.*, 2016). The terminology explicitly reduces the occupational identity to that of *labourer*, with concomitant reduction in the value of skills that may be rendered, and potential payment for their services. The exclusion is compounded by the interpretation and implementation of the transformation statutes: Broad-based Black

Economic Empowerment (B-BBEE) (RSA 2003), and Employment Equity (EEA) (RSA 1998). Large corporations do not employ non-SA work-seekers, as they do not enhance the B-BBEE scorecard rating. Although informality, migration, and lack of recognition for informally acquired skills are not unique to South Africa, the country is engaged in a transformation strategy of redress.

## **POTENTIAL RESEARCH ON OCCUPATIONAL IDENTITY**

The construction sector project-based organisation of work, with sub-contracting, specialist consulting, and the use of unskilled and migrant labour is well established and unlikely to revert to a traditional industrial era large permanent employment format. Nevertheless, there has been relatively little attention paid to the human resource implications on aspects such as development of occupational identity in multiple transient work relationships. Identity is shown to develop in social interaction, but it is not clear the effect upon craft identity, or professional practitioner identity of such transient relationships. Nor is it clear to what extent unskilled labour, or semi-skilled persons may adopt multiple identity formats, and the potential for multi-skilling.

The concentration of research on project improvement has centred upon technical and contractual aspects, but less upon the human resource management impact of the organisation of work, and the effects of transient relationships. Internationally migration continues to impact the construction sector as large contracts continue to attract migrant workers. As Huot and Rudman (2010) point out, migration adds an additional element to identity, in that the migrant is required to re-establish identity in a new *place* (2010: 71). From a HRM perspective, the question asked is: how does the utilisation of short-term contract labour impact the quality of project performance? How effectively does a team comprising multiple occupational identities collaborate - and to what extent have the participants been trained to recognise and acknowledge multiple perspectives? Finally, occupational identity may be developed and persist independent of a formal employment relationship. Such identity may also continue to develop during a multiplicity of circumstances, which may be employment - permanent, or short term project-based, unpaid personal service, or independent self-contracting. The appropriateness of occupational terminology lies in the inclusion of being occupied with work - as opposed to being employed, and the potential to track the acquisition of skills through a range of transient relationships.

## **CONCLUSIONS**

The questions posed in the introduction of this paper were: has the SA construction sector supported implementation of skills development and acquisition of formal qualifications, thereby supporting development of occupational identity; and what further research on identity may enhance the construction sector performance in this regard? The conclusion reached is firstly, that there has been very limited participation by the SA construction sector in the implementation of skills development and the acquisition of formal qualifications and it has therefore underachieved in its potential to enhance the development of occupational identity. Large companies have participated to the extent that they receive contributions to train staff suitable to their own needs, and the small and micro contractors have largely been excluded - at least from the formal qualifications. Secondly, there has been limited research on identity, and future research should focus on semi-skilled and unskilled labour-specifically occupational identity and its relationship with the implementation of skills development. Such research should be context-specific as the relevance of models created in situations of permanent employment to an industry and sector characterised by transient relationships is uncertain. Potentially fruitful

questions for research are: Have apprenticeship curricula changed to encourage a craft identity applicable to both formal employment, projects, and entrepreneurship? Do professional curricula incorporate management of diverse project participants? Do management practices encourage and utilise the contributions of unskilled and semi-skilled participants, who are not formally qualified, but do possess considerable work experience?

While the focus of this paper has been on the SA experience, patterns of inter-continental migration, for example from Africa and the Middle Eastern countries into Europe, create a renewed relevance to how identity is assigned. Media reporting-without information on the individual histories, skills and knowledge-assign a common identity as migrant. As the construction sector will continue to attract such migrant work-seekers, the SA experience may be instructive, not only in avoiding the dehumanisation of common attributed labels, but also indicate how the sector may benefit from the knowledge and experience of all participants, thereby contributing to more productive projects.

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# A HERMENEUTICAL ANALYSIS OF BRUTALISM, EQUALITY AND DIVERSITY IN INNOVATIVE CONSTRUCTION

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Brutalist construction litter many city centers contributing to what is termed skyline. Several of these constructions have indeed elicited some form of identity crisis for the people on the margins given the cultural dimensions of these ‘brutal’ buildings. The buildings’ coldness and its totalitarian gait confront diverse peoples making the construction problematic, in its presence. The very intense use of concrete suggests wastefulness and arrogance, all of which alienate certain sensibilities. The problem of ‘the other’, that is the minorities within the mainstream culture, is manifest in the intellectual constructs of these buildings since the essential characteristics of the ‘other’ is diversity hence a concern for equality. How may brutalism in construction deal with concerns about diversity and equality, which it creates? Do constructions based on brutalism consider equality and diversity and the sensibilities arising therefrom? To what extent does brutalism affect equality and diversity in cities where ‘brutal’ buildings exist? A philosophical hermeneutical analysis is essential to understand the problems created by these building types. Essentially, hermeneutics brings to the fore those parts of brutalism that alienates and which militates against equality. It is concluded that brutalism in innovative construction should now tend toward deconstruction such that a minimalist façade is created in brutalist buildings which accommodates the diverse nature of today’s cities.

Keywords: brutalism, diversity, equality, hermeneutics, innovation

## INTRODUCTION

The purpose of organized construction is to make appropriate space to create acceptable habitation for humans (Kibert *et al.*, 2002, Schoenauer, 2003). This use of space is filled with sensibilities arising from the various forms of life of both the architect and the society where the constructions are made. The brutalist architecture mirrors one of these sensibilities and how societies using brutalists’ constructions are constructed. This research effort contemplates the implications of brutal architecture and its effects on the individual in particular, the ‘other’ in modern societies. Usually one of the questions asked about modern architecture in relation to communal living is linked to ideas about up-to-date architecture in harmony with its local culture and the concerns about the ethical. We therefore wish to extend this question to individuals’ lived experiences in particular how construction type, in this case brutalism alienates the ‘other’ person within

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a Westernized local culture or where Western culture is mainstream in a diverse community. In this context, our paper dwells on creating a hermeneutical approach to brutalist architecture and establishing a thesis that brutalism alienates the 'other' in Western societies where it is used in buildings. Pertinent questions are asked and answered. Who is the 'other' in society? How do buildings affect the 'other'? What can be done so that buildings are integrative in terms of accommodating all citizens and respect diversity? Attempts are made to answer these questions. Brutalism poses a particular research interest since it represents an example of how architectural ideas seeking to maximize constructed spaces create problems in the spaces leading to alienation and dissonance in social spaces. Therefore the aim of this paper is to show that brutalist architecture is problematic in terms of alienating 'the other' in Western societies. Consequently, it infringes on the idea of diversity/toleration on which many modern societies are based on. It is suggested that minimalism, with a bent toward critical regionalism should serve as opposites of brutalism, and they can indeed be incorporated into a brutalist façade to achieve a more inclusive and regional outlook that will better accommodate 'the other' in Western societies where brutalism holds sway.

### **Brutalism and Construction**

Many interesting ideas have been put forth trying to describe brutalism as a construction type and an architectural philosophy. Brutalism of the nineteen fifties refers in name to (among other things) the *An Brui* propounded by French critic Michel Tapié. Brutalism also claims relations with American Abstract Expressionism and Italian artists, such as Alberto Burri, whose work led to the later *Arte i'oura* (MacArthur 2005). A lot of scholars (for instance Zein 2012, MacArthur 2005, Hauvel 2015 and Stalder (2014) among others) describing brutalism suggest that brutalist buildings are usually known with striking repetitive angular geometries which stands out, and, where intense concrete is used, often revealing the texture of the wooden forms used for the in-situ casting giving vent to a nineteenth century architecture type.

Several buildings have the above characteristics and such characteristic litter city centers worldwide. However, there are several criticisms against brutalist architecture. It is believed by critics (for example Darlrymple (2009) that Brutalism makes the style unfriendly and uncommunicative, instead of being integrating and protective, as its proponents intended. Brutalism also is criticized as disregarding the social, historic, and architectural environment of its surroundings, making the introduction of such structures in existing developed areas appear starkly out of place and alien. Darlrymple (2009) submits that brutalism 'seems designed to overawe, humiliate, and confuse any human being unfortunate enough to try to find his way in it.....a style of soulless architecture'.

This criticism shows the general perception of this architectural type among its critics, which in making use of space, redefines it in an unexpected way. This use of space is unexpected since there are issues that arise in its use. It acquires new meanings for many people it intends to serve. For instance, according to Allison and Smithson (1957), 'Brutalism tries to face up to a mass-production society, and drag a rough poetry out of the confused and powerful forces which are at work. Up to now Brutalism has been discussed stylistically, whereas its essence is ethical in the sense that it tried to solve housing problems. Reidel (2013) says that brutalism is a pursuit of anti-beauty and this makes brutalism controversial.

So there is a barrage of descriptions about brutalism which goes to suggest that brutalism is a minority idea in architecture and construction but which has garnered prominence because of its style and successful presence in many city's skylines. Despite this near

rejection of brutalism by many, brutalism is bouncing back in what is called 'new brutalism'. After the surge of brutalism in the 1950s, the period after the Second World War, and its subsequent subtle disappearance, it is now back to take some prominence once again as architectural scholars discuss it again to see its merits. The merits of brutalism lie in its immense appropriation of space. It creates a lot of opportunity in creating an all-encompassing human dwelling, which helps in solving the problem of accommodation in cities.

If brutalism is seen by its critics as 'soulless' and 'ugly' or is out to 'humiliate', then it can be argued that brutalism create alienation problems. Although non-minority residents may be alienated by brutalism, our interest here is in the minority, 'the other'. The 'other', people of minority cultures whose living experiences and history does not accommodate brutalism since it is not like anything they are used to in their cultures. Brutalism creates 'Otherness' in its distancing from the client community. In other words, the diversity of the communities that normally house brutalist architecture is not taken into cognizance in brutalist designs since the designs are usually done not to appeal to the general sense of community sensibilities but simply to house more people and make use of space.

It also ignores any kind of regional perspective immanent in society and this creates some form of environmental totalitarianism. According to Darlymple (2009) brutalist structures represent an artefact of European philosophical totalitarianism, a spiritual, intellectual, and moral deformity, which is cold-hearted, inhuman, hideous, and monstrous. The rise of the modern movement in architecture, which brutalism is part, was inspired and motivated by the rise of industry and not having people's cultures in mind. Such an alliance between creativity and technology exists in the concurrent rise of the historic avant-garde whose shock techniques stemmed from a celebration-of and reaction-to science and production. Industry became aligned with a new 'concrete' utopia (Banham, 1960: 7), a utopia that alienates since its creations does not center of diversity or cultural sensitivities.

### **The Construction of 'The Other'**

It is imperative that when considering the idea of diversity within a given social space, it is important to note the presence of 'Otherness' in such a social space. This is because each social space has an original culture and then other cultures come in to interact with this 'original culture'. This coming together, if successful creates a lived success of social interaction. There are many ways of articulating the other. One of those that have articulated the idea of 'the other' was the Philosopher Emmanuel Levinas (see Levinas 1981). He perceived 'the other' to be an ethical concept pointing towards humans relations. Levinas' writings on 'the other' show that his concern is in the ethical arena where human's dwell. Thus this is ethical concern is not the ethics philosophers ordinarily understood as system of morals and prescriptions. He points 'the path not to a theory of ethics but of orienting the subject towards acknowledging and responding to the 'ethical', before it is categorized by knowledge'. As Derrida noted, what Levinas proposes to understand is the 'essence of the ethical relation in general (Derrida 1978).

So in constructing the other we look for what the other is in relation to what we are. There is that difference, that differentiation of the self from other people. The other becomes problematic when the 'self' attempts to subsume the other into the 'same', then there is violence done against the other. There is an ethical responsibility not to violate the other by reducing it to one's own system of thought, one's own system of building houses. The violence arises in ignoring this ethical call. Ignoring the call is also to view

the other as an object of knowledge (Sarukkai, 1997). Doing so only eliminates the identity of the other and re-figures it in the eyes of the subject, thereby incorporating the other into the identity of the constituting subject (Powell 1995). The dominant ideas in the world today are Western in character and these are spread through various contacts of the West with other cultures leading to a degree of sameness of cultures in the world (Morgan, 2007, Tallman, 2013). Western culture, often equated with Western civilization refers to those social norms, ethical values, traditional customs, belief systems, political systems, languages and technologies that have direct connection to Europe in terms of origins. This Western oriented culture or way of life has now become the principal force in world civilization influencing other cultures. Other non-western cultures, in particular Africans' or black people, with no dominating powers are aptly 'the other' in the global context. So there is the palpable 'other' the one that is not Western, the one whose ideas of a building is not accommodated by brutalism, which is a Western idea.

The concept of 'the other' is also linked to the idea of nation-state or nationalists' ideas. Nation states necessarily emphasize the binary opposition "we" and "them". These nations were created to cater for a particular people and these people will have to compete for resources to stay alive or disappear. According to (Triandafyllidou 2001), "the notion of the other is inherent in the nationalist doctrine itself. For nationalists (or simply for those individuals who recognizes themselves as members of a national community) the existence of their own nation presupposes the existence of other nations too. Moreover, as history and Gellner (1983) teach us, the course of true nationalism never did run smooth.

Thus, most of the nations' existing today had to fight to secure their survival and to achieve their independence. For most national communities, there have been and there probably still are significant others, other nations and/or states, from which the community tried to liberate and/or differentiate itself". The globalization culture concerns the activities of nations in constant opposition to each other. It is the triumph of the Western States that has enthroned globalization as the currency of engagement for the whole world. This triumph also presupposes a general belief that what is Western is also good and so when brutalism is constructed, it is expected that 'the other' should accept it as a form of acceptable building style. The result, of this type of imposition 'has been the acquisition of an aura of superiority for Western cultures and an imposition of a sense of inferiority upon non-Western ones' (Malik, 2000).

### **Hermeneutics of Brutalism: Mediating Between Brutalism and 'The Other'**

Hermeneutics has become one of the alternative voices of contemporary philosophy used in assessing the human intellectual and social conditions in terms of making what is implicit, explicit. It has long become mainstream in philosophy and has garnered profound influences. Hermeneutics has arisen also as a response to the totalizing and perennial nature of epistemology, which seeks to assert that knowledge and understanding are indeed a-historical and apodictic entities. Given the rise of post modernism and also the consequences of (Gettier 1963) counter examples, hermeneutics has become a viable alternative voice in bypassing the protracted debate about traditional epistemology and Kantian ideas of epistemology which has characterized twentieth century philosophy. Maddox (1985) analyzed hermeneutics to designate a classical discipline that formulated rules for correctly interpreting texts as was found in early forms of biblical studies, philology and jurisprudence.

The philosophical discussion of hermeneutics according to Maddox, deftly began in the nineteenth century, likewise initially engaged in the development of rules for proper

interpretation. As the discussion about hermeneutics developed, its attention shifted to the more basic question of the conditions of the very possibility of understanding. The distinctive characteristic that emerged in this 'hermeneutic' discussion of understanding was a rejection of classical Cartesian and Kantian epistemology. Indeed, hermeneutics has more or less taken the place of epistemology for these philosophers. To be sure, they usually refuse to identify hermeneutics with epistemology, but this is due to the empiricist and reductionist connotations, which they sense in the latter term. There are essentially two problems, which hermeneutic philosophers have with traditional epistemology. First, they disagree with the reduction of the entire cognitive process to a single model drawn basically from the natural sciences - i.e. empirical observation. Second, they reject the a-historical conception of the knower as one who stands outside of that which is known and imposes meaning upon it.

So, critical hermeneutics is used to assess tradition in order to correct it based on human interests, with hindsight on history and horizons (Habermas, 1987). In other words, each human idea, in this case, brutalism, must be examined as a historical process that has arisen to enhance human life. Similarly its contours and dimensions must be examined to show that there are no personal and sectional appeals inherent in it since if there are such flaws, it cannot then serve human interests, as a whole. Where critical hermeneutics is humanistic in essence and seeks to use philosophical arguments to remove merely pragmatic or existential components from ideas and enshrine in the idea progress for humanity if that is possible. The major hermeneutical theorist of this idea was Jurgen Habermas. Habermas (1987) articulated the fact that not all tradition is acceptable or desirable. So the project of hermeneutics is to correct tradition as such, in this case brutalism. Correcting it means inculcating emancipatory cognitive interest in it. In some cases due to historical developments, in some concepts or tradition, it is impossible to have an inter-subjective correction of a concept so the concept is discarded as being sectional or detrimental to sociality. There is an understanding that 'a hermeneutical approach realizes that both the work and its interpreter are products of history and are shaped by a horizon of questions, concepts, assumptions, affects, habits, stories, images, and convictions that only fully enters our conscious awareness through something like a Socratic dialogue with the past'.

To do a hermeneutics of brutalism will require dissecting its ethical and social dimensions to see the reasons behind this type of construction and whether it can serve the overall human interests without alienating citizens and also establish a thoroughgoing interpretive trustworthiness. The interpretation given should be trusted despite oppositions. 'What does it mean to understand or interpret?' is a central hermeneutic question (Palmer 1969, Porter and Robinson 2011, van Manen 2014). How can we interpret brutalism is a question central to this paper. Since various considerations and questions are raised in interpreting, why is it, for example, that different individuals, groups, and historical eras, cultural groups may understand the same book, painting, musical composition, or architectural work differently? Becomes our central question. From a hermeneutical standpoint, the understandings and interpretations of any text are said to be inexhaustible in the sense that how the text is examined and understood by any interpreter can be somewhat or greatly different from what the original creator intended. In addition, these meanings and interpretations can vary because of differences among interpreters or because of historical shifts in psychological, social, and cultural concerns or sensibilities (Gadamer 1989, Palmer 1969). This is true when interpreting building as well. Given the fact that those interpreting buildings can come from diverse backgrounds and horizons, many dimensions of interpretation can be given.

To interpret brutalism and its effects on the other in Western Societies we must consider the situation of the 'other' since this other is the interpreter who looks at brutalism and abhors it. As we have articulated, 'the other' here are Africans and other non-Westerners. Jones (2000) submits that the most helpful hermeneutic focus when dealing with a building type is what he calls the 'ritual-architectural event'. According to him, it is not buildings but the human experience or apprehension of buildings that we must focus on. This means that 'the locus of meaning resides neither in the building itself (a physical object) nor in the mind of the beholder (a human subject) but rather in the negotiation or the interactive relation that subsumes both building and beholder - in the ritual - architectural event in which buildings and human participants alike are involved. Meaning is not a condition or quality of the building, of the thing itself; meaning arises from situations'. Hence it can be argued that what 'the other' sees in a building presupposes a special kind of horizon. One cannot simply claim that an interpretation of brutalism given by 'the other' is not true or disagreeable since the person disagreeing is not in the same 'situation' culturally with the other. Rather attention should focus on founding rules of interpretation within the others' horizon. This is why Madison (1988) asked: "how is one to decide which of two or more conflicting interpretations is the better, and to do so impartially, non- arbitrarily, if there are no general, recognized criteria one can appeal to?"

To answer this question, we note that to interpret from the stand point of difference there must be comprehensiveness, which must take into cognizance of history, lived experiences, and culture (Wachterhauser 1996). It is when looking at these from the point of view of 'the other' that we know if the interpretation given is tenable. 'The other' in this context being Africans and non-Westerner in looking at brutalism are indeed seeing an alien structure that has not appeared in the forms of life. The African's lived experiences must include slavery, colonialism, and poverty (Serequeberhan, 1994). With this in mind, we can indeed submit that when the other apprehends brutalism, it alienates the other when the other is situated in the above articulated horizons and the other views it as harmful and unacceptable. According to Baumbergera (2015) 'We criticize other works for the harm they cause to the environment, for their negative impact on the health or well-being of human beings, for the morally reprehensible attitudes they convey or the morally despicable functions they serve. Such assessments of architectural works are of an ethical nature, or at least possess an ethical dimension'.

Following Baumbergera (2015), a hermeneutics of brutalism, that is making what is implicit, explicit in brutalism reveals that brutalism, as a construction type, with its robust presence, alienates the persons whose cultures do not view buildings as such. Brutalist constructions do not even consider issues of diversity and alienation. The buildings, based on brutalist perspective, come into existence to appropriate space in a more encompassing manner and to create a presence different from what is already in place. Indeed, 'brutalism is criticized as disregarding the social, historic, and architectural environment of its surroundings, making the introduction of such structures in existing developed areas appear starkly out of place and alien' (Baumbergera 2015). This is because 'brutalist buildings are formed from concrete. Instead, a building may achieve its Brutalist quality through a rough, blocky appearance, and the expression of its structural materials, forms, and (in some cases) services on its exterior' (Baumbergera 2015). These characteristics do not have any moral dimensions to them. The buildings so constructed do not seek to make any obvious moral statement but are making some aesthetic and useful statements. They are also designed to intimidate and dominate. Indeed proponents of brutalism emphasize this dimension of brutalism. According to

(Banham 1955), 'Brutalist would probably reject most of these buildings, from the canon, and so we must, for all of these structures exhibit an excess of suaviter in modo, even if there is plenty of fortiter in re about them. In the last resort what characterizes the New Brutalism in architecture is precisely its brutality, its je-m' enfoutisme, its bloody-mindedness'.

When a building is constructed in a city, the builders make certain moral statements without necessarily knowing it. In other words, the builders make moral statements. For instance, the brutalist architects are seeking to build in a robust manner to the extent that a look at their building creates the impression of domination, a conquering of space. Usually Brutalist buildings are massive in their gait and their concrete façade sends out messages of being an accomplishment of size and usefulness. Nonetheless they fail to ask important questions about what the buildings can do to the person that does not have any connection to brutalist architecture. Brutalist architecture arises from the Western tradition and so can indeed be accepted within the Western cultural milieu. Yet, when someone, not psychologically and historically immersed in Western culture views a building constructed in brutalist style, a certain dissonance occurs. This dissonance can be in terms of lack of understanding about the nature, purpose and value of the building or a sensing of detachment from mainstream culture, which is Western. Most 'other' cultures have their own building styles that serve their own purposes within restricted cultural conditions. On coming in contact with Western styles, in particular, brutalism, a conflict ensues. So, brutalist buildings can make moral statements in as much as it causes some mental harm or disorientation in another person, of a non- mainstream culture.

To this extent, a hermeneutical analysis must take into cognizance the moral dimensions of buildings in a brutalist style since issues of accommodating diversity and equality are essentially moral. Baumbergera (2015) analyzed certain objections that can be raised in evaluating the moral dimensions of a building with a hermeneutical circle. According to Baumbergera (2015), while relating the objections to moral assessment of building said that the first objection to morally assessing buildings, 'we morally assess people (their actions, motives, intentions and characters), but it makes no sense to morally evaluate artefacts such as architectural works. Moral evaluations of such works, so the objection goes, are based on a category mistake since moral criticism assumes moral responsibility and thus moral agency, but architectural works have no mental states and can thus not be moral agents'. Baumbergera (2015) did not stop there. He also showcases the futility of thinking in this direction but insisted that 'we morally evaluate architectural works with respect to their impact on individuals and society. A building can, for instance, be ethically criticized because it negatively influences the health, well-being, or behaviour of individuals, and because of its negative social ramifications'.

If it can be said that brutalism as a construction type 'negatively influences the health, well-being or behavior of individuals', then we can infer that when there is a negative influence, the idea of diversity is infringed upon by extension there is really no equal existences in place. If there is an immoral dimension concerning a brutalist construction, it means that someone suffers for it in such a way that it can be said that the brutalist edifice has no respect for individuals and does not care about diversity or equality. Wellner (2000) conceptualized diversity 'as representing a multitude of individual differences and similarities that exist among people. Diversity can encompass many different human characteristics such as race, age, creed, national origin, religion, ethnicity, sexual orientation'. But when there is a superimposition of an idea that does not respect this diversity, that idea is condemned. Brutalists buildings, in its dominating type presence send out the message that 'I am above all else'. It also shows an arrogant

posture that seems to minimize all other forms of life around it and this does not augur well with individuals with ‘other’ sensibilities.

Martin Heidegger stated that dwellings are a form of being-in-the-world. In other words, the buildings we dwell in constitute a form of living experience, which is at the core of our very existence. The building is linked to us fundamentally. In Heidegger (1971) essay “Building Dwelling Thinking”, he makes it rather clear that ‘dwelling’ is not merely conceived of as one’s having or possessing an abode or roof over one’s head: it rather designates “the main feature of human existence.” On the one hand, we are to think of human existence as arising from dwelling’. If we follow Heidegger, it means that when a building type is not acceptable to some people, that building deconstructs human thinking about dwellings and creates a huge problem, the problem of alienation.

### **Towards A Critical Deconstruction of Brutalism, Towards Minimalism**

This work is an ongoing discourse, which is geared towards looking at minimalism as a viable alternative to brutalism. Minimalism, according to (Davis, 2015) is a movement that seeks purity as an expression of aesthetic beauty along with practicality. It reduces form, material, connection, texture and colour to their most basic levels. "Less is more" encapsulates the primary focus of Minimalism, which denies decorum and tradition in search for the simplest way to achieve a structure. Simplicity, austerity, pure craftsmanship unhindered by the guise of extraneous moulding to hide flaws and/or joints, essential material usage and spatial composition devoid of artificial superficiality is the core of minimalism.

The bent of this contemplated minimalism is like Critical Regionalism, a concept in architectural design which is known as ‘a synthesis of universal, "modern" elements and individualistic elements derived from local cultures. Critical Regionalist alternatives are more than a postmodern mix of ethno styles but integrate conceptual qualities like local light, perspective, and tectonic quality into a modern architectural framework (Botz-Bornstein 2010). This kind of regionalism can be incorporated into designs derived from brutalism and minimalism to the extent that the location of a building can reflect, as much as possible the cultures where the building stands or intends to stand without ‘othering’ as such. In other words, a creation of a collage of ideas in building to better represent diversity and inclusivity. There is an understanding that ‘othering’ is a relational idea in society and cannot be eliminated completely as long as social construction of self is possible. However, there are principles that ought to be applied in designing buildings that cater for the needs of diverse people.

This involves involving people. Rittel (1972) had already suggested that users should be party to the process as it is the knowledge held by a wide range of people affected by a problem, which should be utilized in seeking solutions to that problem. He claimed ‘expertise does not reside solely in the professional, but in all those whose interests are affected by a design or planning problem’ (Rittel 1972). Rittel saw gaps in the knowledge and expertise of the professionals, i.e. a degree of ignorance on their part, which can only be filled by other people, and succinctly emphasized this point by introducing the concept of a symmetry of ignorance. It is ignorance therefore to go ahead and ignore diversity in designs.

### **CONCLUSION**

The submission of this paper is that brutalism architecture can be jettisoned per se, although not completely. Its strengths, in the skilful appropriation of space, can be harnessed and used to form a kind of minimalist brutalism augmented by regionalism,

such that the local content, as diverse as it is, enters into the façade of brutal architecture. Brutalism as it is today, squares with traditional epistemology to the extent that it suggests a Universalist, a-historical gait, in which everyone ought to accept despite our different horizons. It is appropriating a reductionist cognitive process and suggests that an A-historical conception of the knower as one who stands outside of that which is known and imposes meaning upon it is possible. This indeed needs to be questioned in an era of diversity of conceptual schemes and forms of life. This is why a hermeneutics analysis of brutalism done here is inevitable and the analysis done in this paper, suggest that a minimalist architecture, augmented with critical regionalism can be incorporated into brutalism to accommodate diverse horizons.

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# **INSTITUTIONS AND INSTITUTIONAL WORK**

# THE ROLE OF OBJECTS FOR INSTITUTIONAL WORK IN ENERGY EFFICIENT RENOVATION

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Energy efficient renovation measures for public buildings implicates organizational change. Involved in the processes of change are both humans and objects. Studies on institutional work has hitherto mainly focused on human actors as agents for change, thus taken less consideration in objects' role. In this paper, a sociomateriality lens is applied with the aim to increase the understandings of objects' role for institutional work in energy efficient renovation. The paper is conceptual and data is derived from three empirical case studies encompassing research on organizational change and energy efficient renovation. The cases are used as illustrations on how different types of objects relate to different forms of institutional work. It is concluded that objects, together with the roles and attributes they are given, have effect on the changing organizational practices related to energy efficient renovation and that objects are part of institutional work.

Keywords: energy efficiency, renovation, objects, institutional work, Sociomateriality

## INTRODUCTION

In this paper, the role of non-human actors (artefacts, material objects, hereafter labelled 'objects'), for motivating and shaping institutional work (IW) is discussed. The empirical context is the construction industry, a highly complex and institutionalized industry (Kadefors 1995), facing problems of disrupting existing institutions as well as creating new ones (Bresnen 2013). The paper is foremost conceptual and the discussion is based on data derived from three previous case studies encompassing research on processes of organizational change, with a specific focus on energy efficient renovation of public buildings. In Sweden, many public buildings, both premises (e.g. schools and hospitals) and housing (apartments and row houses), were built during the millennium program, a public housing programme implemented between the years 1965-1974. Many of these buildings are now in an urgent need of renovation as they have reached their technical lifespan. Responsible for this renovation are public construction clients. While renovating, public construction clients need to consider energy efficiency goals established globally as well as nationally. The building sector in Sweden is, compared to 1995 levels, aiming at a 20% reduction in energy use by 2020 (Thollander 2013) and the biggest technical potential to achieve this goal is in adopting energy efficient measures in existing buildings, especially those from the millennium program (Energimyndigheten 2013). The three case studies will be used as illustrations of how energy efficiency issues

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are enacted and unfolded in practice, with a special focus on the objects' role for change processes and IW.

Research has suggested that energy efficient building faces several challenges in disrupting old and creating new institutions (Andrews and Johnson 2016) in which institutions refers to rules, norms, beliefs and logics embedded in an organization and its context. In order to increase the understandings of how institutions are disrupted and/or created (or maintained) researchers need to pay closer attention to practices and to the IW performed by the actors involved (Gluch and Bosch-Sijtsema 2016). In processes of energy efficient renovation, this means trying to understand how IW is carried out and also by which actors. In response to the latter, recent research argues that not only humans, but also objects are actively part of energy efficient renovation processes (see for example Thoresson 2015; Palm and Reindl 2016; Buser and Carlsson 2016). In a study of a Swedish public housing company's energy efficient renovation process, Palm and Reindl (2016) found, by applying a practice theory framework, that existing technical infrastructure largely determined what issues came up for discussion at meetings. Thus, rather than discussing new technology and innovative solutions most meetings were spent discussing technology used in the past. Suggested measures were also based on an idea that energy efficiency is unproblematic, and could be handled in the same way regardless of context and situation. In another study, Thoresson (2015) found, by using an Actor Network Theory approach, that the way energy issues were enacted in practice was not solely determined by the (public) housing organization involved in the renovation project, but also included several intertwined actors and processes such as; urban planning, national housing policies and old technology. Old technology was, for example, not seen as "neutral" technology, rather it took an active part in the energy work (Thoresson 2015).

In this paper, a practice based view is adopted, seeing organizing as something that is becoming through everyday practices (Orlikowski 2007). A sociomateriality lens (Orlikowski 2007) is applied in order to increase the understandings of objects' role for institutional work (Lawrence and Suddaby 2006) in energy efficient renovation. Both theoretical approaches have been used to a low extent in construction management research (Bresnen 2017; Styhre 2017). In cross-fertilizing these two practice-oriented lenses, we acknowledge that objects cannot operate alone; neither can influence be attributed to agency of humans alone either. In line with work by Hampel *et al.*, (2017), Monteiro and Nicolini (2015) and Raviola and Norbäck (2013), this paper argues that artefacts/objects can be seen as complex assemblages of humans and material elements that perform IW when certain alignments are put in place.

We postulate that the material contains agency; and that both humans and objects have the capacity to act (cf. Styhre 2017). Combining a sociomateriality lens with the IW framework, raises a number of questions, such as: Do objects perform IW in processes of developing new practices? Both tangible and non-tangible objects have been found to occur in IW in other organizational settings (cf. Raviola and Norbäck 2013), is that also the case for energy efficient renovation? Could one object alone account for different forms of IW? More, it has been argued that different dimension of agency, according to actions' direction in time (past, present and future) might be associated with different forms of IW (Battilana and D'Aunno 2010). Could it also be that different forms of objects according to their position in time, i.e. past, present and future, are associated with different forms of IW?

Addressing the above questions, a sociomateriality lens is applied with the aim to increase the understanding of objects role for institutional work in construction, and specifically for energy efficient renovation of public buildings.

## **THEORETICAL FRAMEWORK**

As scholars of institutionalism begin to draw on practice theories to inform their theorizing on institutional change, thus focusing on the micro-dynamics of institutional change as performed by people's actions (Feldman and Orlikowski 2011), this has given origin to an interest in institutional work of actors (Lawrence and Suddaby, 2006). Adopting a practice perspective in research recognizes that it is in micro level practices that field-level logics are enacted (Smets *et al.*, 2012), a view which is shared by scholars studying IW. Jarzabkowski *et al.*, (2009: 289) state: "a practice approach is apposite to the study of IW because it focuses on the actions and interactions of actors in creating, maintaining and disrupting institutions. It also puts the level of analysis onto the everyday work of actors and how this work is shaped by institutions, even as it reproduces or modifies those institutions". The concept of IW examines and describes how institutions are created, maintained, and disrupted through purposive actions of multiple actors (Lawrence and Suddaby 2006). In addition to a practice-based approach (Jarzabkowski *et al.*, 2009), IW stems from a research tradition that has agency as its focal point of interest (Hampel *et al.*, 2017). Agency within the IW is viewed as embedded, meaning that institutions both shape, give meaning and hold together material and symbolic structures (Battilana and D'Aunno 2010).

Scholars studying IW have hitherto foremost focused on human actors as agents for change (Hampel *et al.*, 2017), thus to a large extent neglected the role played by the material (Monteiro and Nicolini 2015). Up to today, the role of objects in IW has been explored only in a handful of studies (Hampel *et al.*, 2017). Raviola and Norbäck (2013), for example, studied how an old technology became the object of reference in problematizing a current situation, functioning as a "lawbook" for new actions. This process, in which actors consult and interpret the "law book" was understood by the authors as institutional work, in which meaning and technology was intertwined. In another study; awards (prizes) were viewed as complex assemblages of humans and material elements. These assemblages performed IW, such as mimicry, theorizing and educating, when certain alignments were put in place (Monteiro and Nicolini 2015). The study highlighted how IW depends on the joint work of human and material entities. More, in a study on housing, the roles of physical place (the interaction of locations, material forms, meanings and values) for IW was investigated (Lawrence and Dover 2015).

Firstly, physical place established and maintained boundaries around institutions, and, secondly, it provided an interpretive lens through which people could understand the institutions that actors are working to affect. Thirdly, physical place complicated IW through its "concreteness", meaning its materiality, its association with day-to-day routines, and its geographical location. Thus, a few previous studies have shown that not only humans, but also objects/materials (technology, awards and places) need to be accounted for when investigating IW and changing practices. It has been suggested that the study of the material offers promise for a deeper and wider understanding of IW (Hampel *et al.*, 2017). However, to move forward it is also suggested to combine IW with perspectives from social science, for example, sociomateriality.

Generally, in recent organizational research, the material has been attributed a more active role in understanding interaction, practice, and the process of organizing (Leonardi

2013). Here has sociomateriality been suggested as a viable theoretical lens to understand the material in social practices. Applying the sociomateriality lens means seeing practice as a sociomaterial accomplishment, organizing occurs in practice and practice is neither social nor material; it is both (Leonardi 2013). The material, being all things not human, such as a landscape, material of buildings, rain and software (Carlile *et al.*, 2013), and the social are so fundamentally related that it makes little or no sense to talk about one without talk about the other "... there is no social that is not also material, and no material that is not also social" (Orlikowski 2007: 1437), hence, there is no social action that does not entail material means (Jones 2014).

Sociomateriality is a research stream (Jones 2013) that follow the materiality turn in organizational studies. Being a stream of research, the umbrella term sociomateriality offers different possibilities of how to study the relationship between the "social" and the "material" and researchers have developed an array of perspective that theorize about the relationship between the symbolic and the material world (Jones 2013; Putnam 2015). In this paper, the research interest lies in the study of the "constitutive entanglement of the social and the material in everyday organizational life" (Orlikowski 2007: 1438). The material and the social are viewed as inseparable in practice, however, analytically separable (Jones 2013). Seen from this view, the key is not just to understand how different entities shape each other, but also what the consequences/implications for practice are. Through the sociomateriality lens, relations and boundaries between the social and the material are not given, they are enacted (Jones, 2014), the material is seen as relational; it takes part in establishing and maintaining social relationships (Carlile *et al.*, 2013). With the example of discursive practices, Orlikowski and Scott (2015) underline that in order to exist, discourse must be materialized in some form, thus the discursive do not affect the material, rather it becomes materialized. Discourse lacks an independent, self-contained existence apart from the material. Materiality and discourse are constituted through each other (Orlikowski *et al.*, 2015: 699).

As both the sociomateriality lens and the IW framework share a common ontological base, i.e. they are theoretical grounded in practice theory, it is suggested that these two concepts can be cross-fertilized. We propose that not only will the study of the material help expand our knowledge on IW, but the IW framework can also help shed light on actions and outcomes that are linked to materialized processes.

## RESEARCH APPROACH AND METHOD

This paper is informed by three empirical cases concerning energy efficient renovation of public buildings which are used as illustrative stories of how objects play an active part in IW related to processes of change in construction. All three cases concern a shared challenge on how to renovate rundown public buildings in a holistic and long-term energy efficient way. For the three case organizations, this involved extensive work and increased collaboration with a variety of stakeholders in order to develop long-term strategies, imposing changed management processes and maintenance routines.

Case one concerns a Swedish public construction client organization that sought to meet energy efficiency targets by the means of a development project. Empirical data analysed for the purpose of this paper was continuously collected by the authors in 2016. Data included in the analysis of this paper is based on meeting observations. Case two builds on secondary data presented in a doctoral monograph thesis (Thoresson 2015). The thesis provides a detailed narrative regarding how energy issues were enacted in practice in a large renovation project of a block of flats owned by a public housing company. Data was collected through interviews, observations of meetings and from organizational

documents. To get a deeper insight into the role of objects in this project, one of the authors conducted a one-hour interview with Thoresson. In case three, the study object was a strategic project done in response to a political directive to significantly cut the energy use in hospital buildings managed and operated by a public construction client organisation. Several of these hospitals were built between the years 1950-1975, and the buildings were in need of rather immediate renovation. One of the authors was involved in the collection of data in 2011, following the strategy project in real time. For the purpose of this paper transcripts of nine working meetings in a strategic work group were analysed. Informed by a narrative approach, all three case studies have used ethnographically informed methods, enabling the understanding of how institutions are enacted at micro-levels.

In order to contribute to further development of the IW framework, focus was on the IW processes, rather than institutional outcomes (Lawrence *et al.*, 2013). The sociomateriality lens were used in combined with the theoretical construct of IW when analysing data from the three studied cases, according to the procedure of thematic theoretical coding (Braun and Clarke 2006). Following a call for research that focus on multiple types of materiality (Putnam 2015), a specific type of object was not targeted, rather all kinds of possible objects suggested to be involved in the processes of energy efficient renovation were searched for. This included both tangible and non-tangible objects, as well as objects that were present, objects that were no longer present (past objects) and future objects. Also, accounted for in the analysis was the interaction between the objects and the social world and the consequences from this “entanglement”, i.e. what situated outcomes and what type of IW was enacted?

## CASE ANALYSIS

### Case One - Energy Efficiency and Renovation of Pre-Schools

In case one, various artefacts emerged as influential agents, playing a central role in the process of the development of new practices. The following are two examples of objects that were part of the process of creating new practices i.e. support change; the run-down building stock and temporary rented pavilions. Both of these (tangible) objects dominated the discourse during meetings and were used by the participants as key arguments for the change. As one project-member describes the building stock during an interview: “the [current] large renovation-bulge is knocking on our door, and they are saying: you have to take care of all of us.” Another member referred to the problem with a run-down building stock in terms of “a massive explosive mountain... [and it is] we cannot shove this mountain in front of us any longer” and “[now] comes hell”. Similarly, the rented pavilions (existing and presumed-planned) became a shared object that helped unifying the project team in their change mission. “The alternative that we must avoid, is pavilions...” “We need to present an alternative to pavilions that the politicians can’t reject”. Further, the need for a new IT-based system, that should be “better” than previous ones, be able to handle “all the data”, and possible to be used by various stakeholders, in different organizations, was mentioned as a necessity for the new way of working to be implemented. This kind of IT-system is not yet on the market but the plan still was said to be dependent on it and a large amount of time during meetings was spent discussing it. Thus, in this case various objects served as reference for shaping new practices. Both tangible objects (such as the houses) and non-tangible ones (such as a wanted IT-system) could be identified. Further, the run-down building stock is an object that is present today, whereas the pavilions were discussed as something belonging to the past and/or something that must be avoided in the future and the IT-system is wanted for

the future. Thus, the materials objects can firstly, be divided into three categories depending on their place in time (past, present or future) and secondly, in two categories depending on they were tangible or non-tangible.

### **Case Two - Energy Efficient Renovation of a Block of Flats**

From this case, and as examples of objects that were part of processes of IW, an (old-existing) system for district heating and solar-panels (not yet existing) are chosen as illustrative examples. In the end, solar-panels were ruled out to the advantage of keeping the current district heating system. Two organizations were working together with the issue of energy-efficient solutions for the renovated houses: the municipal energy corporation and the public housing company. These two organizations had different ideas on what energy solution to choose, the municipal energy corporation argued for keeping the existing district heating system in its current form, whereas the public housing company wanted to change the current solutions in several ways, for example by installing solar panels on the houses. The (future) solar panels were given many positive attributes by the municipal housing company; they were sought to provide several parts of the city with electricity, and as such would give the neighbourhood in which they were to be placed good publicity and they were argued to contribute to a decentralised, sustainable and small-scale infrastructure system for energy supply.

The municipal energy corporation on the other hand argued that in the future, the city would be in need of (much) more energy than today, and that solar panels are to unreliable. According to them, the existing district heating system should be kept. By them, the district heating system was labelled as a complex and complicated system, difficult for anyone outside their own organization to understand, and as such no other organizations than the municipal energy corporation themselves could be able to work with it or to truly understand it. They argued that since the public housing company did not have all information needed they could not come up with suggestions for altering the system. Further, the district heating system was given the role as facilitator, with the possibility to create economic growth and an increase in population in the city and thus from this view it was given a large impact on the whole city's future development. In addition to these arguments and the attributes given to the system by the municipal energy corporation, material aspects of the system itself could also be said to contribute to it being kept. The district heating system was imbedded in the infrastructure of the city, for example it was intertwined with sidewalks and streets.

### **Case three - energy efficient renovation of hospital buildings**

In case three, various objects served as non-human agents in playing a central role for the development of an action plan for improved energy efficiency. An example of object that were part of this process was an object named 'the blue ball'. 'The blue ball' was a construct that firstly illustrated additional investment costs needed to cut total energy use to half of today's use, i.e. costs added to the funding already allocated for renovation. The colour blue came from an initial cost estimate graph in which this cost element coincidentally was blue. Over time, the non-tangible 'blue ball' object came to take an all-compassing discursive role in the development process. It was referred to as something 'discovered' in that it was an eye-opener for the strategic work group helping them to shift focus from costs to funding: "Discovering the 'blue ball' helped us to establish that this might very well be about money, but not as (only) costs." It became the focus of attention as it, often without deeper explanations, came to represent funding as a multi-dimensional problem that needed to be mastered; "The 'blue ball' is the hindrance that need to be managed." This could concern questioning others' engagement; "(The

question is) if they are committed... to find the 'blue ball'." To distinct the new way of thinking against the usual way: "The 'blue ball' is outside the box." Or just to emphasise the financial dimension of the problem: "Well it's (simply) the 'blue ball'." In this case 'the blue ball' object and construct served as reference for proposing new investment practices as well as introducing a for the organization new way of thinking. The object is both tangible, in that it is displayed in all types of power-point presentations used both within the strategic work group and outside in them proposing a new way of approaching renovation of the hospital buildings. However, being a loosely defined construct, used to serve a variety of self-centred purposes in various types of conversations, it is also non-tangible. Further, 'the blue ball' is illustrating a wanted future state but also represents the past in terms of what was included in the construct at the time it was 'discovered'.

## DISCUSSION AND IMPLICATIONS

Analysing the empirical cases, we saw, similar to the work by Raviola and Norbäck (2013) that various non-human objects served as reference for shaping new, destroying old and maintaining current practices. This included both tangible, such as the pavilions, and non-tangible objects, such as the IT-system and objects with different positions in time. It was also shown that one object can be both tangible and non-tangible, for example with "the blue ball" in case three. Findings from the cases also suggest that there was a difference between how past, present and future objects were used when creating legitimacy for a new order, and thus what role they had in shaping IW. In case one, past objects were used as examples of how badly old practices had worked and were used to "attack" the taken-for-granted of an old institution (disrupting institutions). In this case the actors were actively trying to establish new practices, "selling" their ideas, whereas in the study by Raviola and Norbäck (2014), it appears as the actors were forced to respond and adapt to new technology and ways of working. Future objects were mainly used in order to create new practices and possibly new institutions, as for example the IT system in case one, the solar panels in case two and the blue ball in case three. Their existence was often depending on trust and collaboration between different stakeholders and they were part of creating institutions. In case two an existing (present) object, the district heating system, were found to be part of maintaining an institution.

We noted that emotions, especially fear, were present when both past and future objects were involved in IW processes. Both new and old objects were seen as "dangerous" and threatening to current ways of living and for the future development of cities. When new practices regarding energy efficient renovation were introduced, this created a feeling of "threat", i.e. these new practices threatened not just processes and work roles (cf. Gluch and Bosch-Sijtsema 2016) but also the existence of present material entities (objects), that brings with them meaning, values and work opportunities. Being not only threatening, future objects could also be seen as a sort of resolution of this fear. They were associated with hope, collaboration between stakeholders, "rational choices" and more thorough planning.

We could see that the same object was involved in different types of IW depending on the context in which it was embedded (cf. Monteiro and Nicolini 2015). The solar panels were used when the public housing company tried to establish new practices, i.e. created institutions by connecting the panels to the government ideals on small scale energy supply and by promoting increased interest for the neighbourhood in which they were to be placed. They were also used by another actor in relation to the district heating system as a bad and risky choice, thus they took part in maintaining an old institution. We could also see that one object alone (the district heating system) was associated with different

types of agency, directed towards the past, present and future, in the IW of maintaining institutionalized practices.

By arguing that new technology was too unreliable the old, legitimate institutional practice (the district heating system) was chosen at the advantaged over a new one (agency directed towards the past). Further, by “black-boxing” the current system, i.e. making it impossible for people outside a specific organization to understand it, and by the system’s embeddedness in the current infrastructure, its current features were associated with present agency. The district heating system was, as an example, promoted on the basis of its usefulness in the future, as in the future development of an entire city, i.e. future oriented projective agency. Thus, like human actors have been found to draw on all three institutional work processes (creation, maintenance, and disruption) to achieve a desired outcome (Jarzabkowski *et al.*, 2009) we found that that same can be true for one object alone in terms of agency. However, in this study we did not find that a single object was involved in all three institutional work processes simultaneously, i.e. both creating, maintaining and disrupting institutions. To get a more comprehensive view more empirical studies are needed.

Exploring the relationship between the social and the material has implications for both theory and management practice. For theory building the paper adds to previous work by the authors (Gluch and Svensson 2016), by furthering layers to a conceptual model envisioning agencies of various actors in processes of change. In this previous research, a process through which new practices were developed and tested was followed in real time. It was found, by applying a distributed view of agency, that candidates for institutions, so called proto-institutions, were created and old institutions disrupted, as key actors, both human and non-human, sought to establish legitimacy for the new way of working and objects served as agents for change in the process of creating and disrupting institutions.

The studies together provide a furthered layered understanding on institutional work related to changes in the building industry driven by a sustainability agenda (Gluch and Bosch-Sijtsema 2016, Bresnen 2013, 2017). For practice the paper raises issues regarding manager’s view on objects. Managers often “treat objects, for example technology, as having specific properties or clear-cut boundaries that determine organizational behaviours” (Putnam 2015). This tells us that technology often tend to become “responsible” for a certain outcome, rather than the material and the social together. Instead, it is suggested that “non-human (material) agencies are mutually responding counterparts of a distributed agency that produces collective actions, by mobilizing a large number of (human and non-human) entities taking part in this action” (Raviola and Norbäck 2013: 1175).

In conclusion, we argue that objects do pursue agency in processes of energy efficient renovation, that agency is thus distributed in a network of human and non-human entities that act (Raviola and Norbäck 2013) and that the IW performed by objects depends on the joint work of humans and material entities (Monteiro and Nicolini 2014). In this arrangement, various objects propose solutions that an individual in isolation would not have thought about or had access to which brings us to the ideas of sociomateriality, recognizing that the human and the non-human is entangled in practice. Thus, objects themselves, together with the roles and attributes they have been given have effect on organizational practices related to energy efficient renovation.

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# TRIBES, WARLORDS AND TRANSFORMERS: AN INSTITUTIONAL LOGICS MODEL OF THE ARCHITECTURAL PROFESSION

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Architecture has often been described as profession divided by a foundational logic of aesthetics versus one of production: Creatives versus Suits. The business plan is one way that architects have sought to reconcile and mediate between the demands of design creativity and profit. In the theory of practice, the business plan integrates and balances issues of strategy, available resources and operational contingencies. Through a survey the business planning practices in different sized Australian architectural firms is established. The institutional logics evident in business planning indicates the way in which architects structure their firms and how they collectively resolve conflicts between design thinking and the prosaicism of efficiency. A survivalist model of institutional logics is proposed for the architectural profession that accounts for a range of reasoning schemas. This logics of market survival is evident as a result of neo-liberal policies, service disaggregation and fee for service competition. The model suggests that the foundational logic of the creative-business divide disguises the survivalist logics of the architectural profession and hampers the architectural professions ability to foster innovation.

Keywords: architect, institutional logic, architectural design, professionalism

## INTRODUCTION

This paper proposes an institutional logics framework that accounts for recent shifts in the Australian architectural profession. Business planning practices are used in this research as a point of analysis to broadly examine the logics of architects in Australia. Business plans provide a window on the socially constructed material practices, assumptions and values and beliefs that shape the cognition and behaviour of architectural firms. Institutional logics are defined as “as socially constructed sets of material practices, assumptions, values, and beliefs that shape cognition and behaviour” (Thornton, Ocasio and Lansbury 2012). Basharov and Smith (2014) argue these logics provide a legible set of “organising principles” for specific arenas of social life. The institutional logics framework proposed here is developed through questioning the pre-existing logic types that see a binary divide between the architect as artist, or “Creative”, and the architect as business person, or “Suit”. Questioning this binary, through a survey, aligned with an investigation of business planning practices, generates an institutional logics framework that better reflects broader developments in the architectural profession in Australia since

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the 1980s. This emergent framework indicates how the institutional logics approach might be further developed in studies focused on architects in the future.

### **Shifting Institutional Logics**

Debates around material practices, values and shifting institutional logics and architects are evident in a special issue of *Building Research & Information* devoted to “New Professionalism” (BRI 2013: 40:1). Here Duffy and Rabeneck argue that the rise of neoliberalism since the 1970s has eroded trust in architects as a profession; engendering a scepticism, both within the construction industry and more broadly, of the architect’s specialist knowledge. They argue architectural knowledge is increasingly being created by competitors and architects may no longer have the institutional structures to resist this. They sound the warning on the basis of: commoditisation of workflows through technology, knowledge concentration in large multidisciplinary firms and the capture of intellectual capital, once the province of architects by contractors, subcontractors, product suppliers and IT providers along supply chains (Duffy and Rabeneck, 2013).

In the same issue of BRI, Bordass and Leaman (2013) contend that the built environment professions, such as architects, have a key role to play in the Anthropocene and are vital to gaining sustainability outcomes. They argue for a “middle role” for architects between supply chains and specialist knowledge mega-firms. To adopt this role, they assert that professionals with disciplinary expertise must adapt their institutions, in order to overcome what they see as two dangers arising from the ongoing commodification of expert knowledge. The first is, a managerialism that constrains freedom, and the second, the contexts that privilege regulations and bureaucracy. In response and concurring, Bresnan (2013) noted that architects are constrained from undertaken collaborative actions because of current divisions of labour. Arguing that, if architects are to be orientated towards sustainability then studies that recognise, “the complex institutional and organizational terrain within which established and emergent professional groups act and interact”, are needed (Bresnan 2013).

Alongside market competition and the need to address sustainability another shift in institutional logics relates to the institutional logics of gender. This is evident in an Australian ARC grant entitled *Equity and Diversity in the Australian Architecture Profession: Women, Work, and Leadership*. The grant researchers found that as of January 2013 there were 11,743 members of the Australian Institute of Architects (AIA) yet only 28 % of these people were woman. Many of these woman (65%) were in the AIA membership categories made available for people who are not registered architects (affiliate, graduate and student). Whilst woman have been graduating from the schools of architecture in Australia in roughly equal numbers since the 1980s, only 14% of female architects identify as either Sole Practitioners, Partners and Directors/Principals of architectural practices. These researchers have now formed an incorporated association called Parlour. Indicative of the crisis in the Australian profession Parlour has produced a series of accessible guides on equitable practice. Pointing to a shifting logics in the profession these guides include resource material and narratives on pay equity, career progression, work-life balance, overtime issue, leadership and negotiation.

### **Pre-existing Logics**

The shifting logics of commodification, the need for innovation around sustainability and gender balance in the profession are in contrast to the entrenched logics that characterise architects. One of the influential strategic frameworks specifically applied to architects is Weld Coxe’s super-positioning framework (Coxe, et al., 1987). Coxe’s work indicates

the institutional logics that underpin the professional services firm in the 1980s and 90s. Coxe categorised architectural firms along two different strategic dimensions. The first dimension is a binary. This dimension is based on participation: “Professional” passion or “Business” drive. In other words, is the firm a Practice-based business where the firm’s owners or employees get value, personal or otherwise, from doing the work? Or, is it a Business-based practice where the impetus is to focus on earnings and making a profit. The second Coxe dimension is threefold and based on how the work is approached. This framework distinguishes three types of activities: Delivery, Service and Idea. Delivery is getting the job done, Service is focus on the relationships and Idea, is of course, a focus on design attributes of the project. Over time firms migrate from being Practice-based and Idea focused to being Business-based practices with a focus on either delivery or service. (Coxe, 1987).

In Australia, another area where an entrenched and pre-existing institutional logics exists is in relation to accreditation standards which have since 1990 been administered by the Architects Accreditation Council of Australia (AACA). The National Standard of Competency for Architects (NSCA) establishes standards for architectural education and assessment of professional competency. The standards are described as the “activities involved in the practice of architecture.” The standards are underpinned by a set of ideas concerning practice management which is described as firstly “the holistic understanding and organisation of the business and profession of architecture in relation to delivering projects.” Involving little to do with an external facing outlook because “It involves the knowledge and execution of the processes involved in providing architectural services” as well as “the knowledge and implementation of appropriate systems to establish and maintain an architectural practice” and “the knowledge and enactment of the broad range of ethical and legal obligations required of a Professional Practitioner.” (NSCA website 2016)

As Ghemawat (2002) notes capitalism has seen waves of various business fads and cycles too numerous to mention. Yet, the Australian system of architectural accreditation appears to eschew matters related to business strategy, planning and implementation, innovation and entrepreneurship. In this system, technocratic regulation and a legalistic logic constrains both practice and architectural education. Derived from the law of Torts a professional architect is one who “can demonstrate the standard of skill, care and diligence widely accepted in Australia for competent professional architectural practice.”

McNeill describes the globalisation of architectural practice and locates architectural design in a global system (McNeill 2009). He, amongst others (Sklair 2006, Sklair and Gherardi 2012), traces the trajectories of star architects and the way in which these architects constitute the global architectural system. Related to these “stars”, he examines and questions the rise of large integrated services firms in this global system. For example, he notes that the rapid growth of AECOM is indicative of a sensibility that views architecture as being “under-skilled” and “under-scaled”, and whilst the media “tends to put the architect at centre stage”, this is despite a global system and a “corporate reality, which is that architects are no longer the key agents in the production of space (if they ever were)” (McNeill, 2009: 380). In another study of the Pritzker prize winners Heynen looks at the identity of the star architects arguing that “the traditional role model for architects has been gendered male” and this construction centres on male genius, gendered descriptors of avant-garde practice (cutting edge, innovative, daring, original) as well as the idea of individual “authorship.” Heynen sees this latter term tied to notions of male genius, virility, integrity and authenticity. All of which, as Heynen notes and is well known, is exemplified in Ayn Rand’s book *‘The Fountainhead’*.

The above perspectives indicate the need to revise the institutional logics which underpin architectural practices. However, no studies in Australia have explored the institutional logics of architectural practice. Thornton, Jones and Kury (2005) use an institutional logics framework that is a dialectic between two different types of architects. They denote these logics in binary terms as an aesthetic logic and an efficiency logic. Predictably, the aesthetic logic is represented by the “designer-architect” and the efficiency-logic is represented by the architect as “engineer-manager”. However, this binary framework is based on their own linear and somewhat naïve summary of architectural history in the 20th Century. It is a binary of ideal types that does not account for neo-liberal economics, competition for saleable knowledge, technology shifts, the fragmentation of the profession in different countries, nor the professions globalisation since the 1990s; and as importantly, issues around gender diversity.

A central issue of the institutional logics methodology is the tendency to reifying of a set of logics and then locate actors within that. Besharov and Smith (2014) argue for the need to develop a multiplicity of logics in order to account for nested, intertwined and interconnected logics. To an extent, this points to the need to develop new models of institutional logics. Ideally, frameworks of institutional logics must resist a reliance on reified, stereotypical, singular, dominant, binary or homogenous approaches to logics; as they argue it is important to recognise that “wide variation in how multiple logics manifest internally” Besharov and Smith (2014). As Linderoth notes (2016) in a discussion of organisation principles across industries institutional logics is shaped by an “interplay among elements in the institutional properties” and not simply binary properties. But for the researcher avoiding stereotypical approaches may be difficult. For example, Jia et al., (2107) appear, at first glance, to reify a binary logic in the construction safety field; resulting in an institutional logics employing a binary logic of religion (Confucianism vs. Pragmatism). But this conceptualisation is based on Friedland and Alford's (1991) societal logics and arguably the concept could include any number of religious categories. But, the tripartite of survivalist logics discussed below (Table 2) suggests that emergent institutional logics, could both be framed, extended and interpreted along a spectrum and incorporated into more dynamic models of institutional logics

## RESEARCH DESIGN

A survey questionnaire was devised to directly discern if the binary of designer-architect Creative vs. Suit, was prevalent in the business planning practices of Australian architects. In other words, the primary research question was to see if this binary was an evident or emergent logic in architectural profession. It was felt that a questionnaire survey would best discern prevailing attitudes amongst the profession prior to more detailed research.

In the third section of the survey questions were asked that directly explored if a binary of institutional logics existed between architects as creatives and as suits. Questions around the pre-existing logics of Coxe's distinctions of Practice based or Business Based practice were asked. Thornton, Jones and Kuris (2005) ideal types of institutional logics were built into subsequent questions. For example, Sources of Legitimacy and Authority were explored though a non-forced Likert ranking question which asked “Do you think strategic and business planning is important in order to enhance” either managerial practices, firm efficiency, firm scale and scope or reputation, design outcomes or design practices of the firm. Table 1 summarises the survey questions based on the characteristics proposed by Thornton Jones and Kury (2005). Later research might

develop different characteristics possibly employing the same methodology evident in the contribution of Jia et al., (2017) regarding the logics of safety management.

The survey employed a gradated Likert scale (1 to 5) without a forced ranking for survey questions as this might then provide false positives that a clear binary distinction existed between Creatives and Suits. The survey was designed in three sections. The first section in the survey focused on firm demographics, history and outlook. In the second section a number of broad questions were asked about business planning practices.

## SURVEY RESULTS

An email pool of around 1793 architects were invited to respond to the survey. The database used was database of mainly members of then Australia Institute of Architects that had been compiled in previous years. There were 129 (7.1%) responses. Given the low response rate later research on this topic will limit the overall size of the pool.

Table 1: Binary Institutional logics model (This authors terms in italics)

| Characteristics                                   | Aesthetic Logic   | Efficiency Logic  |
|---|---|---|
|   | <i>Creatives: Architect as Artist-Entrepreneur</i>                | <i>Suits: Architect as Engineer-Manager</i>   |
| Economic System                                   | Personal Capitalism. <i>Local and Regional Capitalism</i>         | Managerial Capitalism. <i>Global Capitalism</i>   |
| Sources of Identity                               | <i>Creatives</i>  | <i>Suits</i>  |
| Sources of Legitimacy and Authority (Question 11) | Reputation of Architect, design outcomes and design practices.    | Efficiency of managerial and design practices, scale and scope of firm.                   |
| Basis of Mission (Question 12)                    | Personal Reputation of firm with clients, Win prestige and Awards | Knowledge and range of specialisations Reach of firm into new markets.                    |
| Basis of Attention (Question 13)                  | Resolve Design Problems   | Resolve Firm's future IT infrastructure.  |
| Basis of Strategy (Question 14)                   | Prestigious Sponsors, Patrons and clients win Design Competitions | Increase corporate clients Stable and recurring client base Increase markets for services |
| Governance Mechanism (Question 15)                | Atelier Professional Knowledge                                    | Partnership/Ownership Corporate   |

First section results: most firm respondents were from small firms reflecting the Australian profession at large. Many of the respondents stated that their main area of work was in the area of housing. 68% stated that they did single bespoke housing and 52% medium density and 30% high-density. Far fewer firms undertook specialised areas such as ESD advice (22.45%), Urban Design (35.71%) Heritage Advice (22.45%) and Urban Planning (23.47%). Outside of housing the largest area of work was Commercial (48.98%) and then Community (39.80%). Clearly, the stereotype of the design architect who turns down commercial work because it is by its nature driven by financial profit is a fallacy. It would appear from these results that architects are primarily reliant on housing for their income and may do any commercial work that comes along.

Second section results: 83% of respondents felt that strategy formulation and business planning should be either have a great deal or a moderate amount of focus at architecture schools. As one respondent noted “I think it is sorely lacking and needs to be addressed in architectural education.” Going on to say that “The culture of the 'all-nighter' is a classic example of poor time management and acceptance of unrealistic deadlines.” Measure by weighted averages on the Likert scale respondents were evenly divided around the Weld Coxe strategic dimensions. The vocation of architecture and producing designs that serve society (Weighted Average: 4.15) was only slightly ahead of a focus on “Creating tangible benefits for both the firm and its clients.” Whilst relatively evenly spaced, firms appeared to think that their practices were more intent on creating well-built and compliant designs (4.29) and providing services that built relationships (4.38) over and above the drive for unique architectural designs that exhibit firm expertise and innovation (3.97).

Third section results: Business planning practices were evident in some firms but almost 56% of practices said that their business plans were either non-existent or they had not been updated for more than year (30%). Only 19.47% of firms had a regular strategy and formulation and business planning cycle and 14.9% said that their plans were regularly updated. In a subsequent question 31 of architects stated that business planning was a part of an ad-hoc and organic response to the work at hand.

Despite the above lack of business planning there was strong support for integration between design thinking and business planning processes. Respondents felt that strategy decisions in the firm were not primarily the domain of either design architects (23.33%), business orientated directors (6.45%) but by both (33.33%) or as part of a collaborative process between staff and all directors (22.58%). Respondents felt that business planning and design thinking were integrated and complementary activities rather than opposed activities. Most respondent agreed that Strategic thinking and business planning can be regarded as a design exercise (3.78) and that the purpose of a business plan is to integrate strategic, business and design knowledge (3.70).

Paradoxically, despite the lack of business plans, business planning was seen as being more important that the firm’s mission be to reach new places or markets (4.11), or increase the firms range of specialisation (3.36), build reputation with clients (3.91) rather than help win prestigious awards (3.36). Business planning, as a focus or basis of attention, suggests architects would rather use it to focus on future technological infrastructure (3.98) than design problems (3.22). Architects also responded that as a basis of strategy business planning could enhance a stable and recurring client base (4.07) and new markets (3.57), rather than a win design competitions (3.01) or obtain prestigious clients or patrons (3.47).

## **DISCUSSION**

The above results suggests that in practice architects have adopted a more inclusive “both-and” view in regards to the binary distinction between Creatives and Suits. This suggests that a different institutional logics is at play in architectural firms rather than a logics based on a simple binary. This is different to the logics suggested by Coxe’s conceptualisation. The results suggest that architectural firms recognised the value of strategy and business planning even if they were unable to embark on their own business planning exercises. Most respondents appeared to value equally, or rank design values below, more managerially orientated business values. A sharp distinction would be evident if there appeared to be a polarisation in the results between designs orientated values and business values in survey responses.

Comments from the survey respondents reveal, the differences between large and small firms, and a survivalist logic that is at play. As one respondent noted in relation to developing specialist areas of knowledge “Close contact and reach to each specific interest is paramount to both survival and reputation broadly in community and profession.” Another respondent stated that for small firms there was “often the constant switch between short-term project related issues and longer term goals, and making sufficient profit to be able to fund longer term thinking (and when we do, we are too busy!).” The solutions offered by respondents to the dilemmas facing smaller firms was to “operate on a cooperative model as it is the only way.” But as one respondent from a regional practice noted. “We have had very unsuccessful JV experience with large corporate architectural firms” going on to say that the “experience has left us very disillusioned as we have realised that our salaries are very low when compared with the charge out rates of these big strategic practices.” Then stating that “Sadly design expertise is not rewarded in our neck of the woods.”

Survivalism is also evident in other responses such as, “I really think that in the majority of firms, business planning is considered a secondary activity after design. There are many firms that have been active for decades that still struggle with fees and getting paid.” As another respondent lamented: “It's a 'chicken and the egg' situation where stability encourages strategic & business planning. At the moment, it's more about survival than anything else. There are too many architects vying for what little work is considered relevant for us to be involved. I have no doubt that the pendulum will swing back in our favour, but I am sceptical about whether it will happen soon enough to save my career.”

The survey results taken alongside the comments collated above from various respondents appear to indicate that, rather than a binary institutional logic, a survivalist institutionalist logic dominates. This logic is centred on different sized firms. The responses suggest that the fight for survival in a competitive market, particularly the housing market, hampers the ability to innovate. To survive most firms, seem more focused on building compliant designs on time and to budget, alongside a focus on building client relationships through service provision, rather than developing unique designs that exhibit innovation and expertise. This is worrisome given the need to create innovations around sustainability. This survivalist logic illuminates why respondents felt that strategy and business planning should be a part of professional curricula for architects. Yet, as they are struggling to survive, they either do not, or have not had, the time to formulate strategy and business plan. In the housing market architects have many competitors and adversaries along market driven design and construction chains. Housing is a key area where sustainable methods can impact on carbon emissions; yet in this market segment architects may be struggling to make a headway.

### **A Survivalist Institutional Logics**

This overarching institutional logic of survivalism is arguably the result of a number of factors. The changes since the 1970s in professional status as a result of neoliberal policies leading to so-called market competition. The loss of traditional services to project managers and subsequent disaggregation of full fee-for-service regimes. The rise of new technologies alongside new procurement systems have also led to a more competitive environment for architects. Despite its allure and heroic mythology in architectural traditions architects have in reality abandoned the binary logic of Creative vs. Suit. Consistent with the above results architects now conform to a different logics, structured by firm size, as set out in Table 2.

**Tribes:** Tribes are small community based and local practices. These firms create a design knowledge ecosystem around their own local field of practice. These are small firms which develop linkages both within their teams and the communities that surround them. These firms inwardly focused are bottom up in the way they create design knowledge. They are collaborative and community orientated. Whilst a single designer may dominate these tribes the emphasis is on consultation. As many of these firms feel they are struggling to survive these Tribes will sometimes form together to make bigger firms.

**Warlords:** Warlords are best exemplified by the so-called star architects. They dominate the national and global systems. These firms create a knowledge ecosystem around themselves that is dominated by a single, style, aesthetic ideology or person. These firms create design knowledge on a project by project basis. However, the creation of design knowledge is secondary as the firm seeks legitimacy through media hits. They are focused on winning prestigious commissions and often create conflict in order to win media presence. They are intent on creating seminal projects that build their reputation in the architectural canon.

**Transformers:** Are large multi-disciplinary and networked firms that work within the global system and often across borders. In these firms, design, knowledge, systems and governance are integrated. These firms create highly specialised design knowledge which is integrated into their own systems. As a result, these firms are large enough to anticipate, create, design and deliver large meg-projects such as urban infrastructure and cities. These firms are intent on building projects that enable the firm to be continually self-sustaining. They transform as they their constituent networks ebb and flow.

*Table 2: Institutional logics model for Architectural firms*

| Characteristics                                      | Tribal Logic  | Warlord Logic  | Transformers Logic   |
|--|---|--|--|
| Name   | Community Architects  | Star Architects  | Mega-firms   |
| Survival and conflict modes:                         | Territories dominated through local knowledge. Avoids conflict in order to survive. | Territories dominated via media channels. Creates conflict in order to build media presence. | Territories constantly captured, expanded and rebuilt. Resolves conflict in order to govern. |
| Economic System                                      | Local Capitalism  | Regional and Global  | Global   |
| Sources of Identity                                  | Community   | Global Media   | Revenue Growth and Entrepreneurship.   |
| Sources of Legitimacy and Authority<br>(Question 11) | Reputation of Architect, design outcomes and design practices.                      | Media hits, prestigious projects and academic positions.                                     | Revenue, global reach and size of firm extent of specialisation.                             |
| Basis of Mission<br>(Question 12)                    | Personal Reputation of firm with clients,<br><br>Win prestige and Awards            | Knowledge and range of specialisations<br><br>Reach of firm into new markets.                | Predatory<br><br>Revenue growth and Profit.<br><br>Integration of smaller firms.             |
| Basis of Attention<br>(Question 13)                  | Bottom up design and consultation processes   | Avant-gardism.<br>Reputation in the architectural canon.                                     | R&D Integrated Systems and Governance,   |

|                                       |  |   |  |
|---------------------------------------|--|---|--|
|                                       |  |   | Infrastructure Technologies  |
| Basis of Strategy<br>(Question 14)    | Any clients sponsors or patrons. Increase community connections. | Increase corporate clients<br>Stable and recurring client base<br>Increase markets for services | Entrepreneurial Futures<br>Mega- Projects<br>Knowledge creation and integration. |
| Governance Mechanism<br>(Question 15) | Atelier. Professional  | Singular Warlord or Star Architect. Project teams   | Corporate. Multi-functional groups. Networks                                     |

## CONCLUSION

This research questions dichotomising, binary or overly simplistic notions of the logics at play in the architectural profession. In previous work an interpretation of logics in relation to architectural practice has tended to reify around a number of binary and over simplistic notions. Whilst this paper only seems to extend these notions, by replacing a binary logics with a tripartite one, this tripartite model is only a first step to beginning to develop models of architectural practice that embrace complex ecologies and logics of practice. Bronfenbrenner’s social ecological model points to an approach that could be explored further (Bronfenbrenner 2009). Arguably, the development of institutional logics framework is a two-stage process. In the first stage categories are identified and in the second stage these categories are conceptualised, each on a spectrum, with non-static and perhaps overlapping or nested relationships.

The survivalist logic model proposed here could be easily tested in further surveys and research. Indeed, a grounded theory approach might also better justify this research. A Google Analytics analysis of the websites of each of the above types of firms would help to confirm and refine the model. More research is required to more accurately identify and quantify the financial dynamics that underpin the survivalist logic. For example, how many firms in the tribal class are profitable? How different firms come into existence, operate and change over time in for example from a tribal; to Warlord logic to a Transformers logic. Comparative case studies of the different types would also clarify these matters. Following on from Jia and Rowlinson (2015) and Jia et al., (2017) these types could be characterised as different design systems which operate at different institutional levels.

Since the 1980s Australian architects have been told taught that architectural design is important. This has been reinforced via the AIA peer awards system, publication and through networks of established patronage. This notion has in turn reinforced the idea that architects are designers who oppose the strictures of business planning and managerial efficiency. Yet, architects recognise the importance of strategy formulation and business planning practices. If anything, the survey responses indicate an emphasis more on business planning than a drive for design. This is because many Australian architects are driven by the need to survive as the competitive environment eats away at their livelihood and destroys their profession.

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# MARKETS, PROFESSIONS AND FIRMS OF THE CONSTRUCTION INDUSTRY: THE CHANGING ROLES OF ARCHITECTS IN RESPONSE TO VERTICAL INTEGRATION

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The roles of professions in the construction industry in markets globally differ from one another according to the socio-political, cultural and historical contexts they are situated in, reflecting the institutional nature of the markets themselves. The institutional logics of state, market and profession compete to shape firm strategies. We adopt an institutional logics perspective to explore how architecture firms adapt their roles in the project procurement systems in response to vertical integration in the supply chain and the change of logics at the societal and field levels. Three architecture firms were analysed in this exploratory study. Data were collected through structured interviews, completed by company achieves and design documents. As a firm level study, the diversified roles of architects as manifested in their business models and the competition between the profession and market logics nuanced by a bureaucratic state logic. The study sheds light on the role of professionalism in balancing the market logic in shaping the outcome of our built environment. In a more general sense, we discuss the impact of the professional logic of architecture on the making and outcome of the built environment, and the value it can bring to an evolving structure of inter-professional collaboration in an integrating global industry.

Keywords: architect, professional, market, institutional logic, design firms, business model

## INTRODUCTION

The diffusion of BIM technologies has accelerated vertical integration in the construction industry, which demands seamless inter-professional collaborations in project delivery and collapses the boundaries between domains of knowledge that used to be exclusively owned by the segregated professions. New procurement paths such as Integrated Project Delivery (IPD) magnify clients' quest of "more efficient and higher performance buildings at lower cost" (AIA 2013: 14). The pressing demand of efficiency is interruptive to professional roles and authorities, and particularly so to that of architects (Styhre and Gluch 2009). Builders increasingly criticise architects for poor management of design drawings, which is believed to cause construction rework and cost escalation

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(Love and Edwards 2004a, b, Love *et al.*, 2012); while architects find the strong belief on the traditional role has been a major obstacle to IPD (RIBA 2011, AIA 2013). Caught in a dilemma between professional values and economic pressure, architectural firms commonly “have difficulty generating profit from their services” (Bos-de Vos *et al.*, 2016). The profession of architecture is seeing a crisis of identity and role in the industry (Styhre and Gluch 2009). Subsequently, the wellbeing of individual architects is found problematic and is getting more research attention (Sang *et al.*, 2009, Caven and Diop 2012, Manzoni *et al.*, 2012). In reaction, architects theorise themselves as ‘gleaners’ to counter the progressive standardisation and streamlining of works prescribed by technocrats (Raisbeck 2016).

Whilst vertical integration is disseminated through economic globalisation and international practice, the roles of professions in the construction industry in markets globally differ from one another according to the socio-political, cultural and historical contexts they are situated in, reflecting the institutional nature of the markets themselves. Drawing from available institutional logics in their specific societal contexts, professional service firms adapt their roles to gain legitimacy to acquire critical resources and survive the market. With this background in mind, we explore how architects adapt their roles in the institutional environment of China as part of the global market the construction industry of which corresponds to the vertical integration process (e.g. CIOB 22 April 2014). Specifically, from an institutional logics perspective, this paper aims to explore how architecture firms accommodate their business models in China by interpreting and drawing upon the societal-level institutional logics of state, market and profession.

Joining the World Trade Organisation in 2001, China has shifted from a centrally planned, state-commanded system to a market economy in the late 1970s, embarking on professionalising the architecture profession in the 1980s. This transition occurred concurrently with the emergence of a global market for these services and the vertical integration in the construction industry. For China, these processes mean that the central state government started to divide and give out powers to the invisible hand of the market and to the self-regulation of the profession.

### **The Profession of Architecture in China**

A profession is characterised by, among others, a monopoly of competence in the prescribed field (Larson 1977), control of entry, ethics of practice, body of knowledge (through accreditation), and professional development (through mentoring mechanism) (Hughes and Hughes 2013). Professional roles in the construction industry are shaped by legislation, professional institutions, standardised contracts, professional indemnity insurance, and the nature of client (Hughes and Hughes 2013). To some extent, professional association acts as the vehicle of “state-protected monopoly”, which for example in the UK, is legitimised by a royal charter (Hughes 2015). Professional association is important in that it maintains a normative environment through conferring legitimacy to practice embedded a logic that differs from the market logic (Meyer and Rowan 1977). Hughes and Hughes (2013) stress the role of professional association as an organisation fostering a values system different from the market logic, thus provides alternative legitimacy to firms which would otherwise be left to the sole accountability to the buyers and confined to the activities of maximising profit and optimising efficiency (Hill and Lorenz 2011). Hughes (2015) further suggests that professional associations can be an agent of industry change.

Examined against these factors, the institutional environment of the architecture profession in China is characterised by rapidly changing policies, underdeveloped

professional institutions, and the absence of professional indemnity insurance. A powerful state bureaucracy nuances both the profession and the market, where registered architects are to be affiliated to a design organisation to carry out design practice, while the professional authority lies with the organisation instead of the individual, as described in an earlier study in 2004:

...an architect has the duties of designing or providing technical consultation on the design of a building, as well as undertaking building investigation, and evaluating and supervising the construction of work as designed. The duties, however, are to be carried out under the oversight of a building design unit through which all work should be commissioned and to whom fees are to be paid. Construction drawings are to carry the stamp of two parties, the architect and the design unit. If a licensed architect leaves a design unit, the unit is responsible for revoking the license to practice and returning the stamp to the administrative authorities, and the architect is then responsible for obtaining a new license and stamp from the design unit joined thereafter. (Kvan et al., 2008: 207)

More recently, the administrative control of the state has given way to the market logic to some extent. However, the previous institutional environment has fostered a culture of granting professional authority to the organisation, which, in a market environment, leads to a situation that the clients' trust lies with firms with qualifications of signing construction drawings, rather than with individual architects.

### **Institutional Logics**

Institutional logic is the central values of institutional orders of a field, consisted of materialised practice and symbolic construction (Friedland and Alford 1991, Thornton *et al.*, 2013). It is an actor's theory-in-use in contrast to his espoused theory (Argyris and Schön 1974). The institutional logics lens enables us to see that firms take actions for gaining legitimacy defined by the prevailing logic, while profit maximisation does not always explain firm behaviours (Meyer and Zucker 1989, Thornton 2004). At societal level, Friedland and Alford (1991) suggest five central logics of a modern Western society that endorse legitimacy: the logic of capitalist market, which is commodification of human activities; the logic of state, which is rationalisation and regulation of human activity through bureaucracy and hierarchy; the logic of democracy, which is participation and institutional control over government; the logic of family, which is motivation of human activity by unconditional loyalty to an in-group; and the logic of religion (or science), which is people's essential belief of what is truth and reality. While the state and market logics are observed to be dominant in today's economic globalisation, recent research suggests the logic of profession as a viable alternative, which can be realised by professional autonomy in job discretion (Freidson 2001, Thornton *et al.*, 2013). In the field of construction industry, Hughes and Hughes (2013) stress the importance of a professional logics, pointing out that "the idea of placing the interests of the client above all else is tantamount to an abrogation of responsibility for professionals' actions" (35).

In terms of the professional logic of architecture, Thornton *et al* (2005) identified a cyclical pattern of institutional change in the American architecture profession that shifts between a design-technology dichotomy, echoing two contrasting logics: artist-entrepreneur and engineer-manager. Cohen *et al* (2005) analysed the discourse of architects in England, and explicated three themes: architecture as creative endeavor, as business activity, and as public service. Jones and Livne-Tarandach (2008) identified three institutional logics in architects' profession: professional exemplars (artistic aspiration), business practice and state bureaucrats (related to users, community and functionality of the built environment). These typologies extracted from public discourses reflect external observers' perception of what is inside the profession. Cuff

(1992) as an insider in the profession gives an account of the differentiated roles of architects within a design firm, including principals, associates, project architects, design architects, draftspersons and technicians. In this perspective, an architectural design firm is inherently embedded with, and shaped by, multiple logics that are not necessarily professional logics but more of societal level logics practiced by the individuals of various roles. Essentially, the professional logic of architecture can be defined as the creation of spatial order to a given environment, with aesthetics as an essential concern during the creative process (Mitchell 1990). Traditionally, design decision throughout this process is made on an individual base; the professionalism in it dated back to Michelangelo's letter to his client, "*I neither am nor will be obliged to tell your lordship or any other person what I intend or ought to do for this work; your office is to procure money, and to take care that thieves do not get the same; the design for the building you are to leave to my care*" (Vasari 1550 [1963 ed.] cited in Cuff 1996:72). The individual nature of architecture's professional logic is embedded in the curriculum of architecture and carried through history worldwide (e.g. Lu and Sexton 2006).

## METHODOLOGY

The study employed a firm-level exploratory case study approach (Yin 2013), guided by an institutional logics perspective. Methodologically, the concept of institutional logic suggests the study of discourses need to be triangulated with the actual practice for a better prediction of organisational outcomes (Jia *et al.*, 2017). We analyse cases of three design firms on the manifestation of societal level institutional logics in terms of market, profession and state in the business models of the firms. The roles of architects are examined by the firms' business model, defined as a firm's value proposition and strategies undertaken to realise them (Morris *et al.*, 2005). We focus our analysis on how the professional logic of architecture is practised and interpreted in the firm's business model in response to a market context of vertical integration, examined by the state and market logics.

Three cases were selected for the exploratory study in Shanghai, China. The cases were selected to cover a variety of types of practices, sizes of firms and business models. Structured interviews were conducted with the Senior Project Architect in Case A and C, and the Principal in Case B. The interview guidelines were adapted from the instruments developed by Symes *et al* (1995). The original instruments consisted a questionnaire at individual level and two sets of interview guidelines at project and organizational levels. We used all the three levels of instruments for structured interviews to obtain a detailed profile of the firms.

The firm level questions covered topics on firm history, strategies of marketing and approaching clients, source of projects, scope of service, design values and philosophy, organisational structure, decision-making pattern and project workflow. The project level interviews functioned as critical incident technique (Flanagan 1954) to generate detailed descriptions about the team structure, project expertise, and inter-organisational corporations and coordination. At an individual level, the interviewee's personal experience on the link between the education and practice was analysed to understand the background of architectural education in China. Two additional questions were added to understand the compatibility between the architectural profession in the China context and their counterpart in the West, including the role of the professional association and the difference between registered and non-registered architects. The lengths of the interviews ranged from 1.5 to 3.5 hours.

The interview data were transcribed verbatim; critical incidents were verified through triangulation with documentary data including relevant public media reports, company archives and publicly available information of firm profiles and completed projects. The texts in the authentic cases were then analysed with thematic content analysis (Weber 1990)

## RESULTS

### Case A. An Initiative of Transforming the Professional Logic

Firm A employs around 15 staff, was registered in 2003, and was recently affiliated to a listed design corporate in Shanghai to survive an increasingly vertically integrated industry. The firm identifies their core business in the design of commercial buildings. Over years, the architect proactively took up planner's role to provide business-planning service prior to the design stage. As described by the Principal of the firm, the architect provided planning service to bridge a gap of expertise in the market:

Business planning is normally commissioned to retail-investment planners in commercial building projects. The problem is that planners do not have creativity. The business planners in China only copy and paste, but those from overseas are not better. They are efficient in producing an elegant report, but you won't find a single page that is useful. It is a very thick book, but there is no concept. This is the situation of global retail planners. As architect, we are obliged to take the lead.

In taking over the business planner's role, the Principal articulated a broadened professional logic that legitimates his practice:

Social responsibility should be rated as the most important virtue of architects. Architecture is not about realising personal idea. It is about serving the people and the city, be responsible to them. 'People' include clients and users. I am committed to both my client (the developer) and the city. Architects should take the lead to integrate all the built environment disciplines and the developer is one of them.

Regarding the role of the profession, the Principal mentioned an absence of a professional institution that effectively foster professional values.

We have an Association and an Academy. The Academy acts as a government agent to authorise regulations and design standards, while the Association is a trade union for business opportunities. Neither is taking a lead in the technical development of the profession. We are lack of an environment of architectural engagement.

By 'academy' the principal meant the Architectural Society of China, the equivalent institute of the Royal Institute of Architects in the UK or American Institute of Architects in the USA. However, unlike their Western counterpart, the Society is running as an academy that focuses on dissemination of knowledge. There is no code of ethics in professional practice. By administrative structure, the Society is jointly managed by Ministry of Housing and Urban-Rural Development and China Association for Science and Technology (which is directly led by the Secretariat of the Central Committee). In general, behaviours of individuals are subject to regulations of the state bureaucracy while firms are left to market competition without protection. As a consequence, architecture firms often find themselves in a competition of low price that make them vulnerable to high workload and low income.

It was not that we didn't do enough work; the work we have done is enough to feed a family of three generations. The problem is that we don't have a legal structure to support us, not an institutional system to support us to reward the effort of our work. I would have appreciated it even if we can have half of the turnover. But we are not paid for even half of our work. The majority of the clients are voiding payment, both public and private clients. The whole society is avoiding payment. This is the major difficulty of architects in China.

### **Case B. Professional Logic Patronised By Market Logic**

Case B is an architectural design firm consists of 122 staff members, including ten registered architects; the rest are structural and building service engineers, executives and administrative staff. The firm was set up in 2009 as a branch firm of a listed real estate developer (Developer A). The developer's business was focused on development of residential buildings with an emphasis on design concepts. The architect had freedom in proposing design ideas and is secured in cash flow by the parent company. The advantage of Architect A as a branch firm of Developer A is demonstrated in the following case of project:

In the 2011 recession, all companies were in shortage of cash, ours was no exception. At that time, I was assigned a design project which claimed to be vital for the company's survival. It was a very small project, less than 30,000 square meters. We designed and built it. The apartments were quickly sold out for a return of CNY 600 million. The incoming cash revived the whole company. (Project Architect, Firm A)

There was a period that the architects felt interference in design when, in 2014, Developer A was acquired by another listed developer (Developer B). Developer A fosters a strong design professional values and was in a less financially comfortable condition than Developer B which align its organisational logic with the market logic. Developer B had a better cash flow by running a business model of selecting lowest bids and procrastinating on payment to contractors. This strategy resulted in a strong managerial logic focused on cost control. The architects were greatly unsettled. The merger immediately highlighted a conflict between the professional logic encouraged by Developer A and the market logic imposed by Developer B. The merger was cancelled within three months so that the firm returned to the original management structure and culture, thus the design process was once again governed by the professional logic.

### **Case C. Foreign Professionalism Detached From Local Institutional Context**

Firm C is the Shanghai branch of an Architecture firm based on the UK, with offices in Hong Kong, Australia, Singapore, Beijing and Shanghai. In total the firm has around 400 staff, while the Shanghai branch has 50 to 60 staff, half of which are architects and the rest are interior designers. The Director is an experienced British architect. Solely owned by the parent practice, the foreign firm does not have the qualifications to sign construction drawings. The firm provides services in schematic design, design development and construction supervision, while the responsibilities for construction drawings and obtaining planning approvals are assigned to a local design institute partner. The British firm brought with them their professional modes of practice. Contracts are drafted and managed at senior management level. Director has control of all projects. The design fee for a project must not be lower than the professional standards; compromising the fee through low bidding is not permitted. Architects' workload are recorded in timesheets, and charged based on contract. Extra services are subject to additional charge.

All our services strictly follow contract clauses. Any significant variation needs to be legitimated by an additional contract. If the contract does not include services on construction site then we don't go to construction site. We as architects don't go an extra mile to build up relationship with clients. For example, we don't invite client for dinner, because, if any of us wants to do so he has to pay from his own pocket; the company will not reimburse him a dollar. Therefore nobody is interested. (Senior Project Architect)

This strategy implies a higher charge compared to the local firms, where the profit from projects of a private client or public building will not be able to sustain. The firm thus focus their types of projects on commercial development projects only.

## DISCUSSIONS

The cases analyses revealed that in the China context, the architecture profession is struggling with both the state bureaucracy and a prevailing market logic. Meanwhile, both the market and the profession are struggling for independence from the state bureaucracy. Hughes and Hughes (2013) suggest that professions in developing countries can complement the inadequate legal infrastructure with self-regulation, and can even go further to act as an agent to the inactivity of the government on relevant issues. This is not the case for China as discussed in our findings. First, the professional association in China does not regulate ethics of conduct. In fact it does not go beyond managing the body of professional knowledge, although the content of architectural education does have an institutional power in driving the decisions of the architects. Second, in the specific context of China, the professionalization process was simultaneous with the development of an institutional structure for a market economy. Both the profession and the market would not develop in full in the presence of a powerful state bureaucracy which takes over large part of the jobs of both, while a democracy logic does not exist as in a Western society to limit the state power. That said, the architect in Case A makes a case of institutional entrepreneurship that transforms the professional institution into a broader professional logic and take developer's role under the design leadership. As envisioned by the AIA (2013) Foresight Report, a trend of strategising design practice toward social impact through participation, volunteerism and community engagement, results of our study resonate this vision.

Bos-de Vos et al (2014) found that Dutch architectural firms in their study were all involved in certain forms of international practice except for the small or micro-sized firms. The firms recognized that partnering with local firms was vital in order to comply with local legal system and construction methods. Our study provides the other half of the story: the UK firm practicing in Shanghai (Case C) limit their practice up to the design development stage before handing over to the local firms. Bos-de Vos et al (2015) further reported a case in the Netherlands where the architect took a proactive role to provide real estate development service, but found themselves lack of legitimacy to charge for the service. In our study of Case A, the architect offered a similar service without charge, but legitimated this service as part of the professional logic of architecture. However, the lack of a strong professional logic in China leaves the architecture firms in disadvantage to the purchasing power of developers and vulnerable to market fluctuation. The consequence is the local design firms find it difficult to charge for their design services at a fair rate, which devalues the service and risks undermining the profession. In contrast, Case C managed to preserve a clear professional logic legitimated by the profession back in the UK. Their business strategy keeps them in a financially comfortable situation. The results of our study provide empirical evidence that an active professional logic is important in balancing the market dominance in the construction industry. Interestingly, our Case B as a branch firm of a developer that fosters a professional logic, the architect was structurally legitimated to act as part of a develop-design-construct-sell project team to survive the market while preserve professional values.

## CONCLUSIONS

The aim of this paper is to explore the changing roles of architects, embedded in the professional logic of architecture, in response to vertical integration in the construction industry, manifested in the institutional context of state and market logics in China. Through a case study approach, we analysed three business models of architecture

practice in Shanghai: a case of proactive transformation of the professional logic, an architecture firm patronised by a developer, and a foreign firm practising an imported professionalism in China. The findings highlight the need of building a strong professional logic in the architecture profession in China (which is found not yet in existence after two decades of professionalisation) to balance the market logic, where the state bureaucracy is not providing sufficient protection to professional services. The results suggest that the role of architects can be extended to include upper stream services, legitimated by a transformed professional logic. The results also indicate another survival strategy for architects, alliancing with a developer of similar professional logic. However, this strategy is to be adopted with caution in China's special institutional context, in which a powerful state bureaucracy nuances both the market and the profession, which means the survival of developer is subject to periodical reversion of political institutions. The research contributes to the understanding of international practice and the transformation of the architecture profession in the global construction market.

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# CONSTRUCTING BUSINESS MODELS AROUND IDENTITY: TENSIONS IN ARCHITECTURAL FIRMS

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Architectural firms experience difficulties to establish healthy and sustainable business models as they have to reconcile the often-competing value systems that they are based upon. Organizational members continuously negotiate professional values and beliefs with the firm's commercial goals, resulting in identity-strategy struggles. This study adopts a 'work lens' to investigate the reciprocal tensions between identity and strategy in 17 business model design workshops with members of architectural firms. Observational data show that practitioners collaboratively construct their business models around professional values, thereby strengthening organizational identity but constraining innovation in their business models. The research contributes to the literature on strategic management of architectural firms by articulating how professional aspects of identity enable and constrain practitioners to shape and be shaped by their strategic actions and decisions.

Keywords: business model, identity tensions, strategy-as-practice, value creation

## INTRODUCTION

Architectural firms continuously deal with identity-strategy tensions as they pursue multiple strategic goals and organizational members identify with different social groups, such as the organization, the inter-organizational project team and the profession, of which values and beliefs may be conflicting (Vough, 2012). Identity-strategy tensions complicate the creation and maintenance of healthy business models. It was found that architectural firms, for instance, regularly prioritized professional value over monetary value, as the architects of these firms tried to be good professionals (Bos-de Vos *et al.*, 2016). Thus organizational outcomes can suffer from the identity-strategy tensions that firms encounter.

A better understanding of the relationship between strategy and identity seems crucial to unravel the dynamics that are involved in organizational processes and outcomes of architectural firms. Oliver (2015) argues that identity and strategy practice mutually shape each other. Strategy enacts identity claims and may also lead to changes in the identity of organizations or organizational members (Ibid.). Although scholars have increasingly called for more consideration of identity work in strategy research (Jarzabkowski and Spee, 2009), empirical work is still limited. Architectural firms are even more under-researched. This could be attributed to architects' reluctance to think in

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strategic terms because of their strong professional ethos and creative needs (Winch and Schneider, 1993).

In this study, we investigate how identity-strategy tensions play a role in strategizing processes within architectural companies. Specifically looking at the group interactions during 17 business model design workshops in Dutch architectural firms, we address the following research question: How do members of architectural firms negotiate identity-strategy tensions in their business model designs and how do their business models impact existing identity claims? A ‘work lens’ (Phillips and Lawrence, 2012) was adopted to investigate the links between actors’ strategy work and identity work. The study contributes to the literature on strategic management of architectural firms by improving the understanding of how the micro actions of individuals and groups in architectural firms connect to the projects, organizations and profession in which those actions are located and to which they contribute. The study may also be helpful to practitioners to improve their strategizing activities and informative to architecture students who wish to start their own businesses.

## **IDENTITY TENSIONS IN ORGANIZATIONS**

Identity is a multilevel construct that can be understood as the self-concept of an individual or social group (Ashforth *et al.*, 2008). It is a self-referential description that provides contextually appropriate answers to the question ‘Who am I?’ or ‘Who are we?’ (Ashforth *et al.*, 2008). The shared belief among organizational members about the organization’s central, enduring and distinctive characteristics is what defines organizational identity (Scott and Lane, 2000). Although identity has often been conceptualized as stable (Albert and Whetten, 1985), scholars increasingly emphasize the socially constructed and fluid nature of identity (e.g. Gioia *et al.*, 2000). According to Alvesson *et al.*, (2015: 3-4), identities “are constituted, negotiated, reproduced, and threatened in social interaction, in the form of narratives, and also in material practices”. Identities thus require repeated work to be constructed and sustained. The concept ‘identity work’ captures the dynamic nature of creating a sense of self in relation to the environments in which one is embedded (Phillips and Lawrence, 2012). It focuses on the on-going processes of work that people engage in to form, repair, maintain, strengthen or revise identity constructions that provide them with a sense of coherence and distinctiveness (Ibid.). Identity work links individual agency with the broader social context (Kreiner and Murphy, 2016). On the one hand, individuals are influenced by the norms, opportunities and constraints of the broader social structure. On the other hand, individuals’ feelings, thoughts and behaviours collectively build, change or even transcend social structures (Ibid.). As individuals and groups occupy positions in many different networks of relationships, they uphold different social identities at the same time, often causing identity struggles or conflicts. In the contexts of organizations, the existence of multiple social identities encourages identity work at and across different levels, including the individual, group and organizational level.

## **RELATIONS BETWEEN IDENTITY AND STRATEGY**

The relation between people’s identities and their strategizing activities has often been overlooked in management research, yet is now gaining increasing attention (Johnson *et al.*, 2010). Recent research emphasized that identity and strategy have a mutually shaping relationship (Oliver, 2015). Actors enact identity claims in their strategizing activities, and their strategizing processes may also lead to changes in their own, their groups’ or their organizations’ identities (Ibid.). Research avenues for studying the reciprocal relations between identity and strategy seem especially connected to the strategy-as-

practice (SAP) perspective. SAP scholars consider strategy something that organizational members do and not just something that an organization has (Whittington, 2006). A strong process orientation helps SAP researchers to provide important insights into how practitioners are enabled and constrained in their actions and decisions by wider organizational and/or social practices (Jarzabkowski and Spee, 2009). Strategizing refers to the ‘doing of strategy’. Strategizing research explicitly focuses on the human activity that is involved in strategy by studying the actions and interactions of multiple actors and the practices that they draw upon (Jarzabkowski *et al.*, 2007). In line with the ‘turn to work’ in management research, Phillips and Lawrence (2012) emphasize the importance of studying different forms of ‘work’ in relation to strategizing. A work lens helps to look beyond the day-to-day work in organizations by focusing on the “goal-directed efforts” that actors individually or collectively use “to manipulate some aspect of their social-symbolic context” (Phillips and Lawrence, 2012: 227). It thus makes a connection between what actors are doing to influence their own paths (action), why they are doing it (intention) and what the consequences for the organization are (outcomes). Phillips and Lawrence (2012) argue that scholars can significantly enrich the understanding of strategic organization by getting engaged in how individuals and organizations purposefully relate their activities and decisions to their surrounding contexts with different forms of work. Building on the definition of strategy work as “the purposeful activities carried out by actors in the production of strategies” (Phillips and Lawrence, 2012: 225), we specifically examine tensions that arise from the link between actors' identity work and strategy work.

### **RESEARCH CONTEXT: THE BUSINESS MODEL**

The architectural firm's business model was chosen as an empirical setting as it represents an area of strategic decision making in which identity-strategy tensions are particularly salient. Good business model designs are important, as they help to build and maintain a competitive advantage (Teece, 2010). A business model comprises a multitude of strategic decisions, including decisions about customer value propositions, necessary resources and partners, suitable cost structures and revenue streams (Zott *et al.*, 2011). By representing an organization's essential value creation and capturing activities in an abstract and reduced form, business models can be helpful tools in the strategizing process. They serve as “cognitive devices that mediate between managerial thinking and engagement in economic activities” (Aversa *et al.*, 2015: 2). Although the business model literature offers substantial knowledge about how business models work or become innovated, relatively little is known about how business models are crafted in practice (Rumble and Mangematin, 2015). Architectural firms generally employ multiple business models, as they predominantly work in temporary project settings that all have unique environmental contexts (Wikström *et al.*, 2010). Each individual project thus requires a (slightly) different strategy. In architectural firms, professionals dominate the decision-making hierarchy. Due to their strong professional ethos, strategic decisions are always taken against the backdrop of professional values and beliefs, often jeopardizing the pursuit of commercial interests (Bos-de Vos *et al.*, 2016). Identity-strategy tensions are thus inextricably linked to the business models designs of architectural firms.

### **RESEARCH APPROACH AND METHODS**

To capture the reciprocal tensions between identity and strategy in the business model designs of architectural firms, we opted for a process research design (Langley, 2007) that allowed us to observe interactions in concentrated modes of strategy-making (Jarzabkowski and Spee, 2009). We choose to organize business model design

workshops in multiple architectural firms. This enabled us to develop a better understanding of strategizing in architectural firms, of which still extremely little is known, and to see how this process is impacted by identity-strategy struggles. Due to the background of the authors, we chose to study the business models of Dutch architectural firms.

Sampling was based on two principles. First, we selected firms that have architecture at the core of their business model. Second, we wanted the sample to cover different types of architectural firms in the Netherlands to investigate whether the business model design process would be different for firms with different age, size or leadership positions. This resulted in 17 diverse architectural firms (see Table 1).

*Table 1: Firm selection*

| Firm | Founded in | Annual turnover (€) | No. of employees | No. of architects | No. of owners | No. of directors |
|------|------------|---------------------|------------------|-------------------|---------------|------------------|
| A    | 1955       | 2.000.000           | 25               | 13                | 2             | 2                |
| B    | 2015       | 300.000 (2015)      | 9                | 3                 | 4             | 4                |
| C    | 1953       | 1.400.000           | 13               | 3                 | 5             | 3                |
| D    | 1931       | 14.000.000          | 106              | 33                | 10            | 10               |
| E    | 2015       | 12.000 (2015)       | 2                | 1                 | 1             | 1                |
| F    | 2006       | 3.000.000           | 55               | 30                | 4             | 1                |
| G    | 1956       | 500.000             | 6                | 2                 | 1             | 1                |
| H    | 2013       | 4.000.000           | 45               | 30                | 3             | 3                |
| I    | 1914       | 1.000.000           | 9                | 5                 | 3             | 3                |
| J    | 1973       | -                   | 60               | 45                | 3             | 2                |
| K    | 1979       | 6.500.000           | 70               | 35                | 4             | 2                |
| L    | 1988       | 4.000.000           | 50               | 12                | 5             | 5                |
| M    | 1933       | 3.000.000           | 31               | 10                | 5             | 5                |
| N    | 1968       | 6.000.000           | 75               | 25                | 4             | 2                |
| O    | 2004       | 400.000             | 4                | 3                 | 1             | 1                |
| P    | 1993       | 6.000.000           | 165              | 155               | 3             | 3                |
| Q    | 1985       | 3.300.000           | 43               | 49                | 9             | 2                |

Data were collected over a period of two months, during which we organized business model design workshops in 17 different firms. The 17 workshops were all conducted by the same two researchers, including the first author, to ensure robustness. One researcher acted as the moderator, the first author had a participatory observant role and kept track of the process, decisions and outcomes of the workshop in an event log. The workshops were video-taped entirely and further documented with pictures. We used a group setting to enable participants to interact with each other. The group dynamics can reveal insights that are difficult to achieve in individual interviews. We chose to apply a structured workshop format, which had two main aims: First, we wanted the workshops to be similar to the firms' regular strategic meetings on a structural level. We therefore collected the data at the firms' locations and asked the management of each firm to select the participants. The groups of participants ranged between 2 and 7 people. In a workshop

with a small firm, only one person participated. In addition, we asked each firm at the beginning of the workshop to select a new or recently started project as the topic of discussion to ensure actual strategizing. Second, we wanted the workshops to be similar to each other on a content level. We therefore chose to use exactly the same methodology for each workshop. In each session, we pasted a large print-out of a project-based business model design framework on the wall and used this framework as a cognitive mapping tool (Ambrosini and Bowman, 2001). The framework was specifically developed for architectural firms in a previous study (Bos-de Vos *et al.*, 2017) on the basis of business model and project governance literature, field reports and interviews with Dutch architects and clients. The participants were given Post-it notes to fill in the framework. This process was divided into nine steps, which successively paid attention to the firm's value proposition, value capture goals, activities, risks, resources, partners, costs, revenue model and agreements in the project. The workshops all started with an introduction in which we showed the framework and explained each step with examples of possible answers. Firm-specific and project-specific information were gathered additionally for triangulation purposes.

Data analysis is still ongoing and consists of four iterative steps, which result in the construction of a 'discursive event history database' (Hardy and Thomas, 2014), including what was said when and by whom. We used the software program MAXQDA as a supporting tool. In the first analytical step, the process of each workshop was thoroughly analysed by replaying videos on the basis of the event log. We further refined the observational data in our event logs and added additional detail with quotes. In the second step, we coded instances of identity work in the observational data. We particularly focused on the purposeful efforts of actors to form, repair, maintain, strengthen or revise their sense of self vis-à-vis the surrounding contexts of the group, the organization, the inter-organizational project team and the profession (Phillips and Lawrence, 2012). Third, we searched the data for different forms of strategy work. We coded all the efforts that actors engaged in to arrive at a business model design. The framework that participants filled in during the meeting was used as a reference frame of the strategic decisions that were taken during the meeting. Our fourth analytical step aimed to locate interactions in which identity and strategy were strongly interrelated and to identify overarching patterns in the data of the different workshops. We examined the different identity-strategy interactions along the spectrum of what actors were doing (action), why they were doing it (intention) and what the consequences for the organization were (outcomes) (Phillips and Lawrence, 2012). Outcomes of our analysis will be discussed with practitioners for validation and authorization purposes.

## **CONSTRUCTING A BUSINESS MODEL**

We use episodes from the workshop at ARCADE to present and discuss the findings of our study. The ARCADE meeting was chosen as exemplary because it represents the core aspects of the interaction that we observed in different strategy meetings.

### **What are the actors doing?**

While Alan, an owner-architect, is quietly contemplating the framework that is pasted on the wall, office manager Leon thoroughly explains that what they are doing in the project can be further abstracted to what they want to do as a firm. "How do we as an office make sure that we acquire the portfolio that we want to work on?" He argues that although his organization's established "stature" in the field previously generated the public work that employees are willing and happy to work on, they now have to adopt a more active attitude to get this kind of work. Alan seems to agree completely. He walks back to his chair without any facial expression. Alan and Leon both acknowledge that the "public work" that

they have extensive experience with is simply becoming less available in the future, which forces them to enter a new market segment.

The episode above illustrates how strategy and identity were often interwoven during the workshops. The quote “How do we as an office make sure that we acquire the portfolio that we want to work on?” exemplifies that the actors chose to discuss projects that were not only intended to get future work, thereby ensuring organizational continuity; the projects also needed to fit the organizations and the professional beliefs of organizational members. Actors saw the discussed project as an intermediary between strategies (i.e. what they wanted to do to enhance their competitiveness) and identity (i.e. what they wanted to represent as a team of professionals). The strategy related discussions brought to the fore that organizations did not want any type of project. Strategy work helped the actors to reaffirm who they are and what they stand for as an organization, thereby strengthening their professional identity. Regarding this identity, we often observed a strong consensus between the actors. Alan’s quietness and neutral facial expression during Leon’s story, for example, illustrate that Leon’s story is something that they have discussed before and which has developed into a shared understanding. Similar situations were observed in many of the meetings. This strong organizational identity also seemed to influence the strategy work that the actors engaged in to enhance their commercial position. It was because of their strong professional identity that firms decided to engage in the discussed projects. Actors perceived the chosen project as a perfect representation of who they are or who they want to be. They also felt that the project would represent work that was attractive to their people. Participants thereby saw the project as a way to further explicate their organizational identity in the field and to demonstrate what they stand for as a team of professionals.

While considering the revenue models that would be appropriate for the project, Alan almost immediately points out that his organization uses two types of revenue models: a “fixed fee” or an hourly based fee. He mentions that the fixed fee is the most attractive because it allows his firm to make money as his team is able to come up with a design very quickly. Leon agrees and brings to the fore that in this particular case, the second model [an hourly based fee] could also have its benefits, especially because of the uncertainties that may be associated with the existing real estate that they have to deal with in the project. After having a quick back and forth about the two, Alan and Leon anonymously decide that there is no real urge to go for the second option and that the fixed fee model would do just fine in this project.

This episode shows how many participants discussed strategic options based on familiarity and previous experiences. The projects that were discussed, however, often included features that were considerably different from earlier business. In the example, it is Alan’s and Leon’s first time working for a private, profit oriented client instead of a public commissioner. Hence, the project is very different from their former projects. From a commercial perspective, this could provide an interesting opportunity to explore alternative revenue models. Nevertheless, the actors and many of their colleagues in similar situations did not consider other strategic options.

### **Why are the actors doing this?**

Alan and Leon’s behaviour is illustrative of how a large majority of the architects stayed away from exploring commercial options during the workshops. This might partly be explained by a lack of knowledge among the participants. Apart from some individuals who showcased a clear interest or expertise in the business side of their work, participants, for example, often seemed not aware of what a revenue model exactly is or what different types of revenue models can be used. The episode below illustrates another reason for the participants’ disregarding of commercial alternatives.

It is only after the moderator's intervention that Alan and Leon start to discuss other options that could be financially attractive. They immediately agree that this project is just not suitable for innovative revenue models. Talking about a fee based on the sales price of the to-be-developed real estate, they both continue to shake their heads and Leon summarizes that it would not enable them to work with the "joy" and "enthusiasm" that they aim for. He argues that it does not fit their firm's intentions to design something that is commercially attractive. Chuckling, Leon says to Alan: "I think we have quite a strong opinion about things that do well in the market: that's not necessarily architecture, it does not fit the signature that we deliver and have".

The episode illustrates how practitioners feared that new revenue models would jeopardize their professional duty towards the client, society, or would harm their own professional fulfilment. Leon's call for "joy" and "enthusiasm" in their work is a clear example of the latter. The interaction between Alan and Leon unravels that the two individuals have a strong shared belief about what the end result of their architectural work should be, which, in their opinions, is not in line with what people are currently willing to pay for. Their interaction thus suggests that the firm's professional service is not suitable for commercial optimisations. Other observations underline how professionals feared that the core values of their architectural work would not stay intact if they would engage in other, more commercial revenue streams. An owner-architect, for example, stated that even if he would have the money, he definitely would not want to co-finance the project. Direct commercial ties to the project were not considered lucrative by firms as the professionals would then no longer be in the position to comment on the project as "independent advisors". In the opinion of many participants, this independency is crucial to guarantee a 'pure' service provision role and thereby to deliver optimal quality of the end-product. Participants argued that a revenue model that allows the firm to profit from product optimisations would give firm members the wrong incentive. Similar to other participants, Alan and Leon referred to what they stand for as a professional organization to justify why they refrained from exploring alternative business approaches for the project. Other examples in which business model innovation was consciously prevented include firms that initiated a project, but deliberately did not make any financial agreements with their potential clients. Although participants acknowledged that it would probably have been better to make such arrangements, they argued that it "might give the wrong signal to the client" and harm their mutual trust.

## CONCLUSIONS & DISCUSSION

### Framing the business model design

Our findings illustrate how identity and strategy had a mutually shaping relationship during the process of business model design: 1) We found how strategy work helped practitioners to strengthen their organizational identity during business model design. The interaction among participants helped to put identity on the table and to contrast their specific organizational identity to that of other organizations. While pondering about strategic options, actors brought to the fore what they wanted to represent as professionals, thereby reinstating or strengthening their shared understandings of their organizations' central, enduring and distinctive characteristics (Scott and Lane, 2000). In many of the situations, the professional identity of participants seemed surprisingly well aligned. Even actors who were not educated or trained as architects, such as office managers or owners with a non-design background, exhibited a strong sense of professional belonging. This reveals how the organizational identity of architectural firms is inextricably linked to the professional identity of its members. 2) The observations also show how practitioners used identity work to frame their own strategies during the process of business model design. The data provide evidence that actors

continuously related their strategic options and decisions to the values and beliefs that they have as professionals. Because of their strong professional identity, practitioners often waived commercial alternatives away, thereby constraining the strategic options that might be suitable. We found evidence that a similar framing also occurred prior to the workshop. Although the discussed projects had only recently started or still had to be initiated, the firms' business model designs were often largely crystalized. This became apparent by the way in which actors discussed about the project in retrospect and/or gave explicit examples of decisions that had already been made.

### **What are the consequences for the organization?**

Whether the framing of the strategizing process is a good thing or a bad thing with respect to organizational outcomes is an interesting discussion. On the one hand, the practitioners' framing allows organizations to avoid risks as they can simply follow the business approach that they have tried out in many other projects. A context in which the professional organization is valued because of its services and approach would be an ideal environment for this risk-averse behaviour. On the other hand, it seems to make organizations extra vulnerable to constraints coming from outside, such as unexpected budget cuts or unforeseen difficulties in the relationship with other organizations. Professional services are increasingly devalued and contested. When operating under such conditions, organizations often have to fight for a desired role in the collaboration with other organizations (Bos-de Vos, Lieftink *et al.*, 2017). They can either try to claim this role by demonstrating their professional expertise; or change their business approaches and consequently also their organizational and members' identities to acquire this role in new ways (Ibid.). Professionals who do not want to change their identity might benefit from communicating their strategic decisions and underlying rationale to the other actors that are involved, so that these actors become aware of why it is so important to use a 'traditional' revenue model or to avoid the interference of partners.

## **IMPLICATIONS**

Even though the involved practitioners are all used to be creative, creativity in their business approaches seemed limited and further constrained by professional identity. This shows that the professional context highly influences the strategizing of professionals and the outcomes for their firms. It supports the idea that although actors are able to influence their own paths, they always carry with them the enabling and constraining factors of the context that they are embedded in and that they identify with (Phillips and Lawrence, 2012). Hence, practitioners who wish to arrive at healthy business models need to unravel the benefits and threats of their surrounding contexts during business model design. Our study highlights the importance of cross-work related research to develop a better understanding of the dynamics that are involved in organizations with multiple strategic goals and multiple identities.

The feedback that we received at the end of the strategy meetings showed that the involved practitioners were not used to strategize in a systematic way. Many participants described their regular strategizing activities as 'ad hoc', and 'sporadic'. Participants were, however, surprisingly enthusiastic about the structure that was provided. Although some people explained that the way in which the strategy workshop was organized would just not work for their organization, being too time-consuming or because the firm leaders would just go their own way; a majority of participants argued that the workshop had explicated relations and tensions that they normally do not consider in depth. This shows that architectural firms may benefit from more structured strategizing on a regular basis. It also demonstrates the need for more (action) research on strategizing in architectural

firms to develop a profound understanding of strategy-making and how this can potentially be improved.

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# **PLANNING AND PERFORMANCE MANAGEMENT**

# ELEVEN YEARS OF ARCOM: BIBLIOMETRIC MAPPING OF STUDIES PUBLISHED BETWEEN 2005 AND 2016

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The study aims at mapping the intellectual discourse that has emerged from Association of Researchers in Construction Management (ARCOM) conference within the last 11 years. To this end, the 1505 studies indexed in Scopus were examined through scientometric analyses of citation networks. The findings show that the most prominent areas of research including “sustainable development”, “health and safety” and “architectural design” have been predominantly conducted from a project management perspective. New fields of research such as Building Information Modelling have gained momentum with several years of delay after their emergence across the construction context. Besides, published studies in ARCOM have for the most part cited studies from journals allocated to managerial areas of construction management as well as management and business journals. Technology and engineering journals nevertheless turned out to have a noticeably lower share of citation. Moreover, the network of collaborations among countries indicated the dominance of the UK and Australia and underrepresentation of North American, emerging markets and developing countries. By providing a view from a meta-perspective, the study exposes the areas in need of extra attention, provides directions for defining future research themes and suggests remedial solutions for addressing the spotted problems.

Keywords: ARCOM Conference, bibliometric mapping, publications, review

## INTRODUCTION

The Association of Researchers in Construction Management (ARCOM) has been active since 1984 with the aim of bringing together active researchers in construction management field. As per the objectives set out, ARCOM is about lobbying for change in construction management field through advancing research (ARCOM 2017). This necessitates looking into existing literature from a broad view for discovering long-lasting research interests, patterns of scholarly activities as well as spotting trajectories of competing paradigms and paradigm shifts. That is, failure in gaining a wide view of the state of research, might end up in overlooking central aspects and duplication of efforts

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(Yalcinkaya and Singh 2015). To date, however, no systematic attempt has sought to present a picture of the corpus of literature produced through ARCOM in order to provide such a broad view and discover the areas in need of extra attention.

This study intends to address these things. As such, the study maps the state of existing studies published in ARCOM. The resulting accumulated knowledge will uncover patterns and relationships between concepts that have remained hidden within the ARCOM literature. The findings will produce evidence to inform, guide and improve future research areas to be pursued and promoted by ARCOM.

## **BACKGROUND**

Construction management has grown from a new academic discipline to a relatively established research area. Such a quick growth has been catalysed by the formation of research organisations such as ARCOM in the 1980s, a point argued by Birnie (2000). ARCOM is devoted to research in Construction Management, a field that is a synergistic combination a wide range of disciplines (Raiden and Smith 2015). This aim has been pursued through holding annual conferences in cities around the UK every September. The outcome of these conferences has been published in 32 proceedings each containing research studies from an average of 150 delegates in each conference (ARCOM 2017) alongside several special issues of Construction Management and Economics journal (Raiden 2015). Authors and delegates from extremely diverse backgrounds attend and contribute to ARCOM body of knowledge (Raiden and Smith 2015; Smith 2014). That is because, demands and problems of the built environment call for appropriately interwoven areas and topics of inquiry resulting in a cornucopia of theories and disciplines in construction management (Dainty 2008; Newton 2016). With this in mind, for the last 33 years, each year ARCOM has organized and held a conference to promote and disseminate this growing body of research in construction management (Smith 2014). Such a relatively large and heterogeneous body poses critical challenges in terms of identifying the research directions, understanding the primary themes, spotting the gaps and view a broad picture (Lu *et al.*, 2014; Yalcinkaya and Singh 2015).

In addition, existing trends and engagements between ARCOM and external established outlets and fields are to be investigated. That is, construction management field must actively engage with external bodies of knowledge, outlets and other research communities (Newton 2016). Construction research is enriched through promotion of methodological and philosophical pluralism (Dainty 2008) and mobilisation of theories from other disciplines (Schweber 2015). This is of central importance for the construction research community as a pathway to a deeper understanding of problems facing the industry practice and resolve them, an objective pursued by ARCOM (ARCOM 2017; Raiden and Smith 2015). Few sources to reveal the general areas covered by ARCOM are available such as regular newsletter (Raiden 2015). However, studies presenting a systematic and holistic analysis of ARCOM body of knowledge are non-existent. On top of that, there is little prospect of addressing the objectives described above through conducting a manual qualitative review of literature. The discussions above bring to light the relevance of conducting the present study deploying the methodology as described next.

## **RESEARCH METHODS**

The primary method applied in the present study was quantitative bibliometric mapping of published studies. This method was deployed in view of the considerations discussed below.

## **Bibliometric mapping**

Traditional systematic reviews are typically written by very few domain experts, who might be affected by their own specialized areas of interest and their favourite perspectives of the field (Yalcinkaya and Singh 2015). This might end up in selective inclusion of studies and bias in interpretation in order to voice one's own views (He *et al.*, 2016). Use of science mapping techniques such as bibliometric mapping considerably reduces such biases by embracing the studies of authors across a wide spectrum of perspectives, disciplines and schools of thought (He *et al.*, 2016). Bibliometric mapping refers to a knowledge domain analysis and visualisation using large-scale scholarly datasets of published studies (Cobo *et al.*, 2011). This is a quantitative method conducted by computational tools, based on network analysis principles in which the footprints uncovered by scholarly publications are studied to trace the development of science in a domain over time (He *et al.*, 2016). A wide range of science mapping tools for bibliometric analysis is available, each one with a set of different capabilities and strengths (Cobo *et al.*, 2011). Common tools include VOSviewer, Bibexcel, CiteSpace, CoPalRed, Sci2, VantagePoint and Gephi (<https://gephi.org/>) (Cobo *et al.*, 2011). Of these, VOSviewer and Gephi were selected for the present study. VOSviewer, where VOS stands for “visualization of similarities”, is a freely-available tool that offers the basic functionality needed for visualizing bibliometric networks (van Eck and Waltman 2014). Gephi is an open source network graph and analysis tool at the forefront of revolution in network visualization and analysis, which may be used to provide a thorough insight into the information achievable from a given network (Cherven 2015). As recommended by Cobo *et al.*, (2011) the general workflow in a bibliometric mapping study has to follow three main steps: (1) data acquisition, (2) network extraction and (3) analysis and visualisation. Researchers will be able to interpret and obtain some conclusions based on the information provided by the analysed and visualised networks.

## **Data acquisition**

VOSviewer allows users to download bibliographic records directly from Web of Science, PubMed and Scopus. The selected database for the present study was Scopus due to its cover on ARCOM proceedings. As of 11 January 2017, 1505 documents were indexed in Scopus covering ARCOM proceedings published from 2005 to 2016. No limitation on time frame was applied. The starting point for the analyses was nevertheless confined to 2005, that is, the first year in which ARCOM papers were indexed in Scopus. The rationale for this approach was due to Scopus's capability to export all such data in form of a dataset which was downloaded and formed the source of the bibliometric mapping analysis as discussed next.

## **Network extraction**

Different approaches can be taken to extract networks based on certain units of analysis (authors, documents, journals, and terms). Interested readers are referred to studies by Cobo *et al.*, (2011) and van Eck and Waltman (2014) for detailed discussions on common bibliometric mapping techniques and their applications. Having VOSviewer as the tool for network creation, the three techniques below were utilised. “The number of co-occurrences of two keywords is the number of publications in which both keywords occur together in the title, abstract, or keyword list.” (van Eck and Waltman, 2014: 287). Author keywords and fractional counting options as recommended by van Eck and Waltman (2014) were deployed to extract the network of major areas of research. This resulted in extraction of 8450 keywords when the minimum number of occurrences was set to 30.

A common method for identifying the most influential sources of information for a particular body of literature is analysing co-citations, which focuses on the number of references that come together frequently (van Eck and Waltman, 2014). This method was applied to the dataset with selecting co-citation of sources and fractional coupling as recommended by van Eck and Waltman (2014), resulting in identifying 18390 sources (minimum number of citations set to 50).

To identify the most influential countries and mapping the network of collaborations among countries, the dataset was submitted to VOSviewer with the type of analysis as co-authorship, unit of analysis being countries and the counting method set to fractional counting. The minimum number of documents and citations of a country were set to 5 and 5, respectively. Out of 56 countries within the dataset, 18 met these criteria to be included in the network.

## **ANALYSIS AND VISUALISATION**

### **The scholarly impact of ARCOM**

In view of the downloaded dataset, 1505 documents published in ARCOM cited 27924 published studies, and were cited by 1235 documents according to the citation analyses provided by Scopus (by 26<sup>th</sup> June 2017). Using the citations per publication (CPP) values as suggested by Butler and Visser (2006), ARCOM had a CPP value of 0.82. This CPP value was higher than the average for the associated fields, compared against the overall CPP values for Architecture (0.196) and Engineering (0.09) fields (Butler and Visser 2006). Besides, ARCOM papers were found to have impacts beyond the construction contexts, being cited in various fields according to the subject area provided by Scopus. The fields with the largest number of citations were Engineering (923), Business, Management and Accounting (478), Social Science (129), Computer Science (127) and Environmental Science (84). Nevertheless, there were citations from Energy (39), Medicine (23), Mathematics (19) and Arts and Humanities (18). These point to the widespread impacts of ARCOM in areas beyond construction management.

### **Major areas of research**

As the result of the co-occurrence network analysis, 72 keywords connected through 1750 links formed the resultant network, which was submitted to Gephi for analysing and visualisation. Generic research terms such as “survey” and “interviews” were removed from the network and similar terms (such as construction safety and safety) were merged. This resulted in a network as illustrated in Figure 1. The average degree values calculated by Gephi were utilised to resize and recolour network nodes based on their degree values as an indication for the level of importance of nodes in network analyses (Cherven 2015). Nodes with a higher degree were demonstrated in larger sizes and brighter colours. The network in Figure 1 is also a distance-based map that shows closeness among nodes with a smaller distance (van Eck and Waltman 2014).

As illustrated in Figure 1, “project management”, “sustainable development”, “health and safety” and “architectural design” have been the most prominent research areas investigated by the studies published in ARCOM. Figure 1 demonstrates the centrality of “project management” as the main area of research in published studies in ARCOM. Project management is in a strong association with a wide range of research areas in the network (such as “knowledge management”), judging from the size of the links connecting the two areas. In essence, a major part of research areas are investigated against the backdrop of project management as illustrated in Figure 1. Several areas nevertheless have remained underrepresented judging from the network (see Figure 1).



from 2014 onward. Given that construction research is supposed to address the concerns of the industry (Schweber 2015), such a delay is seen as a problem, to be addressed by ARCOM policy makers.

Table 1: Change of themes in ARCOM over time

| Year | Most prominent themes                                    |
|------|--|
| 2016 | Building Information modelling, BIM, Procurement         |
| 2015 | BIM, Innovation, Sustainability                          |
| 2014 | Risk, Procurement, BIM                                   |
| 2013 | Sustainability, Procurement, Project management          |
| 2012 | Sustainability, Procurement, Supply Chain Management     |
| 2011 | Procurement, Sustainability, Supply Chain,               |
| 2010 | Sustainability, Project Management, Knowledge Management |
| 2009 | Project Management, Knowledge Management, Communication  |
| 2008 | Project Management, Education, Health and Safety         |
| 2007 | Project Management, Risk Management, Safety              |
| 2006 | Productivity, Construction, Partnering                   |
| 2005 | Innovation, Knowledge Management, Construction           |

### Influential journals

Analysing co-citations is a practical method to extract the most influential outlets in a dataset. With details as discussed, 38 sources connected via 649 links met the threshold to be included in the network. The network was submitted to Gephi for further analysis. To identify the sources with the highest level of influence, the concept of weighted degree was used. That is, the number of connections is a key measure of importance or influence within the network. The weighted degree of a node is based on the number of links, moderated by the weight of each link to indicate the sum of the weight of the links. Weighted degree provides a good proxy for relative importance in a network structure (Cherven, 2015). Table 2 illustrates the ranking of cited journals based on the weighted degree values calculated by Gephi for the constructed network.

As illustrated in Table 2, “*Construction Management and Economics*” stands out as the most prominent outlet influencing ARCOM research with a weighted degree of 913.51. “*International Journal of Project Management*” (weighted degree 572.23) and “*Journal of Construction Engineering and Management*” (weighted degree 466.77) were also the outlets with a high weighted degree compared against other outlets included in the network. As such, the literature published in ARCOM is mostly concerned with economy, project management and areas associated with management, as subsets of construction management discipline. This observation is supported in view of the appearance of journals from the management discipline such as “*Academy of Management Review*” as well as business-oriented outlets (“*Harvard Business Review*”). This indicates the increasing attention of investigators who publish in ARCOM to mobilise theories from management-oriented outlets for addressing soft and managerial areas of construction management where technology-related areas and innovative methodologies and applications play a smaller role in ARCOM literature. In fact, the findings indicate that ARCOM has a tendency towards managerial areas of construction management rather than engineering and technology aspects. As illustrated in Table 2, “*Automation in Construction*” as the target of technology-oriented publications played a role in the same level with purely management journals and “*Information Technology in Construction*” was not included in the list with “*Construction Innovation*” being the least important within the network (even below “*Administrative Science Quarterly*”).

Table 2: Fifteen top scholarly outlets influencing research in ARCOM (weighted degrees ranking)

| Journal  | Weighted degree | Rank |
|--|-----------------|------|
| Construction Management and Economics              | 913.51          | 1    |
| International Journal of Project Management        | 572.23          | 2    |
| Journal of Construction Engineering and Management | 466.77          | 3    |
| Automation in Construction                         | 193.51          | 4    |
| Journal of Management in Engineering               | 177.43          | 5    |
| Academy of Management Review                       | 172.39          | 6    |
| Harvard Business Review                            | 110.77          | 7    |
| Building and Environment                           | 105.77          | 8    |
| Strategic Management Journal                       | 103.14          | 9    |
| Safety Science                                     | 101.30          | 10   |
| Academy of Management Journal                      | 100.86          | 11   |
| Building Research and Information                  | 97.02           | 12   |
| Organization Science                               | 94.82           | 13   |
| Administrative Science Quarterly                   | 91.3831         | 14   |
| Construction Innovation                            | 82.9328         | 15   |

### Scientific collaboration networks in ARCOM

Awareness of existing scientific collaboration networks in any field of research facilitates access to funds, specialties and expertise, enhances productivity and assists investigators to reduce isolation. This ultimately benefits scientific collaboration and boosts scholarly communications (Ding, 2011). With this in mind, this section presents an analysis of co-authorship network of investigators within the dataset. The resultant network was submitted to Gephi for visualization and average degree values were utilised to identify the most influential countries within the extracted network as illustrated in Figure 2.

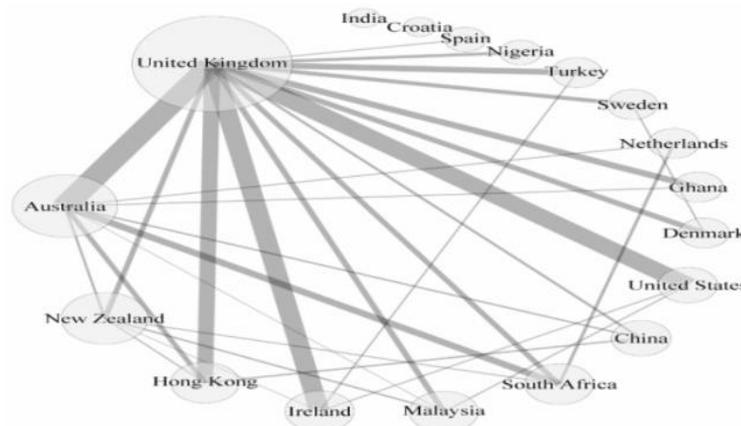


Figure 2: Collaboration network of ARCOM literature among countries

Nodes were resized based on their degree values with larger nodes showing higher average degree values. The network as illustrated in Figure 2 shows that the UK stands out as the most influential country within the collaboration network for publishing in ARCOM. Interestingly, the US and China were not found to be prominent players in the network. Australia and New Zealand researchers turned out to be influential in ARCOM where the strongest links of collaboration were formed by the UK and Australia, the UK and Hong Kong, the UK and Ireland and the UK with the US corroborating the central role of UK investigators as the driving force behind published studies in ARCOM. The findings reveal the low influence of North American investigators in ARCOM in view of Canada being absent from the network and the US showing low influence. Besides, large and emerging construction markets such as China, India and the Middle East had a limited role in forming the body of knowledge produced by ARCOM. The same case was

observed for developing countries from which very few were in the network albeit with a small role.

## DISCUSSIONS AND RECOMMENDATIONS

The study stands out as the first of its kind, presenting a broad picture of the landscape of research published in ARCOM. The findings have three main implications for policymaking and directing ARCOM in the years to come. First, findings demonstrate that developing countries, particularly countries with an emerging construction industry and of largest size of construction market have been underrepresented in ARCOM. The case for China, India, the Middle East, etc. should be of particular interest given the size of these markets in the future of the construction industry (Wang 2014). ARCOM aims at enhancing construction management research (Raiden and Smith 2015). This calls for devising plans by ARCOM policy makers to attract investigators from aforementioned areas. One remedial solution might be incentives in form of discounted registration rates for investigators from developing countries as well as defining conference themes to promote conducting research on emerging construction markets. Location of the venue is another important factor affecting delegates in attending a conference (Severt *et al.*, 2007). Therefore, defining venues outside the UK in future ARCOM annual conferences might be another approach to value contributions from delegates currently underrepresented in ARCOM.

Second, the findings provide evidence showing that research studies published in ARCOM have been mostly driven by or contribute to managerial areas of construction management. More so, the current published studies have been predominantly addressed various problems through the lenses of project management. The findings are in line with statements by Raiden (2015), who argued that project management draws a large number of submissions to ARCOM. Yet, building information modelling was not found to be a dominant area of ARCOM prior to 2014, in contradiction with anecdotal arguments (Raiden 2015). Similarly, sustainability has become a prominent areas for ARCOM with several years of delay. ARCOM policy makers have to deal with the problem of delay in addressing the concerns of the industry through aligning ARCOM priorities with present-day hot topics within the industry, a remedial solution to resolve the issue of delay as came to light by the findings of the study. The flow of information has been from few journals from construction management discipline alongside prominent management and business scholarly outlets. Publishing selected papers from ARCOM (the 29th and 30th conferences) in Construction Management and Economics indicative of the long-lasting association between ARCOM and such outlets (Raiden and Smith 2015; Smith 2014). This might also be a reason behind the profound influence of Construction Management and Economics in ARCOM as discussed. Technology and outlets focused on innovative methods in the construction context have not been influential sources of information for studies published in ARCOM. To provide advice for industry practitioners with regard to current problems facing the industry, however there is a need for greater focus on technological innovations and emerging trends within the industry. This proves a need for extra attention to studies pursuing technological innovation with theories borrowed and imported from the literature outside the boundaries of project management and management-focused areas. Third and finally for future ARCOM research agenda, the findings demonstrate the need for promoting studies that integrate several research areas to address problems. For example, integrating sustainability with innovation to solve problems or enhancing collaboration through information technology as future themes for ARCOM might be beneficial. Interaction with other disciplines, borrowing external theories and combining various methodological perspectives provides construction

management community with an expansive outlook (Raiden and Smith 2015) as an area calling for attention in view of the findings of the study.

## CONCLUSIONS

The findings as reported in this paper have been drawn from 1505 studies indexed in Scopus and the networks of studies associated with them through citations. A number of scientometric analysis techniques were used to highlight and analyse the intellectual discourse from the proceedings of the ARCOM published between 2005 and 2016. Based on the scientometric analysis techniques, this study constructed the network of major areas of research published in ARCOM (see Figure 1). From the analysis, the most prominent areas of research were: (i) Project management; (ii) Sustainable development; (iii) health and safety; and (iv) architectural design. Secondly, “developing countries” were an isolated and under researched field. In contrast, the UK emerged as the most influential country based on collaborations (see Figure 2).

The results of this study are expected to enhance the level of understanding about state-of-the-art of ARCOM as a scholarly outlet in construction management. Furthermore, the discussions put forward provide directions for future developments and collaborations in the field through exposing overlooked areas, existing links with influential outlets and delegations and countries involved in ARCOM. However, this study has a number of limitations that can be addressed in future research. The analysis only covers the literature retrieved from Scopus as published during 2005 to 2016, thus does not fully reflect the entire available corpus of literature produced by ARCOM. Furthermore, the analysis is based on the citation dataset provided by Scopus and hence, the findings are affected by the limitations of Scopus in terms of coverage. Further research hence is required to address the limitations as acknowledged using various datasets. Even more, focusing on the gaps, problems and providing remedial solutions to address these drawbacks with ARCOM are fertile grounds for future investigations. Secondly, conducting cross sectional studies based on methods similar to that of the present study is beneficial in terms of continuous assessment of developments and directions of ARCOM. Finally, there is a further need for investigating the impact of funding priorities, government reforms and restructure of the institutional landscape that sponsors activity around the construction industry. More so, these could be extended by exploring whether the reforms in higher education all contribute to changing emphases over time. In order to enhance and facilitate further discussion of developments in other more mainstream disciplines and fields, it is recommended to use more rigorous science mapping tools such as CiteSpace. Whilst this approach was beyond the scope this study, it would nevertheless provide the opportunity of the creation of a network including ARCOM and other disciplines.

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# THE UNEXPLORED BRUTALITY OF PERFORMANCE RECIPES

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Lean, Partnering and BIM are well-known recipes for construction industry improvement. However, the spread of the ideas, principles and technologies from the recipes into the industry is so far limited. This can be attributed to a gap between the persuasiveness of reductionist thinking and linear diffusion models on the one hand, and the realities of complex, messy, and fragmented construction activities on the other. Still, attempts are being made to broaden the appeal and increase the coverage of performance recipes - also by linking them together into a broader, but still vague notion of Integrated Project Delivery. It is unclear whether merging the different performance recipes and their underlying ideas actually makes sense. To address this issue, we develop a systemic perspective of construction and the complexity of construction is highlighted. Reductionist assumptions that the performance recipes build on are exposed as assumptions regarding complexity and complexity management are analysed. The basic relationships and tensions between recipes and the significance of conscientiously directing future innovation efforts, are highlighted.

Keywords: BIM, Integrated Project Delivery, lean construction, partnering, systems

## INTRODUCTION

Since researchers at the Tavistock Institute of Human Relations in London during the 1960s drew attention to complexity as a core issue (Building Industry Communications 1966, Foster 1969, Higgin and Jessop 1965) there has been a stream of research on the effects of complexity in construction. Schumpeterian ideas on markets and innovation developed by Freeman and colleagues during the 1980s (Fagerberg *et al.*, 2011) have in turn directed scholarly and political attention towards the derogatory effects that complex interactions and dependencies have on innovation in the construction sector, leading to dismal productivity trends and disappointing quality (Dubois and Gadde 2002, Manseau and Shields 2005). The Tavistock researchers recognized that construction communication takes place in a highly complex form of industrial production. Since then, much research has further developed this understanding (e. g. Gann and Salter 2000, Winch 2006), and has analysed in greater detail what the effects are of significant interdependencies between tasks, project phases, and organizations involved in the construction process (Gidado 1996, Kreiner 1995, Winch 2010, Orstavik, Dainty and Abbott 2015).

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In the context of a predominantly managerial discourse, despite recognising complexity innovation in construction tends to be seen as a one-way diffusion process. Innovation is to be facilitated by management and is equated with the beneficial spread of novel technologies and operational ideas to a population of firms: from those that are 'in the know' to those that are not. Innovation is furthermore equated to technological change, as the uptake of new materials, products, equipment or machinery for use in the building process, with little discussion of related adjustments on the side of application, in methods and production process configurations.

Given that the industry's products and processes are dynamic and complex systems, dealing with the challenges facing the industry (in terms of productivity, quality etc.) cannot but depend on dealing with issues of interdependent systems. Making specific improvements to selected elements is often doomed - they do not make a lasting impact. Some issues can only be dealt with through actions that address structural aspects of the overall system. This we take to be an underlying reason why a number of broad improvement recipes have been devised. Lean Construction, Partnering and Building Information Modelling (BIM) are comprehensive and well-intended recipes for industry improvement and change. Lean Construction together with Partnering and BIM arguably form 'primary performative improvement recipes' in the modern construction industry (Sage, Dainty and Brookes 2012). These strategies represent different takes on what is needed, and they have so far been heralded by different people and different communities, making them stand out as diverse "schools" with distinct recommendations for what will deliver a re-constructed construction industry.

Despite rhetoric at times tending towards the euphoric, the actual performance effects of the recipes are more difficult to measure (Ilozor and Kelly 2012). The spread of the principles and related technologies has been slower than many would have hoped for. In part as a consequence, there are attempts made to bridge the conceptual gaps between the different approaches. For example, Sacks and colleagues discuss the potential benefits of combining BIM implementation with Lean Construction principles (Sacks *et al.*, 2010), while Ilozor and Kelly discuss how an overall, Integrated Project Delivery approach can integrate with BIM (Ilozor and Kelly 2012). Is the idea of combining Lean, Partnering and BIM into an all-purpose, integrated strategy sound? Do the three approaches lend themselves to being merged with each other so as to align interests, practices and objectives based on a team based approach, based on multi-party agreements and the use of technology - BIM - that allows for much more extensive information sharing and collaboration between project participants? These are the two questions posed in this paper, where we take as our starting point that construction processes are fundamentally dynamic and complex.

## **THE SYSTEMS PERSPECTIVE**

From a systems perspective, complexity is a processual property that is derived from the configuration of elements and linkages in a system. In terms of managing systems, complexity poses different challenges in different kinds of systems. Coping with complexity depends in a fundamental way on whether the system is open or closed.

### **The Inexorable Complexity of Real World Systems**

The basic definition of a system is simple: a system is a set of related parts (Bertalanffy 1971: 54-56, Buckley 1967: 9, Luhmann 1984: 41-44). Challenging a tendency to think about systems as more or less stable structures, Luhmann employs a dynamic - process - view when discussing the nature of systems and systemic complexity (Luhmann 1984).

Nicolis and Prigogine (1989) similarly define complexity based on the consideration of dynamic behaviour. For example, they show how naturally dynamic systems such as molecules making up a volume of liquid can display patterned but fundamentally unpredictable behaviour (Nicolis and Prigogine 1989, 8-15). It is this patterned, but in some aspects completely unpredictable behaviour, that they define as complexity (or complex behaviour).

Luhmann pursues a similar line of reasoning, namely that complexity is an attribute of any large, dynamic system. All elements must be connected to at least one other already related element, simply to be part of the system. Many elements and groups of elements are not linked directly but indirectly via other elements in the system. Complexity necessarily arises in systems as the number of possible linkages between elements becomes higher than the actual number of linkages that are established (Luhmann 1984: 45-47). Complexity, therefore, follows from incomplete integration of elements. In addition, elements and linkages, not least in social systems, are prone to influence each other.

A fundamental cause of complexity, then, is that elements have a limited ability to 'multi-bond' (or multi-task), in the sense that each element cannot uphold active linkages to more than a few other elements in the system. If elements possessed an unlimited capacity of multi-tasking, systems could in theory become large without becoming complex, but in any large, real world system there is no way to completely avoid complexity. Complexity can be changed qualitatively (structurally), and can be reduced by limiting the number of elements included in a system. However, as Ashby's law on requisite variety makes clear, this can only happen at a cost: a smaller and less complex system is less able to cope with a complex environment than larger and more complex systems (Ashby 1958, Luhmann 1984: 47-48). Changing the complexity in a given system is certainly possible, for example, when a project organization is reorganized into a more bureaucratic structure, or when one-way traffic is introduced in a logistical system on a building site.

### **Complexity in Open and Closed Systems**

Ashby directs attention to the fact that systems generally exist in an environment, and that there are interactions between the system and the environment that are significant, but in terms of function are distinct from the system. To cope with a challenging environment, a system needs to uphold a significant level of complexity, and must therefore learn to cope with uncertainty and risk. This is different in a closed system, within which functionality can make the system stable and developments predictable. Considering society and organizations as systems, the question is whether these are closed or open. While Parsons (1979 [1951]) tended to depict the social system as a closed system in equilibrium, organizational theorists challenged this (Scott 1987). Gouldner (1954) critiqued advocates of scientific management for unduly portraying production systems as closed off from their environment. Efforts to develop comprehensive, self-reliant production systems in his view were doomed.

Part of the problem Gouldner saw was that managerial thinking was reductionist in tending to deal with people as automatons. This kind of reductionism - which for obvious reasons also can be seen as embodying a considerable level of brutality with respect to dealing with workers - was exposed in the Hawthorne studies during the 1950s (Jones 1990), and key insights were re-articulated by Thompson in 1967. The argument he made was that a firm must be an open system. He directed attention towards his contemporary organizational theorists who argued that the organizational complexity that managers

have to deal with is caused as much by the environment as it stems from the production system and the administrative system of the organisation itself (e. g. Cyert and March 1963, Simon 1973). While Taylor and his followers saw routines as procedures worked out scientifically and imposed on workers by unforgiving management, the new organization theorists argued that brutally imposed routines will tend to be ineffective. Routines can only provide heuristic templates for action. This difference forms the basis for the second and more comprehensive understanding of reductionism in the present paper. In non-reductionist organization theory routines have been defined as repetitive, interdependent action that emerges from interaction of multiple actors over time (Feldman and Pentland 2003). Pentland and Rueter (1994) similarly describe routines as ongoing and effortful accomplishments, hence as something very different from the management-defined action instructions envisioned by mainstream, reductionist project management theorists.

## **COMPLEXITY IN CONSTRUCTION PRODUCTION**

Systems theory makes it possible to distinguish complexity in terms of the kind of system that complexity arises within. In construction, different forms of complexity arise in the technical systems making up the built object, in machinery and equipment used during the design and building phases, in the economic, contractual and administrative systems, and in the social systems. In all these cases, complexity entails a level of unpredictability and uncertainty, and therefore risk. In any of the systems, complexity has to be taken into consideration when systems are created and elaborated. Limiting the size and heterogeneity of systems; structuring systems hierarchically; and modularization of systems are three approaches to coping with complexity well-rehearsed in construction and building. Risk assessments made during operations is another example of how complexity is managed in practice.

That construction projects are temporary production organizations only strengthens the argument that construction production systems are open systems. Routines are complexity-processing devices that, for example, serve to reduce social complexity by providing functional connections among individuals and groups (Feldman and Rafaeli 2002). Routines also serve to co-ordinate the actions of individuals and groups within a construction project, while providing flexibility and adaptability to cope with the fluidity of situations (Kreiner 1995). By facilitating effective, joint action, routines serve to integrate tacit knowledge available in a project and to trigger motivation and commitment. In this sense, routines are structuring devices used to cope with different forms of technical and social complexity. Routines, furthermore, embody the results of negotiations in design as well as in production.

### **Lean Construction and Complexity**

The term Lean Production was popularized and made widely known by Womack and his colleagues, in their book discussing the challenges facing the American car industry as it seemed to be out-smarted by an emerging and much nimbler Japanese industry (Womack, Jones and Roos 1990). They characterized the Japanese production system as lean mainly for two main reasons: first, fewer workers were needed in the highly automated Japanese factories, and, second, fewer engineers were needed to manage the workers that remained in the plants.

To see why this could be the case, a paramount difference between the Japanese and American versions of mass production has to be considered. The Japanese accepted that car production systems could not ever become closed systems, and that for this reason

complexity could never be eviscerated. And since some level of unpredictability, uncertainty and risk therefore would remain, it would be a colossal waste of human resources to ask of employees not to be intelligent, creatively problem solving and engaged workers (Womack, Jones and Roos 1990, 53-58). In the Japanese system, every worker were to be engaged in improving technical systems. At the same time they should be integrated into the social fabric of the production organization and join their co-workers in teams responsible for pursuing improvements and quality control (Ibid. 98-100). In the American system, workers were treated differently, apparently as near-equivalents to machinery. As a consequence, the organization of the factory as a socio-technical production system was seen as the responsibility and domain of professional engineers and managers. In the Japanese version of mass production, empowering workers to take part in the ongoing, distributed process of improvement and innovation, led to a lean production system where engineering oversight of production could be reduced, and were "distributed intelligence" instead of overly centralized management afford a more flexible and responsive production system.

This is not the occasion to go into detail regarding the many and significant developments that have been made in lean construction theory and practice. However, the point can be made that in much of the literature on Lean, the complexity theme is discussed in rather terse terms as an issue regarding the need for "flow" and eschewing "waste". In the influential guide to Lean Construction practice known as the Last Planner system (Ballard 2000), it is made clear that complexity structuring of the work process is to be effected in a collaborative effort between stakeholders. The task of coping with complexity not understood as external to the production process. In a system of joint planning and negotiation, employees become integrated in the overall production system in a more engaged way. Furthermore, in line with Ashby's law of requisite variety, the complexity of the social system and the complexity of the technical system are brought to bear on each other. Employing the Last Planner concepts, the interaction between stakeholders (those contributing to the production process) becomes essential for upholding the dynamism and the efficiency of the whole production system.

Arguably, several contributions to the Lean Construction literature are rather dogmatically concerned with Lean as a productivity enhancing arrangement. By working in a "lean way" waste is thought to be minimized and productivity optimized (i.e. Mossman, Ballard and Pasquire 2011), and reasoning regarding work activity tend to become reductionist. Then, anything a building worker does that is not directly contributing to "user value", is defined as waste. Workers and project managers are invited to negotiate and find the most effective way to co-produce, but at the same time, it is claimed that a minute spent with co-workers not producing output, for example, building friendships and discussing how to deal with unreasonable employer demands, represents wasted time and is to be eschewed. Arguably, when lean construction is understood in this particular way, this performance recipe does fit the bill of a reductionist ideology.

### **Partnering and Complexity**

According to Womack and colleagues, commitment, loyalty and community orientation are basic features of Japanese mass production workplaces. This, however, also applies externally, in particular in a production organization's active relating to suppliers and customers (Womack *et al.*, 146-156). Where the American mass production type relies on market transactions that are in principle instantaneous, the Japanese system is based on business relationships of a more lasting kind. Suppliers and customers become parts of

the firm's extended social system. Based on the culture and the values of the company, trust is built. This allows for adjustments being made in order for products to comply with customers' expectations, and for suppliers to be able to deliver goods that comply with the manufacturer's demands.

The literature on partnering has become extensive since the basic ideas were introduced into the industry in 1991. Partnering place trust and collaboration at the heart of efforts to increase performance (Bresnen and Marshall 2000). Early involvement of key actors in early and later project phases is seen as a key factor in successful projects (Cheng, Li and Love 2000, Cheng *et al.*, 2004). Similarly, long-term relationships are seen as providing a social context where trust can be established. Trust is conducive to returns on previous learning investments, knowledge exchange and integration, which are in turn important for productivity and innovation (Dubois and Gadde 2002).

Since Partnering is emphasising the social aspects of construction, what stands out regarding this performance recipe is the importance of involvement of different stakeholders in order to mobilize their resources for the project. Importantly, adequate resource mobilization is seen as a much subtler issue than what can be handled effectively for instance by developing formal contracts alone. The scope and heterogeneity of construction projects demand that many different contributing partners jointly engage in 'accomplishing a sophisticated cooperative project task' (Cicmil and Marshall 2005, 534). This makes it obvious that project success depends also on the ability to integrate diverse types of knowledge. As Bresnen and colleagues (Bresnen *et al.*, 2003) remark, it is only with a certain level of common understanding that the knowledge of others will be accepted as valid and effectively deployed.

Again, as in the discussion of Lean Construction, this is not the place to go into details regarding theoretical and practical advances in research on partnering. The fundamental point we wish to make here is generic. It is that project integration by way of partnering is a method of coping with and managing complexity, and this in multiple systems at the same time. Partnering serves to integrate social systems of different organizations, and thus to restructure the complexity of these systems. At the same time, partnering effects complexity structuring on the level of technical systems of products delivered, and serves to structure systems of material flows and logistics in general. Hence, technical systems and social systems co-develop to a larger extent than what would have been possible without partnering. The complexity of each system is brought to bear on other systems. Seen from this angle, there is little to support a claim that Partnering is a reductionist recipe for improvement of the construction industry. One could be tempted to draw a contrary conclusion, namely that as a broad strategy of integrating projects technically, socially, logistically and in terms of contracting, it may be encompassing too much, for Partnering to be possible to operationalize as a coherent and practical improvement strategy.

### **Building Information Modelling and Complexity**

Womack *et al.*, laud the Japanese form of mass production for its proclivity to develop advanced automation systems in factories, and argue that the general orientation towards empowering employees actually is conducive to further process innovation in the industry. Their argument is the same as the argument employed by other researchers referring to the Nordic socio-economic model, as found in Scandinavian countries. They see Scandinavian workers as empowered and as an active contributing partner in business contributing actively to innovation. A main reason this happens is that workers

themselves get a fair share of the benefits from the use of new technology (Barth and Moene 2015).

In construction, building information modelling (BIM) has the potential to contribute in a similar manner as automation technology does in mass production industry. BIM introduces a new, high complexity information system potentially able to match the complexity of existing systems in the built object and in the production system, and to influence the complexity of different systems (social, technical, contractual, etc.) in meaningful and beneficial ways. For a third time, we emphasise that this paper is not the place to detail recent developments, in this case BIM as a performance recipe. It is the generic principles that are of interest here.

BIM is currently envisioned as an overall information system in which a virtual replica of the built object and the production process can be created even before the actual building effort takes place. Advocates of BIM tend to argue that as much as possible of the overall structuring of the complexity of the built object as well as the production process should be effected *ex ante*, by specialized professionals exploiting their own competence and the powers of software and computers to create detailed models.

The belief seems to be that the total complexity of the built object can and should be modelled and the structure verified before the actual building starts. Furthermore, since the order of assembling all the parts can be clearly defined in the model, the structuring of the entire building project should follow from the logic of the basic BIM instance created for the project. Understood in this way, BIM undoubtedly has a “Fordist” and reductionist bent. The technical systems and their complexity are taken to be primary, and the other systems, not least the social systems involved, are presumed to be secondary and are presumed to be yielding faced with overriding technical considerations and dependencies. Understood in this way, BIM and the conception of complexity management built into it, arguably stands opposed to Partnering and Lean, conceiving of systems as closed and complexity to be technically manageable.

Certainly, there is a significant gap between current BIM practice and such reductionist, grand visions (Harty and Davies 2013, Lindblad and Vass 2015, Miettinen and Paavola 2014). Miettinen and Paavola express doubts as for the usefulness of the idealizing visions of BIM (2014: 88), but they are not explicit regarding the source of this doubt. We would suggest that there has to be fundamental doubt regarding BIM as a reductionist performance recipe. The reason is the same why Ford’s version of mass production proved unworkable and inferior over time to the Japanese version of industrial mass production. Advocates of comprehensive BIM implicitly and erroneously presuppose that the production system for built objects can be set up as a closed system.

## **CONCLUSION**

By developing a systems perspective and considering the way Lean, Partnering and BIM as three broad performance recipes suggest to manage complexity, we have found that the three approaches have clear differences. In its most crude and naïve form, Lean Construction is clearly reductionist. However, a more fundamental message from Lean research and practice is that complexity cannot be handled effectively only up-front and only top down. This corresponds to the conclusion Luhmann arrived at in his discussion of complexity management in organizations. Intelligence has to be distributed, and agency of all involved parties is important to be able to structure operations and work flows in a good way in complex organizations. By focusing on relationships and multiparty contracting, Partnering resembles Lean, but can be seen as addressing

complexity structuring of other systems than those commonly addressed in lean practice (which is concerned to a large extent with work processes on-site). In advocating the need for negotiating satisfactory overall arrangements and the development of trust-based relationships, also Partnering is based on the notion that intelligence and decision making powers have to be distributed among partners.

Finally, we have pointed out that BIM in its most naïve, visionary and comprehensive conceptualization form clearly is reductionist. This kind of BIM also embodies a rather obvious element of brutality, since the social have to obey the demands imposed by the technical realm via the BIM model. However, if BIM-development can be directed towards creating tools for empowering workers, then BIM could be made to serve the purpose of empowering those engaged in building; making them better able to understand dependencies, foresee consequences and to avoid unnecessary risk. Lean, Partnering and BIM can all be made to facilitate what Luhmann recommended - distributing intelligence and decision making powers in the complex production organization. Respecting the essential roles of the diverse systems making up the production system, the three performance recipes adding up more than detracting from each other. In this way, the three recipes can even be made to promote brutalism in construction in a non-brutal way; in the precise sense of the word "brutalist" - construction with everything but the functional essentials removed from it.

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# PROJECT PERFORMANCE - AN EMERGING CONSTELLATION OF MULTIPLE INSTITUTIONS

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Project performance is often conceptualised as a few quantitative and disjointed parameters, like the classical time, cost and quality triangle, or the balanced scorecard's four fragmented dimensions. Rarely, is sociological theory mobilized to appreciate the complexity of a project's performance. However, a design-build project's performance can be conceptualized through the lens of institutional work and as a result, be understood as an emerging constellation of multiple institutions. To understand potential relationships between institutional processes and project performance, an ex-post study was conducted of two completed design-build projects. The ex-post study was based on interviews carried out with key participants from the two design-build projects. While each project developed multiple relationships between institutions over the course of the project, the projects were characterized by particular constellations of institutions which we denote 'settled domination' and 'conflict and competition'. Settled domination resulted in project performance that pre-dominantly satisfied the dominant institutions while project participants expected and more-or-less accepted that remaining institutions were compromised. Conflict and competition resulted in project performance characterized by a mix of compromised and uncompromised institutions. Overall, the two projects show that project performance is an emerging qualitative concept that gradually settles during the aftermath of the building phase.

Keywords: project performance, institutional process, institutional work

## INTRODUCTION

Within management research projects are often framed as unique and uncertain and studied from a functionalist perspective. As a result, project performance is understood as execution-oriented: concerned with how to deliver buildings on time and on budget (e.g. Flyvbjerg 2010) and managing risk and uncertainty (e.g. Winch and Maytorena 2010). However, a number of important contributions highlight how projects are significantly institutionalized and as a result, project process as well as outcome varies little from project to project (Kadefors, 1995). Contending that design-build projects are social structures developing through social processes, project performance becomes less a matter for managed uncertainty and activities, but rather managed shared meanings, interests, norms and values. Institutional analysis is well suited to conceptualise this as stabilized institutions interact with processes of institutional work, changing and developing institutions (Lawrence *et al.*, 2009). However, only few studies have been

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found that specifically define and elaborate project performance as an institutional concept (exceptions include Mahanlingam 2005 and Rasmussen *et al.*, 2017).

In an attempt to get a deeper insight into the phenomenon of project performance and move beyond relatively reductionist definitions, the following research questions have inspired the research presented in this paper:

RQ 1: How does institutional work during the design-build processes relate to project performance?

RQ 2: What characterises a high performance project?

The research contribution is a commencing of conceptualising performance in an interpretive sociological manner. Institutional theory is well suited to perform such an enrichment. Two constellations of performance is thus empirically identified; 'settled domination' and 'conflict and competition'.

## **INSTITUTIONAL WORK**

To understand how emerging design-build processes evolve into a temporarily stabilized order i.e. project performance, inspiration is drawn from recent streams of sociological institutional theory, in particular institutional work (Lawrence *et al.*, 2009). Institutional work, seeks a balanced view of agency and structure: while appreciating, that structures can indeed structure interaction, agency is interpreted as being reflective, politically savvy, and motivated to create, maintain and/or disrupt institutional arrangements for the purpose of furthering the interests of individual organisations (Lawrence *et al.*, 2009). Suddaby and Greenwood (2009:176) propose the following definition: 'an institution may take the form of juridical regulations, informal rules or codified social arrangements, norms of conduct, or cognitive structures that provide understanding and give meaning to social arrangements.'

Initial contributions on institutional work are not explicit about the number of institutions that actors can purposefully attempt to change (Lawrence and Suddaby 2006; Lawrence *et al.*, 2009). However, it is recognised that organisations operate within a sphere of multiple institutional logics (Thornton *et al.*, 2012); have to satisfy pluralistic institutional demands (Kraatz and Block 2008); are faced with complexity arising from the existence of multiple institutions (Greenwood *et al.*, 2011); and, that multiple institutions can coexist in organizational fields (Zietsma and McKnight 2009; Greenwood *et al.*, 2010; Lounsbury 2007). Specifically, Goodrick and Reay (2011:403) developed the term 'constellations' to denote the co-existence of multiple institutions arranged 'in a recognizable pattern'.

Numerous contributions have shed light on the relationship between institutions: how a single institution can dominate another institution (e.g. Suddaby and Greenwood 2005); how a single institution can dominate other institutions (Gestel and Hillebrand 2011); how two institutions compete for dominance (e.g. Greenwood *et al.*, 2011); how multiple institutions compete for dominance (Goodrick and Reay 2011); multiple institutions can be conflicting and/or contradicting (Jarzabkowski *et al.*, 2013); how proto-institutions (i.e. institutions in the making) compete for legitimacy and dominance over established institutions (Zietsma and McKnight 2009); how institutions can co-exist relatively peacefully (Gestel and Hillebrand 2011); institutions can be cooperative, complementary and mutually re-enforcing (Goodrick and Reay 2011; Greenwood *et al.*, 2010; Jarzabkowski *et al.*, 2013); and, institutions can blend, recombine, assimilate and coalesce to form one dominant institution (Zietsma and McKnight 2009; Thornton *et al.*, 2012).

Importantly, multiple types of relationships can characterise a number of institutions simultaneously creating a potentially complex constellation of institutions (Goodrick and Reay 2011).

Due to the potentially complex relationships between multiple institutions, institutional work processes are incremental change processes and less likely to be clearly predefined transformational ones (Gestel and Hillebrand 2011).

Since multiple organisations collaborate in design-build projects, institutional work can be characterised as ongoing negotiations between multiple different political and professional interests, values, norms, cultural cognitive understandings and rules (Yu 2013). These negotiations can be characterised as integrative processes (Yu 2013) where established and proto-institutions are negotiated and pursued on a more-or-less experimental basis (Zietsma and McKnight 2009). As a result, the integrative process is characterized by repeated and concurrent resistance and mutation (Lawrence *et al.*, 2009) that gradually settles into a constellation of institutions even if only temporarily stabilized. This, project performance can be more-or-less intended (Gestel and Hillebrand 2011).

All in all, the use of institutional theory is multi-level: on the one hand we understand the design-build collaboration form to represent an institution in itself; on the other hand, we observe that during the design-build project multiple institutions contributing to the making of the project develop. This occurs predominantly, but not exclusively through the different professions and authorities contributing to the making of the project develop. However, it is in particular the latter understanding that this paper applies to developed project performance as an institutional concept.

## METHOD

The research presented in this paper is extracted from a Ph.D. study concerning coordination and project performance of design-build projects in Denmark. At first, the study of project performance was intended to be quantitative, but during early research stages, it appeared, that performance numbers were fabricated numbers reflecting political and pragmatic negotiation of the institutional order of the project. Therefore, performance numbers were ambiguous to measure and instead more appropriately required interpretation. Hence, a qualitative research design was selected.

Furthermore, in order to study potential relationships between institutional processes during the design-build phases and a project's performance, an ex-post study was chosen in order to be able to capture recently processes as well as the finished building itself and project aftermath processes. Originally, six ex-post studies were conducted; however, to limit the scope of this particular paper, two cases of particular interest were selected. Two projects differing in performance were selected to emphasise that different constellations of institutions do indeed result in different project performance.

*Table 1: Key characteristics of the two cases*

|                        | Ownership | Typology    | Size, m <sup>2</sup> | DB duration, months | DB cost, m. Euros |
|------------------------|-----------|-------------|----------------------|---------------------|-------------------|
| Design-build project A | Public    | Office      | 32,000               | 36                  | 160               |
| Design-build project B | Private   | Residential | 23,000               | 25                  | 32                |

Reflexive interpretation (Alvesson and Sköldbberg, 2009) was used as analysis method as it enables insight into context related social processes. The term 'reflexive' refers

specifically to interpretation of the empirical material at four different levels (e.g. the empirical material itself based on grounded theory; underlying meanings based on hermeneutics; ideology, power, social reproduction based on critical theory; and, the researcher's own (con)text, claims to authority and use of language based on post-modernism) (Alvesson and Sköldbberg, 2009: 7-10, 273).

Suddaby and Greenwood (2005) specifically highlight interpretive methods' superior ability to give insight into highly complex and interwoven levels of institutional analysis, for example, meaning and structure. To that, Pettigrew (1986) recommends using longitudinal methods to capture institutional processes. The two design-build projects lasted around three years each, and while this is relatively short compared to longitudinal studies that may span decades, it nevertheless does represent the life-span of the design-build project (not the building itself) and is thus interpreted to cover the entire institutional process in question.

In total 7 people were interviewed for the two design-build projects. Each interview lasted two hours. First, an open-ended interview with the contractor's project manager was conducted to get an initial understanding of the project and its context.

Subsequently, the architect's project manager, the engineer's project manager, the owner's project manager and the contractor's design manager were interviewed. The interviews were carried out as a combination of semi-structured and open-ended interviews. This combination enabled the interviewer to "drill" into the topics and the interviewee to elaborate on events of particular interest and value.

During the interviews the interviewer and interviewee would jointly develop a process map covering events from early project idea through hand-off, commissioning and occupancy. The process map facilitated a joint understanding of the project process, as well as facilitated the interviewee remembering past events that to various degrees were either vague or post-rationalised memories. Site visits were also conducted at each of the two completed buildings. Although no formal tour of each project was given an informal nose around was conducted. The site visits, in conjunction with the interviews, provided the opportunity to understand how constellations of institutions during the design-build process were reflected in the final building.

## **INSTITUTIONS AND PERFORMANCE IN TWO DESIGN-BUILD PROJECTS**

### **Project A**

#### *Characteristic Constellations of Institutions in Project A*

Project A was characterized as a 'typical' design-build project by project members. At conception, the project was planned as an extension and replica of an existing building in order to increase efficiency and reduce design costs while maintaining a particular level of quality. During the early and basic design phases the architect and engineers worked on preparing a brief in what was interpreted to be integration among collaboration, quality, designing efficiently, and cost optimization. Then, a two-month long negotiation period occurred, and eventually a design-build contract was established. At that point, the contractor entered the project team and hired the owner's architect and engineering consultants. Due to underestimation of the complexity of the technical details, the detailed design phase was extended past 6 months and the building phase postponed for six months to enable the project team to coordinate the design project for construction. Gradually the contractor's pursuit of short-term economic gains began dominating. For example, during the project cost negotiations it was suggested that a

potential 6m. Euro could be saved by purchasing a number of materials from Southeast Asia. The owner and the contractor agreed that this was worth pursuing and a formal agreement to purchase materials was established. Also the architect was fiscally incentivized to pursue cost savings. As the detailed design phase progressed, Project A became characterized by ambiguous domination: conflicting demands imposed on the project caused ambiguity to the architect because they accepted compromising architectural quality of the design solutions in order to maintain collaboration, loyalty, and increase project cost savings.

Furthermore, as the detailed design and build progressed the owner made several major changes to the original project, which increased the cost of the project. The contractor covered the increased project costs with the savings from the purchase savings from Southeast Asia. This meant that the owner's accumulated savings were reduced from an anticipated 6 m. Euros to 0.3 m. Euros. The contractor justified their actions by claiming they saved a number of work processes, however, the owner was left with a perception of having paid full price for poor quality. Nevertheless, the owner's representative expressed a certain ambiguity about the contractor: on the one hand, he thought the contractor was 'bending the rules' to accommodate their own interests; and, on the other hand, he perceived it to be 'part of the game'.

#### *Performance of Project A*

The project was originally scheduled to be handed off to the owner in March 2011, however, the contractor negotiated an additional six months due to increased project scope. The building phase was described as 'uneventful' by the contractor who, nevertheless, was able to optimize and accelerate the building process and reduced the building period with six months, equally. Before the building was handed off in March 2011, the owner and contractor negotiated and settled on a premium that the owner paid for receiving the building six months prior to the negotiated schedule. Although the contractor justified their actions by referring to the juridical provisions for design-build projects, the owner was once again left with a sense of fundamental distrust towards the contractor: a sense that the contractor was 'greedy'.

Once occupying the building, the owner's project manager complained that the building required extensive maintenance and repairs within the first year of occupancy and that the building solutions 'didn't look good'. Also, the architect expressed disappointment with the final quality of the building and said the process was 'frustrating' and 'stressful'. On the other hand, the contractor was able to accelerate work and hand-off the building six months prior to the negotiated deadline and increase their profit by covering additional project costs with the savings from cheap material purchases. Within the contractor's organization Project A is perceived as a success. However, the analysis shows that not all institutions were satisfied and thus the project is not unequivocally successful.

## **Project B**

#### *Constellations of Institutions in Project B*

Project B concerns the design and build of a large apartment building for a private investor. The project was developed in collaboration with a prominent architect consultant who had won the project by competition. During the project development and early design phase, where relatively few actors were engaged in the project, the constellation of institutions is interpreted to have been relatively settled: quality and functionality dominated.

Once the architect and owner had developed the basic design for the building a number of contractors were invited to bid on the project. Once the contractor was awarded the project, at the beginning of the detailed design phase, the constellation was disrupted with the institution of the pursuit of short-term economic gains and the urgency and determination of the build. However, the institutions of quality, cost optimization and collaboration did not cease to exist as the architect continuously appealed to the contractor to, for example, increase the quality of the materials or hire sub-contractors based on their ability to deliver the specified product instead of the cheapest product. However, the contractor wanted to maintain the domination of short-term gains, in order to ensure their own profit. To avoid having the architect disrupt the constellation and jeopardize the contractor's ability to build within the project cost and without delays, the contractor acted increasingly autonomously. For example, the contractor did not establish a joint project office and the architects were not hired for project inspections or invited to participate in project meetings during the building phase.

While the contractor was expecting to manage the project relatively autonomously the architect had the understanding that a certain level of quality was required in the project. Therefore, the architect continuously challenged the contractor and owner's decisions. For example, the contractor dismissed the architect's design manager when she warned, that according to her experience, the façade supplier would not be able to deliver the required quality of work. As a result, according to the project team, the collaboration between in particular the architect and contractor was poor and characterized by verbal fights and deep frustration.

During the building phase the lack of coordination disrupted the project by stopping and delaying work on the building site. Specifically, rework on the steel beams, concrete slabs, balconies, the bankruptcy of the façade supplier are all examples of how poor coordination during the detailed design phase disrupted the project during construction and compromised building efficiency and economic gains. Towards the end of the building phase the urgency and determination to build continued to dominate. In order to meet the final deadline, the contractor accelerated the building process. As a result, the different trades were working simultaneously and working conditions and quality of work became subordinate to finishing to a particular deadline. Overall, the design-build process was characterized by institutions competing for dominance and conflict between institutions that could not be simultaneously be satisfied.

#### *Performance of Project B*

The ongoing competition and conflict among institutions resulted in most institutions not being fully satisfied: residents complained over the poor quality of materials, the lack of heating capacity to enable the required indoor climate, and many errors and deficiencies pertaining to the interior finishes. Also, the contractor's fee eroded and no profit was made on the project. On the other hand, a building was constructed, handed-off and occupied to the original deadline and the building is perceived as an architectural showpiece representing a landmark in its neighbourhood. In the contractor's organization Project B is celebrated as a success partly due to the architectural and public prominence surrounding the project.

## **RELATIONSHIPS BETWEEN INSTITUTIONS AND PROJECT PERFORMANCE**

First of all, the analysis showed that there is a potential correlation between the characteristic constellations of institutions during the design and build processes and the projects' successful integration of institutions at project hand-off and during subsequent

occupancy, commissioning and facility management. It can be argued that both projects were dominated by the understanding that the building must be completed, since both projects delivered a finished building regardless of the circumstances of the design and build processes. Therefore acknowledging variation in constellations of institutions is fruitful to understand variation in project performance.

In project A, the poor quality of materials and extensive repair and maintenance work on the building in project A, reflects on the domination of the pursuit of short-term economic gains and the subordination of the institutions of collaboration, architectural quality and functionality. To that, the owner developed a sense of disappointment with the project performance when maintenance and repair work was required during the first year of occupancy, however, during the design-build process had fully supported the idea of pursuing cheaper building products. Also, the owner had originally awarded the contract to the particular contractor based on a combination of trust, knowledge of pre-existing buildings on site and price. However, due to the contractor's continuous and unambiguous pursuit of cost savings, the owner gradually grew distrustful of the contractor and felt they had had been cheated. As a result, project performance is interpreted to have emerged as a more-or-less stabilized constellation of institutions reflecting domination of a particular institution.

Project B was characterized by conflict and competition and interestingly all the organizations expected that the institutions that they represented respectively, would, ultimately, dominate the project. However, competition implies either a draw or a winner and a loser: the result of the competition and conflict in project B is interpreted to have been a mix of satisfied institutions (e.g. the building has become an architectural landmark and the project was handed off to the deadline) and unsatisfied institutions (e.g. poor quality of materials, the dissatisfied residents, the insufficient heating systems, damages to the interior walls caused by the overlapping trades, the bankruptcy of the façade supplier, and the lack of profit for the contractor). In other words, the final building and the aftermath of the project reflect an on-going battle for dominance within the project team.

### **Project Performance as a Mix of Intended and Unintended Consequences**

The paradox between being placed in relation to a single institution and a constellation of institution pertains to the discussion on intended consequences versus unintended consequences (Lawrence *et al.*, 2009). Institutional work concerns purposeful actions aimed at creating, maintaining or disrupting institutions (Lawrence *et al.*, 2009) and while recognizing that actions have consequences that can be either intended or unintended, institutional work is explicitly not concerned with the consequences of action. However, design-build projects have a relatively clear purpose (albeit sometimes poorly defined and continuously negotiated and changed): the development of a building that satisfies a number of institutions.

As a result, on the one hand the project team has an interest in managing the integrating constellation of institutions in order to increase the amount of intended consequences in order to stabilize project performance. On the other hand, project performance can be defined as a combination of intended and unintended consequences of institutional work carried out during the design and build processes. Contending that the current constellations of well-established and proto-institutions on design-build projects result in a paradox between efforts aimed at single institutions and efforts aimed at the constellation of institutions, then project performance is a result of intended and unintended consequences. While no literature was found on institutional work processes

and organizational performance explicitly, previous contributions on institutional processes frame temporarily stabilized institutional arrangements as ‘negotiated orders’ (Yu, 2013). In accordance, we previously defined project performance as a temporary stabilization of the constellation of institutions reflecting a particular negotiated order. The analysis of projects 2 and 4 showed that project performance was a negotiated order of proto-institutions and institutional debris. For example, the pursuit of cheaper products from South-East Asia is considered a relatively novel experiment supporting a well-established institution (e.g. pursuing short term economic gains), while the joint project office is interpreted to be a relatively novel practice supporting the understanding that collaboration among project team members is important for project coordination.

### **Project Performance is Relatively Stable, Yet Subject to Variation**

The process of negotiating, experimenting, competing, fighting, collaborating, and doing what they perceive to always have been doing, closely resembles the integrative processes of co-creating institutions (Zietsma and McKnight, 2009). While the integrative process among multiple institutions in a field (Zietsma and McKnight, 2009) was described as a process that doesn’t follow a particular path (although bearing traces of institutional debris), projects A and B suggest that constellations of institutions in projects develop according to certain patterns. To recap: peaceful co-existence characterized the early and basic design phases, but was gradually eroded by the perception of a value-chain, the pursuit of short-term economic gains, late changes, and lack of institutional leadership that fragmented the constellation of institutions and was repeated across the two projects. The lack of integration among institutions during the early and basic design phases resulted in a conflict during the detailed design phase between means to increase project quality and understanding coordination as a means to enable efficient building processes.

During the building phase the institution of the build dominated either more-or-less autonomously, or in competition and conflict, or in collaboration with remaining institutions. And in the transition to occupancy, both projects struggled to integrate all institutions (e.g. product deficiencies; poor quality of materials; and fee erosion). In other words, the analysis of projects 2 and 4 suggests that while actors negotiate, experiment, compete, fight, and collaborate, they to some degree reproduce the same intended and unintended consequences from project to project. This supports the findings of Kadefors (1995) who showed that projects vary little in process and outcome. On the other hand, the two project teams created different constellations of institutions and projects that performed differently. This is attributed partly to institutional work albeit it being sporadic, short lasting, and mostly initiated by individual organizations or their members in each of the two projects. And to that end, and more broadly speaking, until projects succeed in collectively, reflectively, purposefully and continuously integrating constellations of institutions, projects are interpreted to remain at a time similar and different.

## **CONCLUSIONS**

Responding to the RQ1, Project performance was interpreted here as an emerging social and qualitative concept. Therefore, theory on institutional work was selected to describe: first, how multiple organisations negotiate their interests, cultural understandings, values, norms and rules during the design-build process; and second, how project performance can be interpreted as the temporarily settled institutional order emerging from the design-build process. In order to gain insight into project performance interpreted as the result of an institutional process, a reflexive interpretive method was chosen. Furthermore, to understand the relationship between the design-build process and the settled constellation

of institutions, two ex-post studies were conducted on recently completed projects. Specifically, interviews with project participants and site visits to the completed projects were conducted.

Design-build processes were characterised as integrative processes through which organisations negotiated their interests, cultural understandings and norms by way of collaboration, competition and conflict. While each project developed multiple relationships between institutions over the course of the project, the projects were characterized by particular constellations of institutions. The analysis showed that domination resulted in project performance that predominantly satisfied the dominant institution. Furthermore, the analysis showed that conflict and competition resulted in project performance that mostly failed to fully satisfy any of the institutions. Second, project performance is defined as a phase at the transition from building phase to continued commissioning, hand-off and occupancy. While the transition itself represents a change in the constellation of institutions, the building itself and the time immediately following the transition also mark a temporarily stabilised constellation of institutions and thus project that performance is an emerging qualitative construct that gradually settles during the aftermath of the project. Finally, responding to RQ2 a high performance project is interpreted to be one that, as the aftermath of the project settles, successfully integrates the institutions represented in the project. These institutions include both the specific interests of the individual organisations represented in the project team as well as larger societal interests emerging from the project context.

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# QUANTIFICATION OF CONSTRUCTION PROJECT RISKS BY ANALYSIS OF PAST DISPUTE CASES

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Most risk assessment models require expert opinions for input data and interpretation of results. This study proposes a risk assessment model that utilizes data from past construction project for analysis of risks. Observations from literature on 'risks management' and 'claim management' identify a causal relationship between risks and claims. Thus, claim documents have potential to provide information on risks. In a claim statement, nature of claims indicates impact of risks, reasons for seeking claims indicate risks that have occurred in the project, and values of claims indicate estimates of the impacts of risks. The model adopts techniques of content analysis and open coding to analyse 276 claims from 28 dispute cases. Number of claims caused by each risk determines the frequency of that risk. Scope variation and execution delay are identified as the most frequent risks. A claim amount expressed as a percentage of contract sum represents quantification of impacts due to risks. Impacts of all risks identified from cases are quantified under ten types of claims. The research outcomes also converge with previous studies. Significant contributions of the study are, the identification of causal relationship between risks and claims and development of the risk assessment model with more objectivity.

Keywords: claim, content analysis, dispute, risk assessment model

## INTRODUCTION

This research work is conceptualised on integration of literature on risk management (RM) and claim management (CM). Researchers have proposed many models to identify and assess the risks in construction projects (Laryea and Hughes 2008). General philosophy of majority of these models is to assess probability and impact of risks based on expert opinion. Product of probability and impact assesses the risk exposure and helps in determining critical risks in projects (El-Sayegh 2008). However, such systematic assessment of risks have limited acceptance in practice (Laryea and Hughes 2008 and 2011). A significant limitation of these models is the need of expert opinion for input data as well as interpretation of the results. Studies based on historical data from construction projects and the models that can provide readily results in readily usable terms are rare. Moreover, construction industry does not have a formal and prevalent practice of maintaining database on risk related information. Thus, initial challenge of this study was to identify a source of information from the industry which could provide historical data on project risks.

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Unlike studies on RM, researchers have dealt with CM and dispute management relying mostly on analysis of documents from projects (Love *et al.*, 2010, Ramachandra and Rotimi 2015, Semple *et al.*, 1994). These documents include claim submissions, arbitration awards and litigation cases. Relevant data extracted from these documents have been analysed to identify and evaluate various types of claims and event or conditions leading to claims, and then to disputes. Moreover, the studies on CM have not delved deeper to analyse the events due to which the phenomenon of claim arises in projects. Literature review on RM and CM has revealed an important link between 'risks' and 'claims'. This link helps to postulate a causal relationship between risks and claims. Identification of the causal relationship between the two phenomena has immense significance as vast amount of CM documents can be now exploited to obtain data for analysis of risks. This study highlights this significance through development of a risk assessment model based on analysis of claims from past dispute cases.

### **Research Objectives and Scope**

The goal of this research work is to develop a risk assessment model using historical data on projects risks and to facilitate quantification of risks in readily interpretable form. Objectives set forth are - (i) to analyse the relationship between risks and claims; (ii) to extract risk related data from claim statements and structure them to facilitate qualitative and quantitative analyses; and (iii) to identify and assess the risks from extracted data. The proposed model is expected to be applicable to all types of claim documents. However, scope of the proposed study is limited to analysis of 276 claims from 28 settled arbitration awards. The focus of this study is to report development of the theory and demonstrate its potential application. Hence, by strategically selecting claims exclusively from settled arbitration awards, issues of possible biasness of stakeholders in preparation of claims are set aside for time being. Arbitration awards are made after rigorous analyses of evidences, testimony of experts and considering views of concerned stakeholders. Thus, for all practical purposes the arbitration awards give a true account of events leading to claims and justified assessment of impacts due to these events on projects.

The research work is presented broadly in two stages. First, summary of observations from literature along with arguments are presented to postulate that risks and claims have causal relationship. Second, based on the causal relationship, a risk assessment model is proposed. Comparison of fundamental aspects of the new risk assessment model with the existing models is also presented in the discussion section.

## **RESEARCH BACKGROUND**

This section includes comparison of basic characteristics of risks and claims. It is followed by comparison of texts used by researchers to describe risks and sources of claims. These two comparisons analyse the relationship between risks and claims.

### **A Relook at Definitions of Risk and Claim**

#### *Risk*

*British Standard (BS 6079-3:2000)* defines risk as the uncertainty of an event happening that can affect the prospects of achieving business or project goals. Project Management Institute (PMBOK 2013: 310) provides more elaborate definition of risk as an uncertain event or condition that if occurs have a positive or negative effect on one or more project objectives such as scope, schedule, cost and quality. These definitions assert the characteristics of risk noted by Al-Bahar and Crandall (1990) - 'the risk event', 'the uncertainty associated with that event' and 'potential loss or gain'.

### *Claim*

Similar to risk, claim also has many definitions. Following three definitions of claim are used to identify characteristics of claim and putting forward the arguments.

1. Any application by the contractor for payment that arise 'other than under the ordinary contract provisions' (Jergeas and Hartman 1994).
2. A claim is a request for compensation for 'damages incurred by any party to the contract'. Claim represents basis of claim (cause and effect), explains the contractual and legal basis for payment (entitlement), and quantifies the resulting damages (Semple *et al.*, 1994).
3. A request by a construction contractor for 'compensation over and above the agreed-upon contract amount for additional work or damages' supposedly 'resulting from events that were not included in the contract' (Ho and Liu 2004). ['Stress' provided].

Consider the phrases from the first definition, '... other than under ordinary contract provisions ...' and from the third definition, '... resulting from events not included in the initial contract ...' These phrases suggest that claims arise from events/conditions which are different from ordinary events/conditions or not included in the contract. Without being envisaged in the contract there will be some amount of uncertainty associated with these events/conditions during the project implementation. Further, a focus on phrases from the second definition, '... damages incurred by any party ...' and from the third definition, '... compensation over and above the agreed-upon contract amount for additional work or damages ...' implies that claims are assessment of impact or damages. From these two observations, an inference can be drawn that claims are assessment of impacts of those events/conditions which have uncertainty associated with them. Moreover, claims are raised usually after damages or additional costs have been incurred. To sum up, claims are characterised by 'assessed losses' resulting from 'uncertain events' that have 'occurred' in a projects. Comparison of characteristics of risk and claim shows two important similarities, 'occurrence of uncertain event' and 'consequent loss or gain'. This observations provides an important insight - Are the claims actually assessed impacts of the risks that have occurred in the project?' Following discussion further clarifies this insight.

### **Comparison of Texts Describing Risks and Sources of Claims**

Texts that identify different type of project risks are compiled from research papers. The texts used to describe a particular risk (for instance, scope variation) vary slightly across studies (see Table 1). In next step, texts used to describe sources of claims are also compiled. A comparison of texts pertaining to 'risks' and 'sources of claims' dealing with similar issues in projects illustrates that researchers refer to same phenomenon when they describe 'risks and 'sources of claims'. Table 1 shows the sample illustration of the comparison of texts for risks and sources for claim when issue of scope variation is considered, and the following paragraph describes the phenomenon of scope variation.

Contractors are assigned to execute a project as per the scope defined in the contract, bill of quantities, technical specifications, design and drawings, and quality assurance plans. Often, the contracts are signed before design and detail drawings are finalised leading to uncertainty in the scope of work envisaged in the contracts. Changes in the scope of work also happen during execution due to project site conditions; changes in owners' requirements, technical specifications; etc. Contractors may incur additional costs

because of differences in the contractual and the actual scope of work. They may also raise claims for compensation.

Table 1: Comparison of texts describing 'risks' and 'sources of claims' for scope variation

| Risks  | Sources of claims  | Remarks  |
|--|--|--|
| Changes of scope, Excessive contract variation, Scope variation (Keci 2015); Incomplete design scope (Al-Bahar and Crandall 1990); Design/project scope change due to extra unspecified work, Specification change (Creedy et al., 2010); Lack of scope definition (El-Sayegh 2008). | Variation initiated by owner, Change of scope, Unforeseen changes (Cakmak and Cakmak 2014); Variations (Yates 1998); Variations due to site conditions, client changes, design errors and external events (Kumaraswamy 1997); Increase in scope (Semple et al., 1994). | Similarities can be observed in texts used to describe 'scope variation' as risk and as source of claim. |

Therefore, the claims rooted in the scope variations are basically assessment of impacts of the scope variation risk in projects. Based on comparisons of characteristics of risk and claim, and sets of texts used to report risks and sources of claims, it is postulated that 'claims are actually the assessment of impacts of those risks that have occurred in the project'. This postulate forms the theoretical foundation of this study. At this point, some questions likely to probe the readers are - what is the extent of validity of the causal relationship between risks and claims; how do other risks and claims in the project interact; how to account for those damages against which claims are not submitted; and what are the consequences of settlement or rejections of claims. This research being first step in this direction, the focus is not on addressing all questions. However, some critical questions are answered through development of the model and discussions.

**Risks as Source of Change Orders, Claims and Disputes**

Researchers have described how claims lead to conflict and disputes (Cheung and Yiu 2006, Kumaraswamy 1997). By extending relationship between risks and claims to conflict and disputes, emergence of disputes due to risks is mapped in Figure 1.

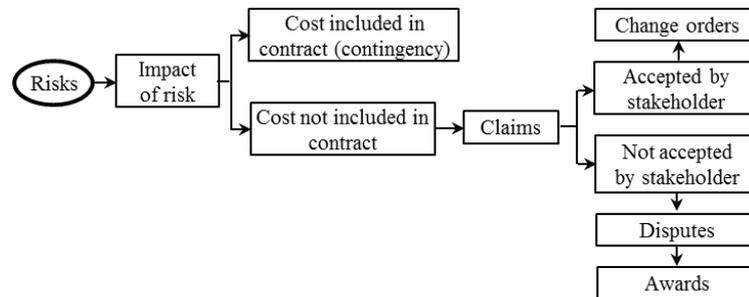


Figure 1: Impact of risks resulting change orders, claims and disputes

If risks occur they can affect a stakeholder at two levels. At one level, some risks are anticipated during estimation and costs of their impacts are included in the contract prices. These impacts are covered by contingency or costs of risks accepted by the stakeholders. At another level, if the costs of impacts due to some risks are not included in the contracts, claims for compensation are submitted after occurrence of risks. A part of claims may be accepted by the counter party through change orders. The counter party may also reject claims due to disagreement over assessment or entitlement of the compensation. Unsatisfactory settlement of claims may lead to conflict and disputes. To resolve disputes, special resolution methods viz. mediation, conciliation, arbitration and litigation are required. The claims which reach the dispute stage pertain to those risks which are difficult to anticipate (these are not included in the contract estimate), quantify and allocate (their assessment and entitlement may be the basis of rejection and disputes).

Therefore, analysis of dispute awards help in focusing on impact of those risks which are most difficult to manage. Difficulty in anticipation, assessment and allocation are the characteristics of critical risks.

### **Critical Review of Literature on Risk Assessment Models**

Risks identified and reported in literature vary from conceptual risk terminology to tangible risk factors. For instance, design risk is a conceptual term represented by tangible attributes such as delay in design finalization by the owner; design errors and changes in designs by designers; changes in specifications by technical consultants; etc. which are rooted into different stakeholders. An objective assessment of risks requires assessment at the level of risk factors (Yildiz *et al.*, 2014). In risk assessment through expert opinions, these details are often sacrificed to maintain practical size of questionnaires. Moreover, the scales developed by researchers using 'impact and probability words' also lack consistency (Kent 1964). Even the interpretation of findings of opinion based studies is also non-intuitive and requires help of experts. Besides, researchers have also recognized the existence of interrelationship among risks in actual project scenarios, thus making assessment of isolated risks even less reliable (Zhang 2016). Laryea and Hughes (2008 and 2011) have observed that complex and systematic risk assessment models are rarely used by practitioners in bidding processes and have argued for simpler models with tangible outcomes.

So sum up the discussion so far, the causal relationship between risks and claims is postulated by comparative analysis of literature on RM and CM. A critical literature review of risk assessment models also highlights the need of a risk assessment model with less reliance on experts for input data and interpretation of the results. Additionally, Semple *et al.*, (1994) have outlined that claim statements contain information on cause and effect (i.e. risk events and their impacts), quantification of risks (i.e. assessment of impact), and entitlement (i.e. risk allocation). Thus, preparation of the claims is actually assessment of impacts due to risks, and by analysing claims risks can be assessed. Following section illustrates the development of a risk assessment model based on the causal relationship between risks and claims.

## **MODEL DEVELOPMENT**

The first research objective is achieved through literature review. The research methodology adopted for the second and the third objectives is illustrated in Figure 2. It includes two steps - data collection and data analysis.

### **Data Collection through Content Analysis**

Techniques of content analysis are adopted to manually extract data through in-depth study of arbitration awards. Content analysis is a research technique used to make replicable and valid inferences from texts to the context of their use (Krippendorff 1980:18). By systematically evaluating texts, qualitative data can be converted into quantitative data. For illustration consider a claim statement, '... compensation for the infructuous expenditure incurred on establishments during the extended period of the contract ... due to delay in site handover, unavailability of owner supplied materials and design changes'. The first part of the statement, 'infructuous expenditure on establishment' describes the type of impact on the stakeholder due to those risks whose information is given in the second part of the statement.

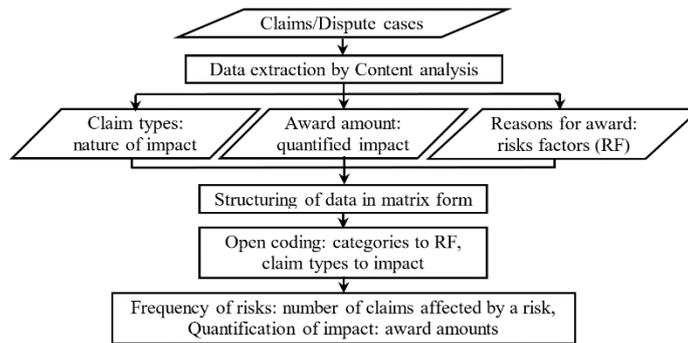


Figure 2: Flow chart showing research methodology for model development

These risks are related to delay in site handover, shortage of materials, and design changes. The claim amount is the quantification of impact of risks in monetary terms. In this study, only reasons and claim amounts accepted by the arbitrator in writing the award have been considered. Table 2 shows the scheme of structuring data in matrix form using Microsoft Excel to map the claims to the reasons provided for claims.

Table 2: Template for extracting and structuring data from dispute cases (INR- Indian Rupee)

| Ref. | Claim statements (↓)  | Reasons for award (→)<br>Generic description of claims (↓) | Work done beyond BOQ scope C3.R1 | Delay in site handover by owner C3.R2 | Claim value (INR)<br>x1000 | Award value (INR)<br>x1000 |
|------|---|--|----------------------------------|---------------------------------------|----------------------------|----------------------------|
| C3.1 | Claim for prolongation of work for a period of 2 years      | Compensation for idle resources and overheads              | 1                                | 1                                     | 2212.8                     | 1222                       |
| C3.2 | Claim for changing specification after receipt of materials | Compensation for change in scope of work                   | 1                                | -                                     | 3000                       | 1000                       |
|      | Total (→)   | -  | 2                                | 1                                     | 5212.8                     | 2222                       |

In Table 2, claim statements are listed along the column and reasons for making each award as provided by the arbitrators are listed along the row. Each case, claim and reason extracted from the arbitration awards is assigned a systematic unique reference numbers which is retained throughout the analysis to allow tracking of information. In the matrix, cell value of '1' is used to map a claim to a reason when that reason is sighted by an arbitrator as underlying cause of resultant claim. Mapping of reasons with claims in matrix form revealed that a claim could result from one or more reasons and vice versa. This observation suggests many-many relationship between claims and reasons, and subsequently between claims and risks. This exhibits the phenomenon of interrelationships among risks. Columns at right include values of claims, counter claims (not shown in the table) and awards. A convention has been adopted such that positive value is the amount to be paid by the respondent to the claimant. Content analysis of 28 arbitration cases including cumulative 276 claims is carried out. Among 28 cases, 3 cases were closed with nil awards. In only one case, award was in the favour of the respondent. Therefore, data from only 24 cases are included in the final analysis. All cases are obtained from Central Public Works Department (CPWD) of India. CPWD was the respondent in all cases and claimants were different contracting companies of varying sizes. No confidentiality or ethical issues were faced during collection of cases.

### Data Analysis through Open Coding

Principles of open coding are adopted to analyse two sets of data - types of claims and reasons for making awards underlying these claims. Open coding is an iterative process of converting textual information into categories that represents a common phenomenon.

Open coding of 'reasons for awards or sources of claims' is done to accumulate similar types of reasons into categories and then map them to risk factors (RF) taking clue from risks reported in the literature. Table 3 shows a sample of coding process. Here, frequency refers to number of claims to which a particular reason was assigned by the arbitrators. Similarly, the data on types of claims were open coded and mapped to 10 major types of impacts that projects have faced.

Table 3: Coding of extracted data from 'reasons for claims' to risks factors (RF)

| Ref.  | Reasons for award                 | Frequency | Coding (RF)            |
|-------|-----------------------------------|-----------|------------------------|
| C3.R1 | Work done beyond contracted scope | 2         | Scope variation        |
| C3.R2 | Delay in site handover by owner   | 1         | Delay in site handover |
| C3.R8 | Price rise due to escalation      | 1         | Inflation              |

## RESULT AND DISCUSSION

### A New Expression for Probability of Risk

Opinion based studies use relative frequency indices (FI) to assess probability of risks and identify most probable risks (El-Sayegh 2008). However, these studies are silent about how to interpret the value of an index. For instance, if design risk has assessed frequency index of 60% or 0.6 - what does it imply? Does it mean that in a very large sample of projects, 60% projects will face design risk? If so, what will be the pattern of occurrence of design risk along project duration or across structures within these projects? How does the index value relate to project costs? In reality, some amount of design risks occur in most projects. Therefore, to address the ambiguity inherent in existing expression of likelihood/probability, this study has measured frequency of RFs to assess probability. Frequency is the total number of claims caused by a RF. Higher frequency means that a RF has occurred in more projects as well as it has caused many claims within a project. Practitioners should be wary of a RF with higher frequency as it would cause large number of claims and, very likely, higher costs. From 30 RFs identified in this study, top ten are listed in Table 4.

Table 4: Frequency (Fr.) distribution of Risk factors (RF) affecting claims

| Sl. | Risk factors (RF)           | Fr. | Sl. | Risk factors (RF)             | Fr. |
|-----|-----------------------------|-----|-----|-------------------------------|-----|
| 1   | Scope variation             | 106 | 6   | Interest                      | 46  |
| 2   | Execution delay             | 102 | 7   | Dispute                       | 35  |
| 3   | Delay in release of payment | 86  | 8   | Over heads and idle resources | 34  |
| 4   | Design related issues       | 62  | 9   | Inflation (Escalation)        | 31  |
| 5   | Poor contract management    | 53  | 10  | Poor communication            | 24  |

Scope variation has affected maximum number of claims being closely followed by Execution delay. In practice, every change in the scope of work directly results in work stoppage, possibly rework, idling and reassignment of resources, and delays in execution. Top five and top ten RFs are mapped to 53% and 85% of claims, respectively. Interest and Dispute risks are typical to projects entering into disputes.

### Quantification of Impact of Risks

Similar to probability, studies express impacts of risks as their severity indices (El-Sayegh 2008) but are also silent about how to interpret these indices. Say, if design risk has assessed severity index of 40% or 0.4 - what message does it convey to the practitioners? How these values can facilitate estimation of risk allowances or

contingencies? These indices are not readily interpretable and needs help of the experts. If the assessment models were to give output in terms of costs due to impacts, decision makers will find the results more useful. In this study, arbitration award amount against each claim is assumed as true assessment of the impact due to risks underlying those claims. However, as a claim can arise from more than one risk, the proposed model assesses the impacts of risks under some major types of impacts and not specific to a particular risk. This simulates the actual project scenario of risks having interrelationships where assessment of an isolated risk shall not give a reliable result. The analysed cases were of varying contract sums executed over long periods. Hence, to normalise the effect of sizes of contract sums and inflation across years on risk assessment, each claim amount is expressed as % of respective contract sum.

Impacts are observed under the ten different heads (see Table 5). IV-Interest over delayed payments appeared in all 24 cases with mean value of 4.5% of contract sum. II-Cost of extra work and VIII-Cost of unpaid work together have impact of 9.5% of contract sum. II and VIII are directly related to scope variation risk which is mapped to maximum number of claims. Overheads and resource idling are noted in 19 projects with mean of 4.5% of contract sum. The impact of all risks averaged over 24 projects is 18.7% of contract sum. While other models provide non-intuitive outcomes for risk impact assessment, this model quantifies the impacts as percentage of contract sum which can be readily used by decision makers.

Table 5: Mean (M) award amounts as percentage of contract sum; (see under table for label)

| Label | I   | II  | III | IV  | V   | VI  | VII | VIII | IX  | X   | Total |
|-------|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|-------|
| N     | 18  | 14  | 15  | 24  | 4   | 3   | 19  | 10   | 12  | 14  | 24    |
| M (%) | 1.1 | 3.0 | 2.6 | 6.9 | 1.2 | 7.5 | 4.5 | 0.5  | 1.2 | 6.5 | 18.7  |

Legend: I-Cost of arbitration , II-Cost of extra work, III-Escalation amount, IV-Interest over delayed payments, V-Refund of levy of compensation, VI-Loss of profit, VII-Overheads and idling of resources, VIII-Refund of recoveries made from bill, IX- Refund of conditional rebates deducted, X-Unpaid work. N is the number of cases in which particular claim was accepted. M is the mean value of impact assessed over N cases calculated from each award expressed as percentage of respective contract sum.

**Comparison of Results with Other Studies**

El-Sayegh (2008) has put inflation; delay in material supply and approval; change in designs among top ten critical construction risks in UAE. Kartam and Kartam (2001) have found delayed payment on contract and defective design to be among five most significant risks in Kuwaiti construction industry. These findings are similar to frequent RFs shown in Table 4. The research team of the proposed study is also conducting risk assessment study in Indian construction industry based on opinion survey. Trends from opinion of 43 experts with average experience of over 15 years show that design risks, quality and rework risk, scope variation risk, time-over run risk and inaccurate feasibility assessment as the five most critical risks. These findings support the findings of the proposed study.

**Limitations of the Study**

This study is the first attempt to identify and analyse causal relationship between risks and claims. The theory is in formative stage. RFs identified by the proposed model include only those risks that have affected one or more of 28 projects/cases and are not exhaustive. Due to various forms of contracting and risk allocations, some risks may not

find its way into the claims and hence are not recognised by the model. Intermediate effects and impacts of isolated risks have not been analysed, instead cumulative impacts of all risks are assessed under ten different claims. Future studies with larger and diverse samples will generate comprehensive umbrella of risks and refine the proposed model.

## SUMMARY AND CONCLUSION

This study has evolved from linking the literature on risk management and claim management. Necessary evidence and arguments have been presented from the literature to postulate that 'claims are actually assessment of impacts of risks' that have affected the project. In fact, texts used to identify 'risks' and 'sources of claims' are found to be similar. Potential of the postulated theory is demonstrated by developing a risk assessment model based on analysis of claims from arbitration awards. The study has employed techniques of content analysis to analyse 276 claims from 28 arbitration cases. Scope variation, execution delay, delay in release of payment, design related issues and poor contract management are the five most frequent risks causing over 50% of the claims. Impacts of risks are quantified as percentage of contract sum under ten types of claim. Convergence of the findings of the proposed model with the previous studies and a contemporary research substantiates the study.

The most important contribution of this study lies in attempt to identify the causal relationship between risks and claims. The study has opened up a new world of possibilities for research on risk management using data from previous projects. Proposed approach reduces reliance on experts for adopting a risk assessment model. The model also illustrates that defining frequency of risks in terms of number of claims these risk may affect is more objective assessment of probability of risks. The model is also able to quantify the impacts of the risks in terms of percentage of contract sum, thus making the results of risk assessment readily interpretable. With limited volume of data analysed so far, the theory has not been supported by statistical analysis. To encompass more types of risks and to address intricate questions related to assessment of individual risks and their interactions, future studies can be taken up.

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# DEVELOPING DECISION MAKING IN PROJECTS: ANALYZING THE MOBILIZATION OF BIAS AND NON- DECISION MAKING IN PROJECTS

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Construction research on decision making is dominated by theories of rational cognition. Behavioural economics introduced an approach through prospect theory that is applied extensively, particularly on public megaprojects by Flyvbjerg. The theorization, especially prospect theory, has made a significant contribution, yet, remains narrow and insufficient. Research on public projects have largely ignored the seminal decision making literature from the public policy domain. This literature potentially introduces new analytical potential to provide understanding of decision making as a layered and dynamic set of processes. The concept of the mobilization of bias and non-decision making offer considerable scope to analyse and improve construction decision making. The mobilization of bias has connection to the concepts of optimism bias and strategic misrepresentation, yet takes the analysis further regarding the processes involved: how bias is mobilized, when and by whom in the hierarchy from policy decision makers down to construction management, and finally for what purpose. It further shows how non-decision making is used to defend the status quo. This is cognitively and intuitively employed by those who stand to benefit from preserving the status quo and are threatened by change. The paper provides the basis for empirical investigation of complex construction projects.

Keywords: mobilization of bias, optimism bias, strategic misrepresentation

## INTRODUCTION

Construction research on decision making has been dominated by rational models. Simon (1982) in his work provided one important avenue with a modified behavioural approach based on intended and bounded rationality. Prospect theory provided a related approach through the work of Kahneman and Tversky (e.g. 1979). Prospect theory has occupied centre stage in the influential work of Flyvbjerg and his colleagues when addressing megaprojects (e.g. Flyvbjerg *et al.* 2003, Flyvbjerg 2008). Flyvbjerg has used optimism bias and strategic misrepresentation. Optimum bias is where an individual or organization assess that they are at less risk than anyone else in the face of a negative consequence (Pinto 2013). Optimism bias can lead to the escalation of commitment in the face of cost overruns (Meyer 2014). This is motivated by the risk of withdrawal from the project, which can do reputational and short term financial damage. The organizational actor is locked into execution, yet proceeding is neither an obvious nor sensible business solution (Staw and Ross 1987). The phenomenon can also apply to the

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project front-end, especially where the complexity, costs and risks are high or are thought to have been externalized to other actors. Escalation of commitment only makes sense if justified against a realistic assessment of returns (Karlsson *et al.*, 2005, Meyer 2013); it should be terminated once this is exceeded (Unger *et al.*, 2011). Yet, many projects continue unabated (e.g. Flyvbjerg *et al.*, 2003).

Is this the best we can do in construction? Can poor project decision making be boiled down to two behavioural factors: optimism bias and strategic misrepresentation? While rationality is bounded and behaviour plays a role, the rational focus is limited. There are intuitive reasoning and subjective factors in decision making. There are socio-political and socio-psychological processes in play that go beyond the discrete events assumed and portrayed in the majority of economic decision making.

Many projects are located in the public sector and almost all megaprojects either have a client that is from the public sector or is indirectly the ultimate owner or sponsor. Even if the megaproject is entirely private, policy and public sector accountability impinge upon progressing a project, typically alongside a range of other external stakeholders from community and interest groups to other economic and environmental representation. Given this context, it is strange that little or no attention has been given to decision making on megaprojects from the public policy research domain? The research in public policy has addressed the pluralism of interests in decision making (Dahl 1957), the institutional practices that lead to an uneven power distribution in decision making, particularly evidenced through the mobilization of bias and non-decision making (Bachrach and Baratz 1962, 1970), which leads to the contribution of Lukes (1974) as to how those in power dominate over other interests, shape the preferences of others and remove conflict to the margins. This shifts the analysis from discrete factors towards process with a fuller range of rational and subjective consideration, intuition and sense making included.

A broader set of processes are needed to analyse decision making in construction, especially for megaprojects. The aim is to address project decision making by moving the emphasis from optimism bias and misrepresentation towards power towards the mobilisation of bias and non-decision making. The research objectives are to move analysis from a decision event focus towards process analysis, and from one grounded in cognitive rationality to include subjective intuition. This is supplementary to the tenets of behavioural rationality and prospect theory, yet notes its insufficiency and need for complementary conceptualization. The concept of the mobilization of bias provides a useful bridge with optimism bias, although the former is richer because it takes a longer timeframe and embraces the conscious and unconscious use of bias.

The structure of the paper is to first address current conceptualization, then move towards additional and complementary conceptualization before concluding.

## **CONCEPTUALIZATION OF PROJECT DECISION MAKING**

### **Rational Decision Making**

Cognitive rational decision making has embodied modifications around behaviour (e.g. Simon 1982) and the assessments of prospects, where decisions may become behaviourally skewed (Kahneman and Tversky 1979). In rational models, irrational behaviour is removed, only to be subsequently reintroduced as limited and discrete factors for consideration in order to try to address anomalies. The mode of reintroduction constrains them to the 'rules' of rational analysis. Rational decision making is normally conceived as a discrete event or short term series of events. This seldom accords with

reality, especially on megaprojects. Decision making is a layered process in an institutional hierarchy of public and private spheres of activity, where power and influence are at play over extended periods of time in and between the layers. Decisions develop iteratively and can be revisited. Intuitive reasoning is used and the predispositions and experience of decision makers are drawn upon.

The costs of rationality are considerable. Obtaining complete information and high degrees of transparency are high cost. Shortcomings lead to imperfect, thus incomplete and asymmetrical information. In projects, uncertainty and ambiguity are inherently high. Projects require experiential evaluation and judgment, particularly at the front end where levels of uncertainty are greatest. The land use planning literature recognizes a combination of open and closed decision making is necessary. Successful governance arrangements need to be shaped by a complex interplay between open and closed decisions in planning developments (e.g. Healey 2004), which has been re-stated in the context of megaproject planning (Salet *et al.*, 2013, Majoor 2015).

Prospect theory offers a critique of the idealized and normative model of rational choice models of decision making, which were provided by expected utility theory (Kahneman and Tversky 1979). Prospect theory specifically tries to account for perception, behaviour and risk. Risk is probability, whereas uncertainty is unknown (Knight 1921). Uncertainty is addressed at the front end by strategically scoping, assessing feasibility, and then tactically shaping and executing projects. Risks are identified as a result. Yet, decision makers can give insufficient attention to types of outcomes, which is referred to as “myopic loss aversion” (Thaler *et al.*, 1997: 648). The result is that decision makers tend towards optimum bias.

Assessing feasibility for a project in prospect theory distinguishes two phases (cf. Kahneman and Tversky 1979). Editing information to provide a sound basis for making a decision by selecting the relevant information and then evaluating the prospect in order to choose the one with the highest value. It is cognitive, rational and assumes sufficient information is available. Rationality underpins decisions except where it is behaviourally skewed by optimism bias and strategic misrepresentation. The way to address bias and misrepresentation is to apply reference class forecasting to evaluate prospects on a comparative basis so as not to solely rely on assessments of the prospects on their own terms (Kahneman and Tversky 1979).

Prospect theory decision making views the process in terms of “individual decision making” (Kahneman and Tversky 1979: 274), that is, decision making as a single event or short term series of events. The longer term and any complex structuring is not addressed. Megaproject decision making tends to be conducted medium-to-long term. Complexity and uncertainty can induce concurrent errors, running the risk of failure (Reason 2000, Love *et al.*, 2012). Errors can also lie dormant or are latent in a system as pathogens that may emerge later during the project lifecycle. Once apparent they become active failures (Love *et al.*, 2009). The best attempt of the rational approach to address these type of dynamic factors is “cumulative prospect theory” (Thaler *et al.*, 1997: 657) and repeat games in game theoretic applications, which are modelled as a series of discrete events. They do not encompass the iterative and layered processes in reaching decisions nor how these may prove to be positive or negative. Economic models and game theory are governed by assumptive rules rather than the actual prescribed formal processes, informal processes and the emergent rules of the game.

## Prospect Theory and Megaprojects

Flyvbjerg has become the main analyst of decision making in projects and for megaprojects (e.g. Flyvbjerg *et al.*, 2005, Flyvbjerg 2008, 2009). He has adopted prospect theory. He particularly focuses upon two factors: optimum bias and misrepresentation. In so doing, he emphasises the inputs from experts, such as forecasters, planners, promoters and political interests (Flyvbjerg 2007). Flyvbjerg's megaproject analysis therefore embodies the strengths and the shortcomings of prospect theory. It tends to view decisions in static ways, and repeatedly refers back to the benchmark estimates, especially time and cost, when uncertainty and a lack of reliable information were at their highest level. Demand and cost forecasts can be inflated, although forecast optimism is more likely amongst the private sector than the public sector (Flyvbjerg 2013). Forecasts are estimates that can simply be wrong, not due to bias or intent to misrepresent situations. Yet these forecasts tend to be mechanically treated as fixed and 'natural' factors. Forecasts can be wrong without any intended bias or misrepresentation being present. Bias can and does creep in as the result of decision making myopia (Thaler *et al.*, 1997), and may lead to deliberate intent to misrepresent.

Two measures are employed to overcome bias and misrepresentation - an internal and external assessment. If the project feasibility and the underpinning business case are subjected to due diligence, this provides a means of assessing or checking the decision. Due diligence is conducted through in-depth investigation into the information, covering investment, financial, legal and professional examination, which is either required in law or undertaken voluntarily (Flyvbjerg 2013). However, due diligence may be influenced by the same institutional perspectives and pressures of the original decision.

The external measure is the application of reference class forecasting (Flyvbjerg 2008). The uniqueness of projects pose a class problem for comparison on coherent basis of categorization. Large data sets are necessary for reliability. Establishing suitable reference projects because of the range of sectors, variances of project type and uniqueness of each project, as well as uncertainty, is problematic. The comparisons used in reference class forecasting ignore the power mobilized behind project decisions in shape and form, even though it is from this source that bias emanates. Indeed, some projects are even set up to fail (Yourdon 2004, Pinto 2013). Political process and the exertion of power that frames decisions is not addressed.

Many projects continue unabated (Ross and Staw 1993, Flyvbjerg *et al.*, 2003). Meyer (2014) identifies several institutional dimensions of influence, which includes portfolio and front-end factors. Where parties are aware of their optimism bias, they do not necessarily moderate their behaviour (Lovallo and Kahneman 2003, Salet *et al.*, 2012). Love *et al.*, (2012) offered a critique, saying optimism bias and strategic misrepresentation inadequately explain cost and time overruns; these 'causes' cannot be automatically deduced or inferred from manifested effects. Using cases, they did not find automatic or complete linkage. They state:

To assume overruns occur due to strategic misrepresentation or optimism bias, or a combination of both, disregards the complexities and underlying dynamics associated with the delivery of social infrastructure projects. (Love *et al.*, 2012: 569).

The different goals of different organizational actors can give rise to project dissonance (Cheung and Yiu 2006, Love *et al.*, 2012). Certain interests can manage to ensure support for certain projects, despite application of a range of checks and balances, and decision iterations, even though the value of the prospect is low. Further, value defined as inputs and outputs, and measured against the original estimates can be spurious

because value outcomes derived from value realization in use and context are overlooked (cf. Vargo and Lusch 2009). Indeed, the decision process at the front end can itself lead to the co-destruction of project value (Mills and Razmdoost, 2016).

Prospect theory offers a number of analytical insights; yet, the arguments set out lead to a critique which suggests they are too simplistic and insufficient. A more cogent and comprehensive approach is warranted for the management of projects.

## **DEVELOPING THE CONCEPTUALIZATION OF PROJECT DECISION MAKING**

### **Towards Effective Understanding of Decision Making**

Prospect theory provides a start but not an end point. Decisions involve, “*a set of actions related to and including the choice of one alternative rather than another*” (Dahl 1960: 26). From socio-political perspective, Dahl (1957) argued that there are diverse interests and power positions between actors, hence the need to examine power relationships between both individuals and organizations (Richardson 1996). The result is the need, “*to analyse concrete decisions involving actors pursuing different preferences*” (Ham and Hill 1984: 66). This approach about power and preference stimulated a debate over the nature of decision making.

Prospect theory views behaviour in discrete events, while Dahl (1957), and subsequently Lukes (1974), place emphasis upon structure above behaviour per se. Another view focuses upon process in the context of structure and power. Bachrach and Baratz (1970) view decision making as *incremental*, taking place in *stratified* and *iterative* ways. Power is exerted by actors in each stratum and at each stage. Some decisions are procedural and power is not wielded nor yielded, although this is infrequent and includes a type of rational idealism of economic based models, such as prospect theory. Actors normally set agendas in their favour to induce certain desired outcomes. There is a rationality from the self-interest viewpoint, which is not necessarily shared by other stakeholders. Bachrach and Baratz (1962) contended that power involves the creation and reinforcement of social and political values and institutional practices in agenda setting to protect the interests of particular groups. The outworking of these factors underpins the decision making process.

The first concept that Bachrach and Baratz (1970) apply is the mobilization of bias, which was developed from Schattschneider (1960). It is defined as

...a set of predominant values, beliefs, rituals, and institutional procedures (‘rules of the game’) that operate systematically and consistently to the benefit of certain persons and groups at the expense of others. (Bachrach and Baratz 1970: 43)

There is a conceptual bridge between strategic misrepresentation and the mobilization of bias. Misrepresentation in prospect theory is manifested in the decision making event as deliberate intent. The process of mobilizing bias in the socio-political view, which includes incipient and unconscious inculcation over a period and may become part of taken-for-granted thinking. The public policy literature is interested in both the source and how bias is mobilized both prior to and in the decision making event. Further, decisions are not always discrete nor short term events, but are the result of evolving views and reviews. There may be multiple iterations. This is typical for challenging and complex decisions, which many projects and all megaprojects embody, especially at the project front end.

The mobilization of bias can also be seen through the use of force and intimidation. This is the naked exertion of power. Manipulation can be applied during discussion and especially reviews. Manipulation, using information selectively, is applied to steer decisions towards certain biased outcomes and to avoid others. Exclusion is another process, which involves omitting certain decision makers on occasions. More commonly, exclusion involves blocking the expression of values that change the decision making criteria (if these have been stated) and the expression of interests. Exclusion may be linked with manipulation where groups and cliques agree preferred decisions outside the main meetings in order to exert power in a meeting to set agendas against other interests and options. In essence, the mobilization of bias involves, “*suppression or thwarting of a latent or manifest challenge to the values or interests*” and bias suppresses or thwarts “*the demands for change in the existing allocation of benefits and privileges*” (Bachrach and Baratz 1970: 44). The mobilization of bias has a deeper meaning than misrepresentation.

A second concept proposed by Bachrach and Baratz (1970) is non-decision making. Prospect theory assumes a decision, but power and related bias can be mobilized to retain the status quo. This is more than a simple basis of ‘live and let live’ or the desire to avoid confrontation. It embodies intent and a specific agenda to protect and defend existing interests. Non-decision making is an outcome, which is easy to induce for it requires no action. Manipulation can also be used to facilitate it. No decision is more difficult to challenge, and so is the underpinning distribution of power among the actors. Non-decision making retains the status quo.

Therefore, non-decision making is a particular form of the mobilization of bias. It is evidenced in various ways, for example procrastination, delays, postponement and commonly a ritual or charade at decision making meetings whereby a ‘rigorous’ process of discussion and review appears to ensue, yet is led in ways that move through the issues without making decisions or only making token decisions. Bachrach and Baratz came under scrutiny from those saying it is impossible to research the intangible or non-events that cannot be directly observed. Yet both the process can be evidenced as noted above, and the outcomes can be evaluated against other criteria, for example negative construction and project management factors bring into question a megaproject decision or non-decision taken on political grounds (see also Isaac 1987, Denham 1975). Further, natural scientists research intangible processes and events, for example in quantum physics, and indeed non-factors such as ‘cold’ being the absence of heat. Methodologies and methods have been developed for natural and social science to accommodate such factors (e.g. Sayer 2000).

Bachrach and Baratz (1970) state that power is largely rational, yet force and manipulation are non-relational and irrational. Force and manipulation are political factors. The irrational is often well-argued and can appear rational. Indeed, rational power can be reinforced by irrational decision making, although this can challenge the legitimacy of power in the long run. The use of force can also erode power, especially under extreme events and in the face of challenging decisions. Power is manifested in institutions. The application of power, combined with the status of the institution in the context, gives rise to authority. Authority can be challenged where force and manipulation are too widely used and bias or passivity dominate decisions over extended periods.

The legitimacy of power and authority invokes a third dimension in decision making, which Lukes (1974, 2005) describes as the influence of power on people. This includes

the negotiations among different groups that hold power in decision making. He examines how the dominated are prepared to acquiesce, a process where powerful groups, other stakeholders and society's breadth of interests become moved to the periphery of social and geographical space (Kühn 2015). Rituals are employed during decision making. The outcomes are presented to the media to legitimize the process, hence preserve status quo (Lukes 1977). The dimension that Lukes adds is the use of power to shape preferences of people and groups to overtly or covertly remove conflicts from decision making. Decisions that may appear consensual may have involved considerable exertion of power:

...is it not the supreme and most insidious exercise of power to prevent people, to whatever degree, from having grievances by shaping their perceptions, cognitions and preferences in such a way that they accept their role in the existing order of things (Lukes 1974: 24).

### **Towards A Decision Making Approach Suited To Megaprojects**

The work of Flyvbjerg and those that cite him has dominated megaproject decision making. A deeper and more nuanced approach is needed. Let's start with the structure. Morris identified three layers for managing projects which developed as waves chronologically (Morris *et al.*, 2011, Morris 2013). The first two are project management as execution, which is supported by the bodies of knowledge, especially PMI (2013), and the management of projects to address the front and tail ends (e.g. Edkins *et al.*, 2013). The third is the institutional level (Morris and Geraldi 2011), which is the third layer from which power is exercised and cascaded down to the project level. The layers in megaproject decision making need to be brought together to understand the processes and examine the outcomes. Combining the strengths of prospect theory, work from the socio-political and public policy arenas with a stratified approach to the management of project research, three characteristics can be identified in decision making:

1. Rational and intentional;
2. Irrationality: a) unintentional irrationality; b) intentional irrationality, which may be rationally justifiable from another institutional level of decision making on occasions;
3. Intuitive assessment informed by experience and common sense.

In the third and hence intuitive way, common sense is distinguished from taken-for-granted thinking. Common sense relies on sense making that is derived from experience and expertise that is not fully articulated or remains tacit, yet constructively informs decision making. Taken-for-granted thinking does not involve any sense making. It is based upon unchallenged values and ideas that may be inappropriate, and therefore may lead to ineffective and potentially destructive outcomes. It is an intuitive part of the mobilization of bias and may underpin non-decision making. Taken-for-granted thinking is essentially structurally embedded bias. Putting these elements together, six types of decisions are possible:

4. Rational based on complete information - *ideal* yet extremely rare.
5. Rational based on incomplete information - currently *rare*.
6. Intuitive based upon available information, experiential assessment and common sense that is unbiased - *rare* yet possible.
7. Intuitive based upon available information, experiential assessment and bias - *commonplace*.
8. Irrational decisions that are motivated by high level biased criteria - *unexceptional* for megaprojects.

9. Combinations of the above in a layered process - *the norm*.

The mobilization of bias and non-decision making occur in the last four types, hence underlines their importance. Decisions are iteratively progressed and reviewed at times at policy and operational levels. Power exerted through the mobilization of bias, including non-decision making and associated rituals to legitimize outcomes, induce lock-in without a shock to the system. Yet, bias is also aimed at creating “lock-out” for certain interests and those who represent such views. Lock out of groups and the lock in to decisions superficially creates project certainty in the stratum the decision is taken, yet typically increases uncertainty in the next layers down and in subsequent phases of execution because the real issues have not been operationally removed.

## CONCLUSIONS

The rational economic model of decision making provided the point of departure to review and critique economic behavioural approaches, specifically prospect theory. There are general shortfalls, which are amplified when applied to megaprojects. A socio-political and public policy approach was introduced, covering issues of structure and power, process and legitimacy. In particular, the mobilization of bias, as a richer and deeper yet complementary concept to strategic misrepresentation, was introduced. The nested concept of non-decision making was also introduced. Six potential decision process characteristics and outcomes were presented. The process was portrayed at incremental and iterative within a structure of institutions and organizational settings, which are imbued with power and layered from the level of public policy and to the project organization. This approach provides a broader and deeper examination of project decision making for the future examination of megaproject decision making.

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# PLANNING IN CONSTRUCTION - HOW ARE THE DIFFERENT PLANNING PROCESSES LINKED?

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There is a current debate among construction researchers that resources and materials are not efficiently coordinated between projects, which in the long-run can negatively affect productivity and profitability. Other industries have improved resource utilisation with a hierarchical perspective on planning and tactical planning, the MPC perspective (Manufacturing Planning and Control). Adopting this way of planning among construction contractors would allow for improved coordination and resource utilisation as an overview of the project portfolio is taken. However, this perspective is new to construction contractors and learnings need to be gathered for understanding MPC in a construction context. The purpose of this paper is by taking a MPC perspective to increase the understanding of how resources and materials can be coordinated within a contractor's project portfolio on a tactical level. The study is based on case studies within two Swedish contractors. The study presents a structure for how to include a tactical planning process within a contractor's overall planning and what the main components are of this process.

Keywords: material planning and control, resource coordination, tactical planning

## INTRODUCTION

Already in 2002 did Dubois and Gadde describe the construction industry as decoupled. More recent reports from e.g. McKinsey (2017) confirms that it is still true. The lack of coupling is present both between the construction project and its subcontractors as well as between the project and the parent company and other projects. This hamper the possibility to have a successful coordination of resources on a portfolio level within the contractor, as resources are in many cases utilised from a common resource pool (Engwall and Jerbrant 2003). In multi-project environments, such as construction, it is important to link the planning of the individual projects to project portfolio planning (e.g. Engwall and Jerbrant, 2003). Portfolio management in construction today take place at a strategic level, by the contractor developing marketing business models and decisions of markets and products to develop, cf. Höök *et al.* (2015).

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Meanwhile, the operative planning is up to the single project, where emphasis on developing the production time schedule (Thunberg 2016). The effect is that the ‘parent’ company has little control over the planning of single projects (Dubois and Gadde 2002). Structured planning at a portfolio level linking the strategic portfolio management and operative project planning seems to be missing in construction today. This make questions, such as: “According to available resources which projects should we tender to maximize profits for the company as a whole?” hard to answer. And there is a risk contractors take on projects requiring resources that are occupied by other projects causing delays, having severe effects on the contractor’s reputation and profitability. Another effect of the lack of planning at portfolio level, also called tactical planning, are lack of information sharing between projects (e.g. Dubois and Gadde, 2002).

There are several trends going on in construction for the moment increasing demands on planning and coordination between projects; i.e. standardization of activities and materials, the boom of construction in e.g. Sweden, and the globalisation of the industry. The need of standardization is driven among others by the use of different logistics solutions such as terminalis and resource pools, which need to be planned on tactical level for serving several projects with materials. The standardization of activities and materials is complicated by the autonomy of each project. The boom of construction creates problems employing personnel for white-collar specialist functions, increasing the importance of improving the utilisation of these. The globalisation leads to longer supply chains creating a need for central purchasing securing supply to several projects at the same time to reduce costs (Frödell 2014). To deal with these trends and improve coordination between projects there is a need to start planning at portfolio level within contractors.

In the manufacturing industry, planning has been a major research area for a long time and an effective manufacturing planning and control system (MPC) is seen as key to the success of any company (Vollmann *et al.*, 2005). MPC is concerned with planning and controlling all aspects of manufacturing and coordination with suppliers and customers (Vollmann *et al.*, 2005). Planning in this paper is seen in accordance with the MPC system as hierarchical, with processes at different planning levels; strategic, tactical, and operative. Tactical planning processes are in manufacturing companies seen as a key process enabling holistic planning by balancing demand and supply, enforcing integration and coordination among company functions, business strategy, and operational planning and in the supply chain (Tuomikangas and Kaipia 2014). As mentioned, the construction industry today is lacking an equivalent process to the tactical planning processes used within manufacturing. Thus, the purpose of this paper is by taking a MPC perspective to increase the understanding of how resources and materials can be coordinated within a contractor’s project portfolio on a tactical level. The work is of a more conceptual nature and focus on the technical and process parts of planning and not the human and organisational (Jonsson *et al.*, 2013). The study is based on two case studies within two Swedish main contractors studying the development of planning at project portfolio level: One taking the resource perspective and one taking the material perspective.

## **THEORETICAL FRAMEWORK**

### **Manufacturing Planning and Control (MPC)**

The MPC system is hierarchical (strategic, tactical and operative level) with both a capacity/resource and materials planning perspective. These needs to be linked to each other, enabling materials and resources to ‘arrive’ at activity at the same time (Jonsson and Mattsson 2009). The planning levels within the MPC system have differing horizon

(the time-span covered), planning object (what to plan), and frequency (how often updated) (Jonsson and Mattsson 2009). The strategic planning has a long-term horizon and sets the boundaries for the mid-term horizon tactical planning, which sets the boundaries for the short-term horizon operative planning. The higher up in the MPC hierarchy, the lower level of detail and the more approximate the information (Jonsson and Mattsson 2009).

The analysis in this paper is structured based on the framework presented by Tavares Thomé *et al.*, (2012) which organises planning processes into the integration of setup and process parameters. The setup parameters deal with the scope and the basic principles of an MPC process. This refers to the *planning frequency*, *planning horizon*, and *planning object* (Jonsson and Mattsson 2009) and the process parameters are the *inputs*, *activities*, and *outcomes* together with *key performance indicators* (KPI) to measure the effectiveness and efficiency of the process (Tavares Thomé *et al.*, 2012). The inputs consist of plans, constraints, business visions and strategies, and goals (Kjellsdotter Ivert *et al.*, 2015).

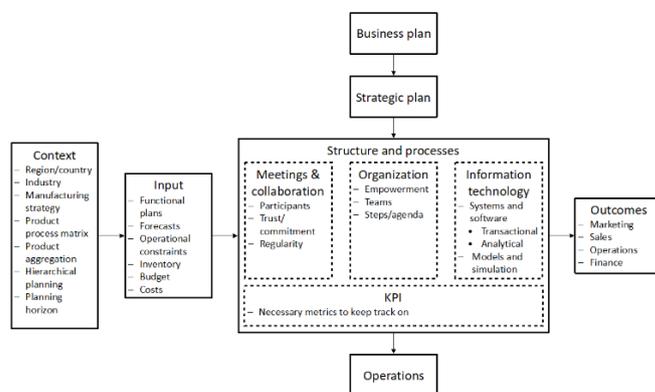


Figure 1: Planning framework (Tavares Thomé *et al.*, 2012).

Sales and operations planning (S&OP) process is commonly seen as a tactical planning process (Tuomikangas and Kaipia 2014). The aim with this process is to establish overall plans for sales, supply, and production (Jonsson and Mattsson 2009), by uniting different business plans into one integrated set of plans (Tavares Thomé *et al.*, 2012, Tuomikangas and Kaipia 2014). The S&OP process can be seen as a powerful tool to reach business targets where the main goal is profit maximization (Tuomikangas and Kaipia 2014).

The planning horizon is usually between 6 and 24 months to include any seasonal effects on demand (Jonsson and Mattsson 2009). Planning frequency is between quarterly to weekly and planning objects are often product groups (Jonsson and Mattsson 2009). The outcome of the tactical capacity planning for a traditional manufacturing firm is from a resource perspective a rough-cut capacity plan and from a material planning perspective a master production schedule (MPS) (Jonsson and Mattsson 2009). To develop the rough-cut capacity plan and the MPS ‘recipes’ of the needed resources and materials to produce a certain product are required. These are usually summarized into so-called Bill-of-Resources (BOR), resource profile, Bill-of-Materials (BOM), and product structure. Furthermore, the planning aims to mitigate for uncertainties in demand, capacity, and supply to maintain a high service level (Kjellsdotter Ivert *et al.*, 2015). Forecasts and other important upcoming changes are therefore important input to the tactical planning. Kjellsdotter Ivert *et al.*, (2015) have however shown that the tactical planning process have to be adapted to the specific context of the industry, such as the supply uncertainty of the food industry.

The structure of S&OP activities has been described by many authors (Grimson and Pyke 2007, Jonsson and Mattsson 2009) and typically consists of the following five activities: 1) Forecast generation: the marketing and sales department or other responsible departments produce a forecast for the coming planning period's demand; 2) Demand planning: the marketing department prepares a preliminary plan for future sales and delivery volumes. The delivery plan is based on the forecast and refers to the volumes that the company wishes to sell and the delivery per period; 3) Supply planning: the production department and those responsible for the procurement of raw materials will prepare a preliminary production plan expressing the volumes that are to be produced for each period during the planning horizon; 4) Pre-S&OP meeting: the managers of the marketing, production, procurement, and logistics departments meet in a reconciliation meeting during which any adjustments to the production and delivery plans are made; 5) S&OP meeting: the top management meets, unresolved issues are raised, and the plans are settled.

### **Planning in Construction**

Planning in construction borrows its content from general project management theory (Winch 2010) and includes portfolio management, programme management, project planning, and scheduling (Wysocki 2012). In a construction context a programme is often translated to a multi-project environment where several projects should be managed and coordinated. Wysocki (2012) gives a business perspective on portfolio management by defining it as all projects managed by the company. The strategic plan and demand forecasts is input to portfolio planning to identify suitable projects to run or tender on. The project portfolio yields a long-term resource plan and input in planning of a certain project. Portfolio planning sets the boundaries for the project planning. It is therefore necessary to have information about available resources and what materials are needed and when. This can however be hard due to the fragmented contractor and supplier basis and temporary organisations (Betts and Ofori 1992).

Project planning in construction can be separated into pre-construction planning and on-site planning (Johansen and Wilson 2006). The first comprises selection of project team, creation of the project documentation system, initiating the purchasing of materials, development of the time schedules and milestones, and other pre-project-execution activities (Menches *et al.*, 2008). The on-site planning comprises ensuring that planned activities can be fulfilled, schedule adherence, material procurement, weekly meetings, etc. (Johansen and Wilson 2006). This is complicated by the several planning phases in the project and different uncertainties related to the project (Johansen and Wilson, 2006). What also can be necessary to consider is the situation of having "unique" project and what the off-site conditions might be (Murphy 2013).

Another important part of planning is to coordinate the work with other project participants, like confirming that all participants share the same view of the project goals (Fellows 2009). Effective planning should ensure that all involved actors know what to do, when to do it, and whether the required resources are available. Fellows (2009) describes that coordination is most often absent in construction projects, which leads to unshared goals between participants and unsuccessful projects. As Zwikael (2009) pointed out, a project plan also includes procurement and material plans that are dependent on the project plan. These need to be developed early in the project (Johansen and Wilson 2006). This is however, complicated by the temporary supply chains (Modig, 2007).

## Synthesis and Research Question

From the description of the planning practice in construction today it can be seen that this focus on how to manage projects. Questions such as resource utilisation and material supplies are presented as important, however they are not considered on higher planning level than the project. This shows that there is a lack of both practical and theoretical studies on how material and resources should be coordinated from a tactical point of view in construction. The framework offered by Tavares Thomé *et al.*, (2012) can be used as a starting point in discussing tactical planning within construction. However, as Fernie and Tennant (2013) argues, adopting practices from other industries into construction is non-trivial. There are aspects and characteristics of the construction industry that need to be considered, such as the temporary organisations (Modig 2007) and the project driven processes (Winch 2010). Therefore, the tactical planning processes from the MPC structure needs to be analysed from a construction point of view to make it fit within this context. To answer the purpose, it is thus necessary to examine what tactical planning is within construction as well to recognise what is to be planned. To do this a research question is developed: *What are the main components of a tactical planning process in construction and how should it be structured?*

## METHOD

This study is based on two case studies within two different Swedish main contractors. The research is grounded in the basic assumption of contingency theory, where the structure and processes of an organization must fit its context (characteristics of the organizations culture, environment, technology, size or task) if it is to perform well (Drazin and Van De Ven 1985). The case study methodology is a valid choice when the context and experiences are critical to understanding the phenomenon (Barratt *et al.*, 2011). The case companies are contractors participating in a research project about developing IT-tools and processes for tactical planning within construction. This gives the researchers unique insight in each company and how planning is performed. It should be mentioned that this research is of conceptual nature. This is the first part of theory making and means that focus is on gathering understanding and defining important concepts for improving or revising in future studies (Meredith 1993).

Main contractor A (MCA) is a small to mid-sized Swedish construction company. In contrast to many other construction companies in Sweden MCA does not have own craftsmen resources. Instead they procure crafting services for each construction project. This makes MCA a pure coordinating actor in a construction project with all services (except the coordination function) outsourced to subcontractors, in line with the construction management project form (CM). Main contractor B (MCB) is one of the three major construction companies in Sweden. The MCB group's business is divided into four business areas Building, Infrastructure, Property Development and Industry. MCB is organised in departments. A department serves a certain geographical area and plan their own resources. MCB have their own craftsmen.

Data has been collected through semi-structured interviews, company documents and workshops within the research project. Semi-structured interviews in particular can be a suitable method by which to obtain the respondents' perspective on a topic. In total have five group interviews and three phone meetings been conducted with MCA and four group interviews and four phone meetings with MCB. Interviews have been structured according to the framework presented in Figure 1 discussing what the output should be, important input, activates to carry out, responsibilities, and KPIs. However, focusing on the specifics of the problem studied at the company. Persons interviewed have been

people involved in the current planning processes within the companies and a system developer. Each case has been discussed at two workshops within the research project, discussing the drafts of processes. Following the interviews and workshops, comprehensive documentation was developed for each case. As commonly suggested in case study research (Barratt *et al.*, 2011), a first case analysis was done by analysing the description at hand of the data within each of the cases, followed by cross-case analysis to identify commonalities for designing the tactical process in accordance with Tavares Thomé *et al.*, (2012). This resulted first in a process for each company to deal with the local problem focused upon in the research project. The cross case resulted in an understanding on how these two can be combined into a tactical planning process.

### Case Descriptions

**Main Contractor A (MCA) Materials planning:** Within a project, an important part of the resource planning is the quantity survey. This starts during the tendering process with developing a rough time plan and the quantities of materials to be used. The next phase, if the tender is accepted, is to plan for the actual project. The project manager develops a new time plan and together with purchasers procure contractors and materials. The contractors get information about expected delivery period for their work package and the contractors develop their own time plan based on their own quantity survey. As can be understood, the same planning and the same quantity survey is repeated several times, however by different companies and persons. An overall process for coordinating the different plans from the different contractors is lacking today. The result of the many and uncoordinated planning and survey processes is waste of time and increased costs.

MCA has recently introduced a logistics solution, including a distribution terminal, to improve material flows to construction sites. This solution allows for consolidation of materials between projects and subcontractors. It also aids in smoothing out the lumpy demand pattern of materials and provides suppliers with reliable forecasts. It also helps the construction sites to better control the flow of materials and coordinate this with the activities on-site. For example, if one activity needs to be postponed, the scheduled delivery from the terminal can in comparison to a regular supplier-buyer setup be easily postponed. However, also the planning of the terminal and its utilisation can be improved. For the moment, the linkage between the project planning and the planning of the terminal is lacking. Thereby it is not possible for the terminal to develop forecasts for capacity planning purpose and the different projects cannot get information about available capacity in the terminal during the construction period or reserve capacity at the terminal.

The CM role of MCA requires planning processes facilitating coordination, where the planning process within the company are linked. This means that output from one planning process is the input to the next in line. To accomplish this, clarification of responsibilities are required. Despite the focus on coordination the CM implies, MCA is experiencing troubles with the connection of planning processes and a lack of understanding in who is responsible for what. Also, in relation to the terminal MCA is experiencing that material delivery schedules are “living their own life” disconnected from the overall project time schedule of the individual projects. Construction site managers are good in developing their plans and purchasers are good in developing their plans, but the link between them is missing. Also, it is not clear who should be responsible for what, who should develop and update the material delivery schedules, and who should consolidate schedules at the terminal.

**Main Contractor B (MCB) Resource/Capacity Planning:** MCB is today lacking a system that connects marketing (tendering) and resource planning. MCB would like to have an overview of the project portfolio, both ongoing production and tendering processes as well as coming tendering processes to avoid a situation with both too much resources as well as too little resources. This is especially relevant regarding white collar specialist resources as these are scarce as there is boom in construction in Sweden for the moment. Furthermore, such an overview of upcoming projects would make it easier to prioritize which projects to devote resources to.

MCB make their resource planning in power-project. Power project in MCB includes all production projects as well as the tendering process for upcoming projects, it allows for planning both from a project view and an individual person's view. The planning horizon is 6 weeks to 6 months. MCB also have a project portal presenting all the tasks that have to be made for different projects, such as risk management, tenders etc. This is however not connected to power-project. Projects become known to MCB either via a database or personal contacts. As soon as a project is known it is registered into the customer relationship management (CRM) system. In the CRM system information such as client, planned start of construction, tender date, possible hit rate, and project turnover are registered. The CRM system also covers the tendering process, making it possible to identify in what phase a project is, i.e. before tendering process starts, during tendering process or a production project.

Every week each department has a market meeting. At these meetings are the resource planning managers, the business managers, and the project managers present. Here the projects registered in the CRM system are studied to identify upcoming projects and what projects are in the tendering process. Furthermore, the progress of ongoing production projects is discussed. Based on available resources, identified through Power project are tendering decisions taken or suggested depending on the sum of the tender. For the projects who are in the tendering process are decisions taken if the tender should be submitted or not. In this meeting is also a manual what-if analysis made, historically have Excel been used to some extent as well. A decision to submit a tender can be made based on several reasons except economic. A tender can be submitted depending on if it suits the profile of a certain site manager, available specialist resources and if it is possible to finish the project within the given timeframe. The tendering process usually is between three and six weeks. The time from submitted tender until decision is between one to two months.

## **ANALYSIS**

MCA and MCB have different reasons to start planning with a longer horizon and covering several projects. What is in common is that the need is a result of scarce or limited resources that have to be shared between projects. MCA identified their need to coordinate between projects during their work on improving the planning of material deliveries with the help of the new distribution terminal. To make the terminal capacity planning possible it is necessary with a tactical planning process covering all ongoing and upcoming projects that are to use the terminal. For MCB on the other hand, the need was identified because of the scarce availability of white collar specialist resources.

To allow for the resource sharing, the projects have to start sharing plans with each other. The sharing should not take place between each project, instead it should be on an overarching company or department level within the contractor. Figure 2 illustrates the connection between project and tactical planning. From the MCA case, sharing plans would also allow for decreasing the amount of quantity surveys as an overview of the

activities within each project would be created. Thus it can be seen that the tactical planning within construction need to link the resources and materials demands from different projects and the structure for how this can be accomplished is presented in Figure 2. Case MCB shows that it is important to include also the tendering process of each project in the project portfolio planning as this process consumes resources and the amount and types of resources consumed varies with the type of project and the contract form. It was seen in MCB case that each construction project can from a white-collar specialist planning perspective be seen to have three phases; before the tendering process starts, the tendering process and the production process. Figure 2 also illustrates that in all phases of the project the supply chain have to be considered. Decisions during tendering affect materials, suppliers, and subcontractors as well as during production, utilisation can be improved and collisions avoided by considering the supply chain on a portfolio level. Especially as suppliers and sub-contractors are shared between projects, which have been seen in MCA.

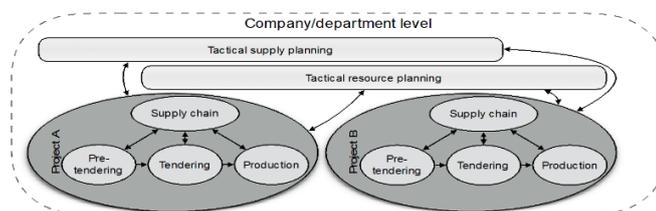


Figure 2: Illustrating planning on project level and connection to tactical planning

Following the structure of Tavares Thomé *et al.*, (2012) the main components of tactical planning: planning frequency, planning horizon, planning object, input, activities, outcomes, and KPIs' are here analysed.

**Planning object:** As resource and material demands are generated based on projects in the construction industry the planning object should be projects.

**Planning horizon:** As the planning object is projects and the need identified in MCB of seeing projects as divided into three phases; pre-tendering, tendering process and production process, should the planning horizon include at least the time frame of the tendering process and the production process. The longest horizon should cover all ongoing production projects, which in many cases are two to three years ahead.

According to MCB, the tendering process is usually between three and six weeks. Thus, to have a shortest horizon of about one month should cover ongoing tendering processes as well as upcoming tenders, i.e. projects in the pre-tendering phase.

**Planning frequency:** The tactical planning has to be a repetitive ongoing process in order to capture the progress of on-going production projects, be updated on accepted tenders and to handle new upcoming tenders. Both MCA and MCB have weekly meetings today and utilising these existing meetings should be suitable.

**Input:** The input needed and the input available differs depending on what phase the projects are in. A lot of the plans used in a project are created during the tendering process, thus production projects can share more information than tendering projects. Production projects have to deliver input in form of plans such as project time schedules, project material delivery schedules, and project resource plans. For projects in the pre-tendering and the tendering process it was in MCB identified that the time frame of the project, the turnover of the project, type of project, and contract type decides the resource needs within the project on an overarching level. In both MCA and MCB it was also seen that to start developing IT-tools, recipes of different roles in the projects and their

resource need in the different phases of a project had to be identified as well. In MCA, the quantity survey made during the tendering process was seen as a possible input to get an overview of the materials demand and supply.

Outcome: The outcome of the tactical planning process is for MCB a plan of what projects to tender on as well as a rough-cut capacity plan for the resources. For MCA the outcome is a rough cut capacity plan for the terminal as well as long-term materials delivery schedule for the different projects utilizing the terminal.

Organisation and structure: It can be seen from the above analysis that the materials and the resource planning not necessarily should be handled within the same process. This as the materials planning is connected to the purchasing function whereas the resource planning is connected to the market function. What functions/roles that should be included in the process therefore depends on the organisation of the individual company. KPIs: KPIs' should mirror the goal of the process. For MCB is the goal to improve profit margin of production projects and hit rate in the tendering process, whereas for MCB the goal is to improve utilisation of the terminal and decrease the costs for materials handling and purchasing.

## CONCLUSIONS

The purpose of this paper is by taking a MPC perspective to increase the understanding of how resources and materials can be coordinated within a contractor's project portfolio on a tactical level. The paper identifies a need for a tactical planning process taking both a materials and resource perspective at a portfolio level within main contractors as such a process would improve resource utilisation as well as what projects to focus on. The paper presents a structure for how the tactical planning process can be related to existing planning processes within main contractors in Sweden today (Figure 2). It also presents what the main components of such a process should be in relation to the MPC structure. The paper is based on two case studies of tactical planning processes under development. Therefore, further studies are needed to verify the suggested structure as well as studies of implemented processes.

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# HOW DO PROJECT BASED ORGANISATIONS DEVELOP, IMPLEMENT AND FOLLOW UP ON STRATEGIES AND OBJECTIVES?

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Strategies and objectives are set to give long-term directions. The underpinning rationale for these strategies are increased competitiveness and profitability, which often imply or necessitate change. The aim of this paper is to gain deeper understanding of how strategies are perceived and acted upon in a large construction company in terms of strategy deployment and performance management. The theoretical framing consists of four perspectives: first, general strategy theories representing a traditional view of strategy as something that an organisation owns and manages; then a newer perspective advocating strategy as practice, as a functional everyday operations strategizing. The third perspective is operations strategy which define how an organisation create value for its customers. The fourth perspective and the framework used for data collection is the management methodology Hoshin Kanri which have successfully in other industries. The data consist of in-depth interviews with three managers at different levels in the same line as well as document analyses. The results show that there are discrepancies between how strategies are perceived and how they are managed at different levels in the organisation. The conclusion drawn is that strategy formulation, interpretation and implementation need to be much better aligned down and up the chain of command. The paper suggests a framework that could be suitable to achieve such alignment.

Keywords: strategy, deployment, operations strategy, Hoshin Kanri

## INTRODUCTION

The construction industry is facing huge challenges; it is also burdened with a reputation of being unproductive, conservative and slow to take on innovations, such as industrialisation (Egan 1998). Historically, strategy management in construction has focused on what to construct, in what regions and for what market shares. Little attention has been paid to how to produce and deliver value to customers based on their actual needs (Lidelöv, Simu 2016). The strategy management that has been prevalent to date could be defined as classical (Whittington 1996), a top-down view with focus on planning and execution.

Despite its reputation of being unproductive and resistant to change, there are strong and rapid movements of change being undertaken. During the last few years, Sweden, for example, has been acknowledged as being in the frontline of industrialized housing production, and Lean Construction and VDC have made a difference for companies using these approaches to improve their business (Tauriainen *et al.*, 2016, Forbes, Ahmed

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2011). Some organisations are currently using totally new ways of 'doing construction', and are coming into the market as strong competitors (Buhler Michael, Rodrigues de Almeida Pedro 2017). This indicates that things are moving forward in the construction business and sector. However, the ability to lead change, i.e. to work toward continuous improvement and driving change relies heavily on an organization's ability to align its strategizing at the top with the operations lower down the chain of command, or being able to construct an environment that encourages change and improvement.

The problem with strategic change is misalignment between levels in the organisation, resulting in failures to implement and get effect from top management's formulated strategies at operational level (Bourne *et al.*, 2003). Another problem is that strategy is viewed as something that the top management possess and have responsibility to manage rather than something everyone in an organisation does and thereby also owns (Whittington 2006). The commitment and understanding to what to do and why is there for an obstacle for change. Depending on the viewpoint, strategy work will be managed differently, resulting in different outcomes.

To improve engagement with strategy at lower levels, the top-down command and control approach is being replaced by a process-oriented, interactive and inclusive way to proceed (Roos *et al.*, 2004, Whittington 2001). This is also in line with theories of change management (Kotter 1996) and learning organisations (Senge 1990), where there is an emphasis to engage and motivate people rather than telling them what to do, and sometimes also how to do it.

Construction companies are project oriented organisations with a large extent of decentralized management and decision. The deployment of strategies and policies that goes from the top out through all levels in an organisation, due to this decentralization, meet challenges of communication (Björnström 2007) and follow-up on performance (Samuelsson 2006). The aim of this paper is to gain deeper understanding of how strategies are perceived and acted upon in a large construction company in terms of strategy deployment and performance management. The framework used to increase this understanding is Hoshin Kanri, a management methodology that have proven to be successful in other businesses (Jolayemi 2008, Kondo 1998) but is novel to construction industry. With a deeper understanding a suggestion on next step for improvement is possible to formulate.

## **THEORETICAL FRAME OF REFERENCE**

Strategy are usually viewed through different lenses (Johnson *et al.*, 2008). Strategy as design which is the classical approach of seeing builds on organisational experiences from previous strategic work. Strategy as ideas comes from the notion that innovation and strategic development is emergent in day-to-day activities and managers at different levels set the context and prerequisites. For an organisation, it is valuable to reflect on both lenses as these together may provide a better understanding of opportunities and constraints. A recent perspective that could prove useful is strategy-as-practice (SaP).

Strategy as practice is how people, managers and non-managers, act and interact with the strategic intent at all levels and in the strategy-making sequence. SaP is how strategy as such is done rather than what it is as in the classical approach. The how in this sense is about details in everyday business and is expressed through meetings, talking and daily management - how to get things done. In this sense strategy as practice is related to operations strategy (OS), which describes how an organisation creates value and manages competition. Strategy from both these perspectives are dynamic, thus not easily

characterised or copied. The difference between an operations strategy and the SaP approach is that the former is often an intended top management overall strategy such as Lean or Total Quality Management (TQM).

An operations strategy is a functional strategy for how operations are managed and developed within an organisation (Lewis, Slack 2011). From a top-down perspective, it is about a common way of working within a group and business. Operations strategy is, therefore, a rather classical perspective on strategizing (Sage *et al.*, 2012). Yet, learning and improving from day-to-day business and the integration between market requirements and use of capabilities are also important factors of an operations strategy (Lewis, Slack 2011). For this reason, OS can also be said emerge from "how things are done" rather than being predetermined choice of how to do things (Lidelöw, Simu 2016). In this sense, there is a close connection to SaP. In the construction literature, however, there is scant mention of OS in relation to strategy approaches (Lidelöw, Simu 2016).

In construction companies, frameworks for long-term strategic management have been developed and used especially since the mid 1990 (Junnonen 1998, Price 2003). Recommendations by Price, (2003) was that the industry continues to develop, especially within three areas: development of strategic process, improvement of audits and applications of appropriate tools and techniques. Those areas are fundamental parts of total quality management and is also highlighted by Price and Newson (2003).

The construction industry has tended to be highly confrontational and needs to encourage new forms of behaviour through more effective communication and better training, especially during the implementation of new strategies. This would be best achieved within the context of total quality management. (Price, Newson 2003: 191).

Löwstedt (2015) concluded that despite development of long-term strategic attempts in construction companies, there is still a predominance of on-site reactive focus at the expense and long-term strategic investing. Björnström (2007) and Samuelsson *et al.*, (2006) found that neither performance management nor communications related to strategy deployment were functioning efficiently in construction organisations.

To be able to develop and continuously adapt the formulated strategy, and implement it, integration into the daily work is a winning way to work (Kondo 1998). To do this, there also needs to be a systematic approach to measurement and follow-up of set targets and objectives. Performance measures and performance management are therefore vital ingredients for strategic success (Yang, Yeh 2009). The other side of the coin is put forward by Rangone (1997), who claimed that any performance-management system needs a strategy to align with. Hence, the performance of the organisation must be put into the context of a strategic ambition.

The balanced scorecard (BSC) (Kaplan, Norton 1993) might be the most known tool for such an endeavour, but is in no way the only one, and may not suit all types of organisations (Samuelsson *et al.*, 2006). The aim of BSC is, after Kaplan and Norton (1993), is to relate and connect measures of performance to strategies. Other models that are frequently mentioned in the performance-management literature are: The Performance Pyramid (Lynch, Cross 1995) and The Performance Prism (Neely *et al.*, 2001). Common for these is focus on finding relevant measurements targets for proactive work, for improvements and fact-based decisions related to the strategies and of ongoing changes in the organisation. What Samuelsson (2006) found was that there are gaps between different levels in the organisation that influence how effectively the strategies are implemented and deployed in the organisation. Neely (1999) also emphasized the

alignment of performance measures to the context, and suggested that this means different criteria apply in different organisations due to what is most important for them.

Hoshin Kanri (HK) was developed in Japan in the late 60's (Kondo 1998) and applied at Hewlett-Packard (Calingo 1996) in the late 1970's. The development of HK is a reaction to, and development of, earlier methods for strategy deployment/management and puts an emphasis on both communication and performance management, topics identified by Price (2003) to be of importance to improve for construction.

According to Kondo (1998) HK started in Japan when companies applied PDCA at company level. The cradle for HK comes in other words from the influences of Deming and his work with continuous improvement and quality. Policy deployment, strategy management and TQM are hence similar and yet somewhat different ways to describe how businesses go about implementing and obtaining effects on their strategic work. The difference motivating HK in this study is the focus of iterative processes, involving all employees at all levels. This also gives a close connection to operations strategies as standards and procedures on how to work as defined by Lewis and Slack (2011).

HK have a strong emphasis on engagement of people who work towards deploying strategies through their involvement and commitment and is neither a pure top-down nor a bottom-up way to proceed. Catch-ball, a phenomenon of working in an iterative process, throwing the "ball" (strategy) back and forth until a final decision is reached, is how this is done in practice. Progress is one vital part in HK process, hence, to define objectives and targets and assure to measure and follow up on those, at all levels in the organisation is important. The short term and daily execution on strategic targets is one of the differences between Hoshin Kanri and Balanced Scorecard (Yang, Yeh 2009).

*Table 1: Summary of the HK fundamentals based on Jolayemi (2008)*

| Fundamental area of HK   | Description  |
|--|--|
| Preplanning and preparation  | This stage is to grasp the context and surroundings of the company. To analyse the trends in the business and sector that is relevant for the company. This is also the first chapter in ISO 9001.   |
| Development of mission, values and vision statements   | The mission is to define the and why, values to declare how to behave and what to believe in and the vision tells where the company is heading.  |
| Development of plans for long and medium-term goals and of annual plans for short term targets | To make the vision to come true there need to be goals and plans for how to achieve the future state. To reach the long-term goals, annual plans are set with few critical objectives that in turn are realized through defined targets set in time and means for measurements.                        |
| Strategy deployment and catch-ball   | How to engage an organisation through all levels, horizontal as well as vertical to the overall strategies with an iterative process that achieve strategy formulation and implementation simultaneously and through that find a base for continuous improvement and learning within the organisation. |
| Reviews  | Reviews of the strategy process aims to measure the effectiveness of it. It also serves to transfer knowledge about best practice within the organisation between different business areas and geographic areas at local level.  |
| Standardisation  | To be able to do improvements and continuously go forward there needs to be standardised descriptions on the core business process and the business fundamentals.  |

## METHOD

This pilot study has used a qualitative research approach as its aim is to understand how strategy and objectives are managed in a construction company (Yin 2013). In accordance with SaP (Jarzabkowski and Spee, (2009) a starting point would be to seek answers at the micro level. To find and relate to how strategies in a large construction company are managed at different levels, in-depth interviews with three managers at top and middle level were carried out. The selection criterion was key, knowledgeable persons, who were actively involved in formulating, communicating and implementing corporate strategies. The manager responsible for leading a strategy development process was interviewed to find out how the strategy had been developed and launched. The selection of a top-manager at business level was made to gain insight into how managers had been involved and accountable to drive the implementation. The chosen business area is a vital part of the company and has one large customer, covering the public sector in Sweden. The choice of the third manager, a department manager, was based on the findings from Björnström (2007), who found that there are different mental models of strategy at different levels in an organization. He found that middle managers at department level had an approach and view on strategies that differ from those of top managers. The interviews were semi-structured with predetermined themes, starting with open questions where the interviewees were asked to talk freely about their involvement in the strategic work.

As a second source of information, relevant corporate documents were analysed. The researcher has had full access to all internal material regarding strategy work, and has also received work material from the interviewees to complement the interviews. The case-company is one of the larger construction companies in the Nordic countries, and it launched a new strategy in 2016. It is currently in the process of implementing this strategy in the organisation. Therefore, the interview themes cover how the strategy was developed, communicated and planned to be implemented as well as how it is intended to be followed up.

The theoretical framework used to analyse the data comes from general definitions of strategy (Johnson *et al.*, 2008), Strategy-as-Practice as described by Whittington (2006), Jarzabkowski and Spee (2009), and Operations strategy as described by Slack and Lewis (2011) and Hoshin Kanri as described by Jolayemi (2008). HK have been used as the framework for the data collection and hence the data have been categorized and compared to the fundamental areas of HK described in table 1.

The interviewer (author), who is also employed part time at the organisation, has very good knowledge about its culture and practices. The summaries of the interviews have been submitted to the interviewees for their review. The strength from having long and close relations to the organisation being researched is the trust and common understanding built up over the years. This makes it easier to obtain and corroborate information in rather sensitive areas, which might not have been the case otherwise.

## FINDINGS

The preparative work with the new corporate strategy began in 2013 with an introduction of a new vision for the company. The top-management team was responsible for the process of formulating the new strategy. The framework and the proposal for the strategy was based on an external analysis with megatrends, predicted for the construction business in general. The top-management team put forward a proposal for a new strategy, which was then presented to, and refined together with the business units (BU). During

this work, no external consultants were involved and the work included both specialists and line managers from BUs that participated in different working groups, focused on different themes and initiatives. The BUs were tasked to come back with business plans on how the different initiatives apply to their business and flowingly how to continue work with the strategy. The BUs organised themselves and made a thorough work on what core capabilities that were needed to be able to deliver results according to the proposed strategy. Based on the input from the BUs, a corporate strategy was finalized and launched by the CEO and his Executive Management Group. The corporate strategy came out to consist of three 'Must Win Battles', MWB, which summarises 11 strategic initiatives to be handled by the BUs. To follow up those initiatives five financial objectives, one objective for safety and one objective for sustainability were decided, a total of seven objectives. Additional to this there were and still are ten KPI's to measure progress in the different initiatives and through that the MWB. Those objectives and KPI's are reported to the Executive Management Group on a quarterly basis. The seven objectives are broken down to annual targets to be reached throughout the strategy period of five years. From the top management perspective, there has been an involvement that has gone both deeper and wider prior to earlier strategy periods and the expectations are hence greater regarding commitment to work more unified.

At the business unit, they recognized that they had been involved in preparatory work with the strategy but, the perception was that they had been presented a new strategy that they had to adopt and relate to rather than to revise and improve. The business unit have also made a choice to hold on to their 'Must Win Battles' established from the previous strategy cycle, and have related and connected these to the corporate strategy. According to the documents the different MWBs does not necessary relate to each other and give an impression of not being part of the same cooperate strategy. The BU top manager did however affirm that it is easy to see how they are related and that it works to communicate in the organisation. In practice the BU managers work with action plans with teams being responsible for different actions to be made the up-coming years. This was a way to prioritize and focus on a few actions rather than going to broad and not get things done and delivered. Despite this priority they had to let go of strategic work for periods of time due to short time operative work that needed attention. The perceived challenge is pinpointed by this quotation:

It is not too hard to come up with strategies, the difficult part is to implement. [Manager BU]

The business unit strategies and 'Must Win Battles' were communicated to the department managers at the yearly top-management summit. There are also annual action plans communicated to the different departments and followed up on a quarterly basis as are the corporate KPI's. Those cooperate KPI's are, however, less important to the BU. The BU have struggled to define their KPIs but have not yet succeeded. Instead, the focus on short time deliveries of economic result is something that is mentioned several times from both BU manager and the department manager. The challenge with finding the right KPIs and measurements were referred to as a general concern rather than something that have happened just this last year.

Despite all the ambitions with KPIs - the focus is on financial targets and exclusively bottom line result. [Department manager]

At the department level, the management team have their on-going and annual strategic work although they are also in part involved in the strategic work at the BU level. The department manager made a choice to continue with their own themes in his strategic plan that they have had on the agenda for some years already. The Strategic plan from BU

with its MWB were not perceived as applicable for the department and hence merely presented as something to be aware of but not to manage and control. Consequently, the corporate KPIs, demanded from the BU to report, are an administrative task to do - not something that add value or affect daily work. To control the department's strategic progress the department manager have tried to put forward his own targets and measurement that are proactive and easily reported more frequent than today's quarterly report. This work has not yet reach a satisfactory level according to the department manager and he recognise that other departments are even further behind in this matter which is he perceive as worrying.

Feedbacks from reported measurements seem to be non-existent, at all level. The department manager acknowledges that there is a lack of attention to following up on the actual work being done in the department, both measurements and content in strategic action plans. Both BU manager as well as department manager conveyed that there were neither actions nor response on reported measurements that they had been part of or were aware of. Audits and reviews made in the company, and the reports that follow them, are neither connected to nor included in the strategic work. Work with quality management and audits is something managed a separate support function.

## **ANALYSIS AND DISCUSSION**

The mental model of strategy, the strategy lens adopted, is clearly the classical top-down, strategy as design, with preparatory work in a relatively small team at top management level and a plan for implementation. Further out in the organisation, at BU and departmental levels, the strategy model seems to be more based on experiences of how work is done rather than implementing and following the corporate strategy. Still, despite practice, the perspective from all three interviewees, is that a company have one strategy and it is owned by the top management at corporate level. This stance, with strategy as something a company own, in the opposite to SaP, where strategy is how you work in an organisation (Whittington 2006). In the department studied here, strategy practice is undertaken locally, at each level for its own purposes, and that the common practice that would unify/align the company and BU is lacking showing that the operations strategy is rather emerged locally than intended (Lidelöw, Simu 2016). The way to realise and move forward at each level are a variety of strategy activities such as workshops, seminars and action plans. This shows how the strategy practitioners are individuals that make their own decisions based on existing, but local, structures and routines (Whittington 2006), and that this could also be seen in that the BU manager as well as the department manager did not seem to interact in any way, instead each ploughed their own path forward.

There is no systematic structure to support in the follow-up on the strategic work. This is a critical part of the HK process (Jolayemi 2008) which put an emphasis on the iterative process and the ability to engage and strive for continuous improvements through 'catch-ball'. The importance and lack of systematic structure for reviews and follow up is also emphasised by Price (2003). To be able to control and react on measurement there need to be short time spans between results which is one of the unique parts in HK (Yang, Yeh 2009) and something that is lacking in this case. Being given results on measurements 1-4 times a year does not give the prerequisite for being quick and drive necessary changes. There is more focus on reactive measurements (financial results) and short term actions than how to manage people (give feed-back) and work with proactive measurements. An apparent risk is that an organisation fails to evaluate if their strategic actions are giving them the sought after result in time, and consequently end up with actions that merely spend the employee's time and energy. It is also recognised by Whittington (2006) that

an important part of the managers' task, is to ensure that the apprentices have the right experience, skills and competence to be effective strategists. The shortcomings in feedback and proactive measurements give that the possibility to develop managers and employees to the right competence and work strategically is poor.

The traditional strategy as design with top-down implementation has proven to be inefficient as there are people with own ambitions and drivers along the way. As there neither is a well-functioning performance management nor an aligned operations strategy to support how to work, the strategy implementation is slow and frustrating. In the studied company, quality management is regarded as something part from strategic work. This stands in contrast to what Price and Newson (2003) have suggested to be a possible way, to work with total quality management, to achieve a better communication and training during strategy implementation. This is also in contrast to the parts of HK defining how to review and make standards is part of the strategy deployment process, table 1.

### CONCLUSION

This pilot study has taken its starting point from the challenges of working with strategies in a project based and decentralised organisation such as construction business. The aim was to gain a deeper understanding for how to proceed with strategy management in construction.

First conclusion is that how an organisation works makes a difference on what they achieve, still this is the least described part of the strategy implementation. With HK as a framework there is a need for a more iterative process from the development of vision and strategy, all the way through to targets, follow-ups and reviews to be aligned as one company and have this related to the quality management system (ISO 9001 as an example). That calls for engagement and involvement of managers and teams at all levels in the organisation. The findings in this case show that there has been involvement of employees at different stages but, focus have been on information and launching of already decided strategies and objectives, not on how work is done. The interface between the different perspectives of Strategy as Design and Strategy as Practice needs to be heeded as both perception do and will continue to co-exist. This comes to practice in operations strategies for how to work to give best value for money to customers.

Second conclusion is that communication and alignment between levels and functions is vital to see how different parts of a corporate strategy is kept together. To see how different parts of the strategy make change happen, to see effect of the strategic work, it is also necessary that KPIs, objectives and targets are connected and drive the behaviour and result in the sought-after direction.

Third conclusion is that the challenge lies neither in structure, systems nor performance measurement. It comes down to people and their ability to learn and continuously strive for improvements, and the organisations to create an environment that aligns their efforts.

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# A CRITICAL ANALYSIS OF STRATEGIC PERFORMANCE MEASUREMENT IN SUPPORTING ESTATE DECISIONS IN NHS SCOTLAND

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National Strategic Performance Measurement Systems (SPMSs) for Estates Management (EM) are becoming a more common tool among governmental agencies and the enforcement of their adoption to the different operational (regional or municipal) units. In theory, governments assume that Senior Estate Managers will use the information provided by the performance measures for strategic decision-making over the life cycle of the facilities; however, there is little evidence that in practice this is happening. To address a gap in the literature this study seeks to understand current practice in the use of strategic performance measures set nationally for Estate Management strategic decision-making at Senior Estate Managerial level. The research looks at the healthcare sector, taking the case study of NHS Scotland. Based on sixteen semi-structured interviews with Senior Estate Managers across different Scottish NHS Boards, the study found that the implementation of SPMSs has a symbolic power rather than instrumental. The lack of integration between Clinical Services and Estate Management and issues related to the design reduces the potential of SPMSs to be an effective instrumental tool.

Keywords: healthcare estate, strategic performance measurement systems

## INTRODUCTION

Since the 1980s public organisations in many countries have been embarking on management reforms directed at improving efficiency, effectiveness and accountability. As a result of these reforms the power for policy making and service functions were separated, and issues of accountability and performance measurement (PM) became increasingly important.

In most countries, central governments' own or control a large amount of property and have the responsibility to provide real estate for public services within their respective jurisdictions. As governments and stakeholders have begun to view buildings as a strategic resource, an increasing demand has arisen from the governmental agencies reflecting different operational (regional or municipal) units to become more accountable and demonstrate that the capital is spent efficiently and effectively, and also for the planning, management and performance of their facilities to achieve best value. Thus, the

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last couple of decades have seen governmental agencies establish Strategic Performance Measurement Systems (SPMSs) for assessing performance of their property portfolios and in the majority of the cases it has been made mandatory for their adoption and reporting on the respective measures by their operational units. This is the case of the healthcare sector, where previous research showed that this practice has been adopted in the UK, New Zealand, the US and in some regions of Australia, driven by strong government direction and presenting commonalities on the attributes measured (Rodriguez-Labajos *et al.*, 2016). The guidance documents published by different governments conclude that the purposes for the implementation of these systems are to show accountability and transparency, but ultimately to support decision making over the building life cycle (planning, investment/procurement, management-in-use and disposal phases) with a view of improving overall performance.

Recent studies have found that the use of performance information for different purposes at the same time (e.g. as managerial tool and as tool for the purpose of achieving accountability) is self-defeating, losing the effectiveness of the SPMSs (Bromberg, 2009; Gao, 2015). Scholars agreed that for the benefits of PM to be fulfilled in the public sector, the information resulting must be used for decision making (Cuganesan *et al.*, 2014; Moynihan, 2005). However, in the public sector this practice has contemporarily a negative connotation within a neoliberal market context, as it is shown in earlier studies of the like of Carter *et al.*, (1995) who stated that this practice was adopted by governments of many western countries promoted as a technology for the control of the public sectors; or Osborne and Ted (1992) who emphasised the importance of measuring through performance indicators as a means to ensure governmental control. More recently Le Galès (2016) argued that benchmarking comprehends instruments as technologies of government that associate knowledge and power. Drawing on the findings from the literature this research asks the question: 'Is performance information used in practice to inform decisions and integrated in a true strategic performance management system when applied nationally, or it is just a means to show accountability and legitimise power? And in this case, what are the consequences?'

Measuring estate performance strategically presents methodological and practical complexity. Poor or not relevant designs for their users and their unsuccessful implementation have led this practice in non-profit organisations to become 'a tick box exercise', a well-documented issue in the literature that reduces the potential of PM to be maximised. LeRoux and Wright (2010) suggests that more focus should be on investigating and testing performance measurement practices in the public sector to identify how these systems can be designed and implemented to obtain the maximum benefits of the tool. These authors also indicate that how performance data is used in decision-making in the public sector is not well documented. This paper is a starting point for addressing this gap in the literature through examining current practice in the use of SPMS for EM in the healthcare sector, taking the case study of NHS Scotland.

### **Strategic Performance Measurement for Estates Management**

In the literature and in practice it is often heard the well-known adage that says, "If you cannot measure it, you cannot improve it". PM encompasses the processes of establishing goals, developing a metric set, and collecting, analysing and communicating performance information and results within the organisation and its key stakeholders (Brudan, 2010). This practice takes place at a number of different levels: strategic, tactical and operational. It starts at the strategic level and involves decisions at senior levels on appropriate investment and management of property assets to service delivery

requirements. It encompasses activities such as planning in the longer term and options such a new-build, modernisation, refurbishment or disposal of facilities (Støre-Valen *et al.*, 2014). The tactical approach is derived from the strategies adopted, having an impact on the provision of space, services, costs and business risk. Then it runs to the operational level where the focus is on the ongoing management of the facilities over the short to medium term within the allocated budget set at the strategic level (Jones and White, 2008). In scientific management, performance is associated with both, PM and management. These two key processes follow to each other and cannot be separated from one another (Brudan, 2010). Støre-Valen *et al.*, (2014) stated that to gauge the effectiveness of FM it is necessary to reach an understanding of the current conditions of the facility and thus make changes in current practices in order to achieve the desired performance. The authors concluded that it is necessary to develop assessment tools to be able to get a greater understanding of buildings as strategic means.

Data from the assessments is used to support portfolio-based facilities management and the strategic decision-making about investments in maintenance and repair (National Research Council, 2012). A number of studies in the property and asset management literature agree that ultimately performance data supports decision-making surrounding whether or not to make an investment and to assess the appropriateness of the facility towards organisation mission, facility expansion, real estate acquisition, facility's renovation and retrofit (Lavy *et al.*, 2014). In a previous study Council *et al.*, (2005) stated that performance measures inform decisions on the allocation of resources within an organisation and to make and justify future decisions. The costs associated with data collection, analysis and maintenance can be substantial (National Research Council, 2012); therefore, for measurement to be useful it must be effectively linked to other management and decision making processes. Without strong links the information generated is good to know but does not lead to improved decisions, get better performance or deliver more effective control and accountability (Wong, *et al.*, 2015).

### **Research Aim**

This research seeks to take healthcare as a case scenario to identify and outline current practice in the uses given to the performance information when SPMSs applied nationally, with a view to critically analyse the potential value of the tool. The research attempts to bring the theory into practice with the aim of improving the use of formal SPMSs.

## **RESEARCH METHODS**

As pointed out earlier, there are a handful of key governmental agencies that have adopted performance measurement reporting systems. For this study, the healthcare sector was selected for different reasons: 1) it has been documented as the most difficult to manage in the public sector (Talib *et al.*, 2013: 2) recent literature recommends the implementation of this practice at national level in healthcare (Støre-Valen *et al.*, 2014; Hareide, *et al.*, 2016: 3) the study is part of a wider project in collaboration with Health Facilities Scotland (HFS) that attempts to identify the potential value of SPMS for EM in the healthcare sector.

The NHS Scotland is taken as a case study and the main research strategy. Two methods for data collection are used to answer the research questions, including documentation analysis and interviews. LeRoux and Wright (2010) indicated in their study on how performance data is used in decision-making in the public sector the need for qualitative research based on interviews to fully understand how performance information is used.

### *Documentation analysis*

Guidance documents produced by the Scottish Government, public and internal reports accessed via HFS, as well as information obtained through informal discussions with members of HFS were analysed to identify NHS current practice in the following process of PM: implementation of performance measures, data collection, communication and reporting.

### *Interviews*

The interviews were conducted with one selected member from each of the 16 NHS Scottish Boards. Since the interviews focused on the overall Board' perspective in the use of the performance measures, each healthcare body was expected to provide only one response. Most of the representatives occupied Departmental Heads positions from different areas including capital, estates and finance, or similar roles responsible for the implementation of the Boards strategic plan at the operational level. They have dealt with the collection of data and reporting on the performance measures in their organisations since its implementation back to 2009 and participate in the elaboration of the annual Property Asset Management Strategy. For the purposes of this research and due to the large variety of role names, the interviewees are referred to as Senior Estate Managers. The interviews were conducted largely via videoconference due to the geographical distance and time constraints. However, where possible, they were conducted face-to-face allowing to directly observe behaviour and obtain more objective data.

The interviews consisted of open ended questions designed to last 20-30 minutes, mainly covering two areas: the value of collecting and reporting the performance data, and the uses given to the performance information resulting. Since the research was financed by the NHS, it was perceived that the participant's answers were in some occasions vague. In those cases the research evaluated the responders' attitudes and behaviours. Interviews were recorded and transcribed by the authors and analysed using thematic analysis with support of qualitative analysis software NVivo. The transcripts were initially coded line by line, followed by focused coding where the most significant and frequent codes were selected that made the most analytical sense when categorising the data into themes. Techniques like memo writing were also used for this research. The analysis of the data also includes comments that came across with the findings from previous interviews with the Policy Advisor and the Assistant Director (Property and Capital Planning) of HFS.

### *The context of SPMS in NHS Scotland*

Health systems across the world have different governance systems. The NHS Scotland is characterised for being highly centralised and is financed from general taxation. The Scottish Government Health and Social Care Directorate is responsible for allocating capital investments but also for setting healthcare policy, providing strategic direction to the twenty-two healthcare bodies (named Boards) and overseeing delivery of services; while the healthcare Boards have more planning, managerial and operational functions. They are required by the Scottish Government to have appropriate governance, accountability and reporting arrangements in place to ensure the efficiency and effectiveness of the planning, operation, management and disposal of the facilities. In 2010, the Scottish Government adopted the National Asset and Facilities Services Performance Framework that consists of a combination of twenty outcome key performance measures, both financial and non-financial, as it has been emphasised by many authors (Franco-Santos, *et al.*, 2012). The measures, also referred in this study as Key Performance Indicators (KPIs), reflect healthcare policy and organisational strategies. Prior to 2010, Boards used to have operational monitoring tools, but not many had strategic indicators in place with condition and suitability being the most common.

Since the ‘Policy for Property and Asset Management in NHS Scotland’ was implemented, Boards are required to record, monitor and report the operational performance of their estates on the 20 KPIs annually to the Government in order to compile the Annual State of NHS Scotland and Assets and Facilities Report (SAFR), a public document that provides a national perspective on the Board’s assets and facilities management performances. To support this portfolio-based estate management, the Government adopted the Estate Asset Management System (EAMS) which is the national data collection for all properties from NHS Scotland. Data is recorded at block/department and site level for the following performance facets: physical condition, statutory compliance, environmental management, space utilisation, functional suitability, quality of the environment and the cost of the different levels of risk backlog maintenance. This data, together with finance related data that comes from the Cost Book, combine to support the development of the twenty Government wide performance measures (see table 1).

*Table 1: Aspects looked at by the strategic performance measures adopted by the Scottish Government for the NHS*

| Property based measures (from EAMS)   | Measures from Cost Book   | Others   |
|---|---|--|
| <ul style="list-style-type: none"> <li>• Physical condition;</li> <li>• Statutory compliance status of property asset base;</li> <li>• Backlog maintenance expenditure requirement;</li> <li>• Significant and high risk backlog maintenance as percentage of total backlog expenditure requirement;</li> <li>• Estate functionality suitability;</li> <li>• Space utilisation;</li> <li>• Quality of physical environment;</li> <li>• Percentage of properties less than 50 years old</li> </ul> | <ul style="list-style-type: none"> <li>• Building area;</li> <li>• Property maintenance costs;</li> <li>• Facilities management costs;</li> <li>• Cleaning cost;</li> <li>• Energy cost;</li> <li>• Rates costs;</li> <li>• Catering costs;</li> <li>• Portering costs;</li> <li>• Laundry &amp; linen cost;</li> <li>• Waste cost</li> </ul> | <ul style="list-style-type: none"> <li>• PAMS reflective of service needs and patient preferences;</li> <li>• Patient opinion of healthcare accommodation</li> </ul> |

In addition to the annual returns provided by the Boards on the 20 KPIs to the Government, they are also required to produce the biannually mandatory Property Asset Management Strategy that seeks to support the questions: "...where are we?...where do we need to be?...and how do we get there?" with an evidence base. Recent concerns have emerged relating to the extent to which performance measures are in practice used to support strategic decision-making; or who benefits from current SMPSSs, other than Estate stakeholders, Governments or both?.

## FINDINGS

Participants stated that they tend to use the performance data from the KPIs to justify funding requests and allocation to the Scottish Government as part of the business cases, and as a means to review performance annually with the Directors of Finance. This involves identifying either improvements or deteriorations of their estates that facilitates further interrogation and development of appropriate actions, understanding lack of investments and the effectiveness of the management strategies. To some extent performance information is also used to confirm their judgments, although not in all the cases, strongly linked to the size of their estates. Small healthcare bodies express concern about all the efforts put into -time and resources- for the limited perceived benefit which they obtain. Statements such as “the data collected merely supports what is already known” or “we are a small health Board and I know every building we have” arose continuously during the course of the interviews within this group. This is not surprising as the healthcare estates of small Boards comprise of less complex and fewer buildings. This allows having a more in-depth understanding of their estate with the ability to identify the problems without the need for undertaking facility performance assessments or the continuously recording and monitoring of data. This argument is also supported by a Senior Estate Manager from a large Board who mentioned how the usefulness of the

data collection varies according to the size of the Board. But to what extent has the information provided by the current set of performance measures for decision-making been integrated in a real management system? Interviewees stated that their use was limited, associated to: 1) the relevance of the measures; 2) the lack of resources and time to analyse the information, and 3) the reactive-secondary role that the estates performance information currently plays within the healthcare sector.

### *The relevance of the measures*

The NHS Scotland performance measurement framework consists of a mix of efficiency measures, effectiveness measures and patient satisfaction. These three factors of building performance are defined by ISO 9241 (1998) as “usability”, a concept that denotes the effects on the user rather than the intentions of the building and its monitoring have been recommended by Støre-Valen *et al.*, (2014). However, the interviews reveal that the performance information provided by the measures with most significant financial impact (i.e. related to soft FM, energy costs, etc.), which constitutes half of the reported measures, are neither used for decision making nor for the operational management of the facilities. The information provided is pitched at too high a level and that are not useful for operational matters, where more focused data is needed. These measures, together with patient satisfaction and some of the property based measures, such as quality of the environment, age of the building and, in a minority, the overall backlog maintenance cost, were perceived to not be useful for analysis purposes, seen by most of the interviewees as promoted by the Government and used merely for reporting performance to the Finance Directors, Chief Executives and Government.

### *The lack of resources*

When the respondents were asked to what extent they manage their estates with a view to improving performance of the aspects looked at by the property based measures, the answer was: "only to a very limited extent". The majority of the respondents pointed out that lack of financial resources and time were the main barriers to moving forward performance improvement. A selection of interview responses is provided to help illustrate this point: "we just need to accept that we have got buildings that are not right, but there is not a fix, because there is no money", or "there is a little I can do without major investment in that building to improve functional suitability, so basically I only can acknowledge that there are requirements, and when the opportunity arises, then I would try to do something". A key comment reflected that in terms of priority, it is only after health and safety issues were addressed and resolved, that functional suitability and the space utilisation issues are considered.

### *Clinical is first*

During the course of the interviews a question arose a few times concerning how this data is used by high level authorities (Governments, Chief Executives and the Director of Finance) in the decision making process; but also the lack of consideration given by the clinicians. In healthcare, strategic planning and management is conditioned by the clinical strategy. The statement "clinical is always first" came up often during the interviews. Estate and Facilities Departments need to adapt their management strategies to respond to the clinical requirements and often it supposes a challenge. In a few of the Boards, when high level strategic decisions are taken at an executive level, there is little or even no representation and involvement of the Estates Department and never enough reference to the facility performance information. Senior Estate Managers find that their KPIs are not given the same priority as clinical ones, citing difficulties in having estates issues raised at Board Level. A Senior Estate Manager stated: "the organisation does not look at the estates and facilities KPIs with the same going for the waiting time KPIs. We

struggle to get that information at the top table". Decisions which are made at high strategic level in many cases are not informed by the asset, or the suitability of the asset to accommodate the proposed change.

## DISCUSSION AND CONCLUSIONS

The under-utilisation of performance information derived from the SPMSs with respect to strategic decision making, particularly from an operational and long term strategic planning perspective, calls into question the value of the current approach which has been described as "limited at best". Despite the Scottish Government's desires for performance information to add value to the decision making and thus lead to improvements in the way estates are managed, the reality appears to be different. Most of the measures, except for those related to health and safety issues (high risk backlog maintenance and statutory compliance) and in some instances functionality, are perceived by the interviewees as produced from a governance perspective for justification for funding and accountability purposes. Earlier, Halachmi (2004) pointed out that the agencies that produce the KPIs include performance information that is important to them and in many cases it is not what is needed for the external stakeholders who use the KPIs.

But what are the consequences of this? At first, those who are responsible for populating, updating and reporting the data may feel that they are overloaded with extra work and information that adds little value or benefit to their roles; therefore, increasing the likelihood of getting low quality data that may affect to the accuracy of the performance information which is relevant and also the quality of the returns demanded by the governments, reducing the effectiveness of measuring estates performance for the government purposes. In addition, there is the finance issue including the resource consuming and high costs associated with the data collection, maintenance and reporting, which could be allocated to solve other issues of higher priority. This was articulated mainly in the case of small boards which are facing a particular challenge in this regard.

Previous studies argued that the implementations of performance measurement systems are linked to both symbolic and instrumental benefits (Modell, 2004; Moynihan, 2005). Taylor (2007) pointed out that the symbolic benefits are the core strength of performance measurement as it helps to promote the Government's image of objectiveness and rationality and as a means to show their effectiveness and efficiency (Moynihan, 2005). By contrast, as stated earlier, the greatest potential of PM is as a tool for supporting decisions, otherwise the overall benefits may not overcome the negative potential. The findings reveal that current practice in the use of the tool in the NHS Scotland is mainly a symbolic character, with the instrumental potential not being fully exploited. In the NHS, as well as in other public organisations that are publicly financed, the issue of accountability and transparency becomes a key element and the symbolic benefits provided are of huge importance. Nevertheless, the instrumental potential of measuring performance is not diminished by the organisation; as it was also produced with the purpose of supporting decisions with a view to improve the way their estates are managed aligned to the organisation's goals and strategies.

This research has identified several themes of why the instrumental element is not fully realised related to the design and implementation of the systems and also the influence of the clinical services.

### *Design*

The types of measures adopted by the Government are all outcome based and long-term performance measures. These are more meaningful for reporting purposes and the

delivery of long term-high level strategies; and also for the Government to gain a better knowledge about how well the estates are managed by the Boards and the attributed power to decide prioritisation for funding but also to point out underperformed estate portfolios. However, the information resulting from these measures are non-meaningful at the operational delivery, where other types of measures/information short term related may be more relevant, such as process measures that provide information that is actionable (e.g. what is being done well and what needs improvement) (Mant, 2001).

Another aspect is the type of data drawn on to construct the measures, which affect their potential for impacting the decision making. For example, patient satisfaction, one of the core KPIs of many organisations in the public and private sector and recommended by Lavy *et al.*, (2014). Patients are an integral part of the services provision with high impact on the way services are delivered. At the moment this measure is very ad-hoc as the current surveys for patient satisfaction struggle to pick up the estate related aspects and there is not a comprehensive-systematic approach to its application. As Patwardhan and Spencer (2012) stated, patient surveys used merely for falsely publicised positive results supposes a lost opportunity for improvement. Well-designed surveys incorporate the voice of the patient into strategic decisions, an essential element of the meaning of “patient centre” but also it can help streamline processes and save costs (LaVela and Gallan, 2014).

### *Implementation*

Large importance has been given by scholars to the importance of having the right measures in place, but communication cannot be dismissed. ‘When, to who and how’ performance data is communicated may improve the potential use of the performance information and to achieve better EM outcomes. At the moment, the use of performance information is limited to Government officers, Senior Estate Managers and in a minority, to the Directors of Finance (or similar); being reported annually, and lacking or having minimal influence in the formulation of the clinical strategy and therefore reacting to this. Adopting a more proactive communicative approach and including clinicians as users of the information may improve the extent at which information is used for strategic decisions; a practice that is already happening in NHS Fife.

### *Clinical services*

In healthcare, different from other public sectors, the clinical services are the primary focus in the organisation. Estates and facilities are left as secondary, lacking the recognition they deserve, and therefore reducing the potential of realising the instrumental element of SPM for EM. In other words, Estates Managers need to react to the clinical priorities, limiting their ability to manage their estates effectively but still leaving them with the responsibility for deciding the operational plan for moving forward. In addition, 'clinical services' are the main drivers for the allocation of resources, restricting the capital directed to improve the estate performance.

Investments at more operational levels are primarily aimed at dealing with health and safety issues, rather than being allocated to improving other aspects of the facilities which could potentially bring large benefits to the overall organisation performance, such as space utilisation and quality of the environment. Accordingly with these findings, it can be asserted that the level of investment allocated to the estate and the reactive-secondary role that the estate plays in the organisation, influences in part the extent at which performance information is used for management purposes. Does this mean that in healthcare the instrumental benefits of SPMS cannot be realised? Well, although clinical is highly influential in the healthcare sector, the potential of current practice may be

further enhanced and increase the significant tangible gains in EM as long as the organisation promotes the use of estates performance information across the different users including clinicians, being more proactive rather than reactive, as well as improving the design of the systems making it more relevant to the users.

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# LIES, DAMNED LIES AND QUALITY MANAGEMENT SYSTEMS: A PILOT CASE STUDY

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An externally accredited ISO 9001 Quality Management System is a prerequisite for tendering for many public-sector projects, leaving Small to Medium Enterprises little choice but to implement such a system. A link between the motivation behind implementation of a Quality Management System and its effectiveness has been found through quantitative analysis of survey results in recent studies. However, existing studies have failed to examine the mechanisms behind this link. This paper aims to address this gap in knowledge, through a case study investigation of a mid-sized Mechanical Electrical and Plumbing Contractor. Five interviews with key individuals are undertaken and analysed using qualitative analysis software. The company's Quality Management System documents are used for comparison with actuality. The findings indicate that, although they take pride in the quality of their work most interviewees perceive a disconnect between the Quality Management System and the delivery of quality 'on the ground'. The system is perceived as a paperwork exercise, required mainly to maintain accreditation; hence 'stretching the truth', backdating documents and deception in ISO 9001 procedures are commonplace. The desire to hold ISO 9001 accreditation for the 'certificate on the wall' creates a culture which undermines its implementation.

Keywords: ISO 9001, deception, Quality Management Systems, quality control

## INTRODUCTION

ISO 9001 is a prerequisite for tendering for many construction sector projects (Chan and Tam 2000; Ribeiro 2000; Gunning and McCallion 2007). Although the standard is used extensively, its effectiveness has yet to be established. Research has used quantitative methods to examine its financial and management benefits, with conflicting results (Heras *et al.*, 2002; Douglas *et al.*, 2003, Llopis and Tari 2003; Sampaio *et al.*, 2010). Corbett *et al.*, (2005) find a link between enhanced business performance and use of ISO 9001; whereas Terziovski *et al.*, (1997) find no significant correlation between business improvement and ISO 9001 certification. Quantitative examination of the impact of ISO 9001 can be problematic; both Heras *et al.*, (2002) and Dick *et al.*, (2008) find the contribution made by the ISO 9001 system to an organisation's performance is difficult to separate from other factors. The work of Heras *et al.*, (2002) illustrates the potential dangers in inferring that ISO 9001 certification leads to superior business performance (2002: 774). Use of ISO 9001 is intended to ensure consistency, improved customer service (Benner and Tushman 2003) in addition to regulatory and statutory compliance. Gotzamani and Tsiotras (2001), Douglas *et al.*, (2003) and Sampaio *et al.*, (2010) have

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used quantitative analysis to examine the relationship between motivation to introduce ISO 9001 for internal reasons, (that is, to improve business processes), and its full and effective implementation.

The ISO 9001 standard is essential for all contractors who wish to undertake public sector works. This accounts for approximately 40% of construction industry turnover in the United Kingdom (UK) in 2010 (CIOB 2010) and 50% in Northern Ireland in 2012 (CITB 2012). The compulsion for accreditation to tender for public sector work suggests that some organisations achieve accreditation merely to meet this tendering prerequisite. If this is the case, the ulterior aim of the ISO 9001 system would be to maintain a façade of compliance which is sufficient to pass external audits, described by MacLean and Benham (2010) as 'regulatory decoupling.' Whether this is the case, and what happens beneath the façade, has yet to be examined in construction management literature.

Although the studies outlined above have examined the effectiveness of the ISO 9001 system and motivations for its implementation with mixed results, none have delved deeper into the underlying mechanisms behind this relationship; particularly by applying a qualitative case study approach. Therefore, this study examines the mechanisms behind the day-to-day operation of an ISO 9001 Quality Management System in a mid-sized Mechanical Electrical and Plumbing (MEP) firm. The case study method used, in combination with the trust developed between the researcher and interviewees, enables detailed and open examination of the thoroughness and effectiveness of, and shortcomings in, the implementation of the ISO 9001 system in context.

## **ISO 9001 QUALITY MANAGEMENT IMPLEMENTATION**

Quality Management implementation is more effective when quality management values are adopted by an organisation (Lagrosen and Lagrosen 2005). Gotzamani and Tsiotras (2001) suggest that companies claim they gain certification in order to improve quality internally; however, their 'true' motives may come from external pressure and a desire for positive publicity. They argue that this approach leads to a focus on short term benefits, leading to reduced overall success. The motivation behind accreditation can determine how comprehensively the standard is implemented (Gotzamani and Tsiotras 2001). Gunning and McCallion (2007) find that 40% of construction companies surveyed did not fully apply the ISO 9001 standard, using it merely as a marketing device. The benefits of certification are greater when a company's motivations are focussed primarily on the internal benefits to be gained (Llopis and Tari 2003), as these companies are more likely to fully embrace implementation of the system. Genuine commitment and leadership from top management is key to successful quality system implementation (Chileshe 2006), as the involvement of high level management is critical to its success (Douglas *et al.*, 2003). Clearly the belief that a system will make a positive impact will lead to more willing and enthusiastic implementation. Martinez-Costa and Martinez-Lorente (2007:496) suggest that companies who are accredited to ISO 9001 for external reasons, for example as a pre-requisite for tendering, might be 'going through the motions' of applying the system and trying to deceive the auditors. University staff were observed by Van Kemenade *et al.*, (2011) subverting quality system implementation through dramaturgical compliance, if rules were over complex.

## **EXAGGERATION, DECEPTION AND DISHONESTY**

Jenkins and Delbridge (2017) studied workplace deceit and formulated a model which suggests that deception can become normalised in an organisation through

institutionalisation, socialisation and rationalisation. This model is used as a framework to examine deception and dishonesty:

### **Institutionalisation**

In order to thrive, Jenkins and Delbridge (2017) find that dishonesty must take place at multiple levels in an organisation's hierarchy and be condoned by the organisation to some extent, whether explicitly or implicitly. MacLean and Benham (2010) describe the process of 'decoupling' of regulation from day to day activity, where informal business as usual processes, are protected from scrutiny, whilst maintaining a veneer of compliance. 'Symbolic' processes used for 'window dressing' lack management support leading to the delegitimisation of the regulatory system, creating a 'legitimacy façade' and institutionalising misconduct (MacLean and Benham 2010). Implicit permission for wrongdoing can come through lax or unobtrusive regulatory control (Palmer 2012). When an organisation's values do not align with those of a regulatory system, where it perceives rules as unnecessary, it does not anticipate a harmful outcome from non-compliance and tolerates deviation from procedures (Gilliland and Manning 2002).

### **Socialisation**

Group behaviour with shared norms and values can reinforce and maintain deception in an organisation, by creating a context for deceit (Jenkins and Delbridge 2017: 20). Unethical behaviour can be contagious (Gino and Bazerman 2009) as new recruits, keen to fit into the culture of the company, are taught to disregard unethical behaviour. An environment where unethical acts are accepted can lead to further deviations, where they change social norms and become such an integral part of daily behaviour, that they are no longer of note (Gino and Bazerman 2009). Conversely, where dishonesty is likely to be uncovered and the consequences are harsh, people balance the advantage of deception with the ensuing punishment and are less likely to lie (Gneezy 2005).

### **Rationalisation**

Deception flourishes when resultant harm is denied or minimised (Jenkins and Delbridge 2017). Lies and deception can be justified as a means to avoid hurt feelings and difficult questions. Most people perceive themselves to be ethical and rationalise deception as a 'white lie' that will have little impact (Gino and Bazerman 2009). Shalvi *et al.*, (2011) describe this protection of self-image as 'ethical manoeuvring.' People are likely to justify deception to themselves and others; thus, preferring to lie modestly than undertaking deception on such a scale that their perception of themselves as morally just is no longer maintainable (Shalvi *et al.*, 2011). Similarly, if the consequences of deceit are not seen as important or hurtful to any individual, the ethical self-image is maintained (Gneezy 2005). In construction, the fragmented nature of the industry and prevailing culture, permit widespread practices of corruption, dishonesty and unethical behaviour (Arewa and Farrell 2015).

## **RESEARCH METHOD**

It is incumbent on any study with the word 'lies' in the title to state its claim for legitimacy of knowledge and thus 'truth.' The study adopts a critical realist approach. This asserts a realist ontology - that a 'real' world exists, but that this world is understood imperfectly through the filter of our experience and mental constructs recognising the value of an interpretative perspective (Bhaskar, 2008). In addressing the 'critical' aspect, the results are considered in the context of the interviewees' comments and how they align with the literature and their peers' interviews. This standpoint necessitates an

acknowledgement that the researcher's embedded values have an unavoidable impact on the conduct and interpretation of the research, regardless of endeavours otherwise.

In order to establish grounding in the research, a desk based narrative review of recent peer reviewed works was undertaken. This ascertained a gap in knowledge and identified themes to inform the following investigation. Recent studies have used quantitative methods to examine the effectiveness of quality management systems, but none have used qualitative analysis to probe this area in depth and in context, hence a qualitative method was applied. A single case study was undertaken as a pilot to a larger subsequent investigation. The case study approach enabled in-depth examination of complex issues in context (Fellows and Liu 2008), broaching 'how' and 'why' questions (Yin 2009). The organisation examined is a typical mid-sized MEP construction company, with an ISO 9001 system which has been in operation for 6 years; thus, well established within the company. The organisation is known to the researcher, who has built up a relationship and established trust with those selected for interview. A non-probability and purposive sampling method was adopted to aid interviewee selection. The General Manager, Quality Manager, Quality Management Consultant, and two Contracts Managers ('A' and 'B') were interviewed. Semi structured interviews were held at each interviewee's place of work, during December 2016 and January 2017, lasting between 50 to 80 minutes. The semi structured interview format allowed main themes to be covered in each interview to enable comparison, but permitted further in-depth exploration of each interviewee's experiences which may not be covered by extant literature. Prior to the start of each interview, an information and consent sheet was forwarded, emphasising that all responses were confidential and anonymous. An assurance that confidentiality would be maintained was repeated verbally, immediately prior to each interview. Efforts were made to ensure that each interviewee felt comfortable with the interview, and with proposed themes drafted, to reinforce the established trusting relationship and to facilitate frank and honest responses as far as possible. The interview topics were developed from the literature review and outlined in the interview protocol sheet in three main sections - background information, motivation and assessment of the usefulness of the quality management system, and quality management compliance. With the permission of the interviewees, each interview was audio recorded and subsequently transcribed verbatim. The transcribed interviews yielded 86 pages and 41,406 words of information.

Case notes were made from the inspection of quality management files held on-site at two locations and at head office. The files were compared to procedures set out in the organisation's quality manual and gaps in compliance were noted. Notes were made regarding whether the files were as-new or heavily used, and whether this circumstantial evidence could suggest potential non-compliance with procedures.

The transcripts and case notes were uploaded into Computer Assisted Qualitative Data Analysis Software. The first cycle of exploratory coding was followed by a second cycle of more detailed pattern and longitudinal coding (Saldana 2009), during which individual responses were compared internally for contradiction. Once themes were identified, categories were refined and relationships and links established through axial coding. Two main categories 'Quality Management System' and 'Deception' were used to organise the data. Qualitative analysis has been described as a 'narrative of a narrative'. In the analysis that follows, common themes are illustrated through direct quotation to allow the respondents to speak for themselves.

## **FINDINGS**

### **Pride / Quality of delivery**

The quality of each completed project is central to the organisation's core values. All five interviewees take satisfaction in the quality of their work and the organisation's widely acknowledged reputation for quality. The General Manager, when asked for the most important factor in the delivery of quality by the firm, replies pride...I wouldn't want to do it if we couldn't do it 100% and that's been instilled in every person that we have. The staff in the company are a small band of highly skilled employees, most of whom have been with the organisation for over 10 years. The company has a very low turnover of staff. The Quality Management Consultant observes that the guys are very interested in showing you around, you know they're interested in showing you the quality of their work. This applies equally to the staff who are poor at paperwork and Quality Management compliance, as the Quality Management Consultant illustrates: the boys that are bad at the paperwork they've come round and will show you this, they're interested in their job, they're interested in what they do. The organisation does not use the cheapest fittings as this kind of short term cost cutting measure will cost in the long run through defect correction - as the General Manager put it, it's going to be found out if things aren't right and harm the organisation's standing.

### **Purpose of the ISO 9001 system**

All interviewees agreed that the ISO 9001 system is installed and maintained to enable the organisation to continue to tender for government contracts. The Quality Manager states for no other reason; on a purely needs basis only according to the Quality Management Consultant. Public sector contracts account for the majority of the work undertaken by this organisation, with estimates varying from 80% (Contracts Manager A) to over 50% (Quality Manager). None of the interviewees can think of a similar organisation, in terms of size and sector, which does not have an ISO 9001 quality management system. ISO 14001 has recently been attained by the company, again for similar reasons, where this standard is also becoming a requirement to tender for public sector contracts.

The phrase certificate on the wall was common to several of the respondents, who describe the ISO 9001 quality management system merely in terms of a badge that must be kept, to maintain access to tendering opportunities, with little impact on the organisation's operations. This attitude is widespread amongst similar organisations according to the Quality Management Consultant. The Quality Management Consultant characterised the General Manager as someone who basically doesn't give a flying fiddle about the system. The commitment of senior management does not extend far beyond what is necessary to maintain the badge. Amongst those interviewed, time and energy expended on the system varied widely.

### **Separation of the Quality Management System and quality 'on the ground'**

How, then, is the undeniable focus on quality within the firm aligned with a superficial commitment to the quality management system? The quality management system is seen as a completely separate entity to the delivery of quality on the ground; something which can be safely circumvented and ignored without adversely impacting on what matters-the end product. The Quality Manager bemoans the inability of the operational staff to see the integration of the system with quality. This may be due to the distance between operational staff and clients. They do not experience the additional demands of

sophisticated clients for additional documentation and certification, beyond merely MEP systems which work.

The Plumbers and Contract Managers came into the MEP sector to apply their skill, ingenuity and experience, to install excellent installations that satisfy their clients; not to process paperwork which they consider to be largely superfluous. When asked how he thought the ISO 9001 system has improved quality in the company, Contract Manager B responds ...do you mean the quality of workmanship? It hasn't degraded it or brought it down - it hasn't helped to make the quality better. I don't see it having any effect myself - well maybe it's had an effect in the office, with the paperwork and that, but not on site, on the ground. This sentiment is echoed across all interviewees. For instance, the Quality Manager observes The paperwork doesn't exist more or less for the boys; and even the ones that are good at doing it and record it at the time, doesn't necessarily make them any better at delivering; no definitely not ... If we didn't have this quality system, it wouldn't make any difference, the workmanship would still be the same, it's just the boys have more sheets to fill in.

### **Compliance with the ISO 9001 Quality Management System**

The Quality Manager and Quality Management Consultant claim that the majority of people in the organisation do 'the bare minimum' to maintain and retain the quality management certification. This is with the exception of Contracts Manager A, whose participation is more enthusiastic. Those that most enthusiastically partake in the system, can see its use and describe the value and efficiencies which the system brings to their work. There was little staff consultation when the system was introduced, and little ongoing engagement and discussion between management and users, although according to the Quality Manager on paper there are loads of meetings. However, there is little appetite for engagement or discussion, as most interviewees and operatives just want to 'get on with the job.'

A few of the quality procedures are perceived generally as less useful to operatives. Some procedures are all for show according to the Quality Manager; in particular, the assessment of subcontractors. The firm has developed a relationship with its regular suppliers and assessment of suppliers is informal and ongoing. The Quality Management Consultant admits that this procedure is extraneous. All those interviewed who have to complete this sheet, admit to inputting fictional assessments, only if required by an imminent quality audit; an understandable reaction to paperwork which is not adding value and required solely for the purpose of the system and underlying audits.

None of the interviewees felt that their job security depended on their compliance with the quality management system, with few consequences for non-compliance and no rewards for compliance. If paperwork is not completed, the culprit will be asked by the Quality Manager to comply. Occasionally, the Quality Management Consultant will meet with the person responsible and help them to complete the information. The Quality Management Consultant has bent over backwards to help the organisation maintain the certificate if I didn't do what I was doing-and sometimes you're ... doing stuff you shouldn't do to fix it-they'd lose their standard. He describes himself as a victim of his own success; the more he does to help maintain the system, the more others rely on his intervention.

### **Exaggeration, Deception and the Quality Management System**

The question 'have you ever exaggerated, pretended to comply, or made up paperwork to meet ISO 9001 procedures?' is asked towards the end of each interview, when a rapport

had been established. Some respondents are wary of giving a frank reply and at first deny any deviation from procedures. For instance, when asked, the General Manager at first replies 'no' but when probed more specifically, admits that he has backdated signatures and 'silly things like that.' The deviations tend to be minimised or justified as minor or unimportant, where the Quality Management Consultant characterises it as not lying but its close, and continues this is happening in 80% of all companies. Procedures and tests with 'life safety' implications are mentioned by several respondents as those which are never falsified, although many of these tests are required by Building Control or the client, and as such, could be considered as separate to the quality management procedures. In terms of completing paperwork, the Quality Manager states if it doesn't happen on site, then we have to make it up, and that just defeats the purpose of it.

### **Contradictions amongst respondents**

The interviewees who are most able to admit to their failings at compliance with the quality management system are those who are most enthusiastic about its maintenance. Contracts Manager A, who has been characterised by the Quality Management Consultant as the best in the organisation at compliance, readily admitted to 'bluffing' procedures which he finds add no value; notably the assessment and selection of subcontractors. The two respondents described as largely non-compliant by the Quality Management Consultant, deny anything but complete compliance. When probed further, one of these respondents did admit to minor infringements; however, the other maintained that he never deviated from the system.

## **DISCUSSION**

Exaggeration, concealment and deception in the quality management system is widespread throughout the case study organisation, although it is not consistent amongst respondents, nor explicit or organised. This deception follows the framework for workplace deceit proposed by Jenkins and Delbridge (2017). Firstly, the deceit is institutionalised. The analysis finds a text book example of regulation 'decoupling' as described by MacLean and Benham (2010), where compliance with the quality management system, and delivery of an MEP service, are considered as two separate entities by operatives. This separation can be seen as a by-product of the imposition of the system onto all contractors who wish to tender for government contracts. Under such conditions, it is logical that regulation and maintenance of the system be 'light touch' in order to maintain the 'certificate on the wall' with as little expense as possible. None of the interviewees thought that their job security depended on complying with the quality management system. The deviations, exaggerations and occasional deception required to maintain certification under these conditions are widespread, and acceptable within the company.

Secondly, subterfuge and deceit has been socialised. Although individual respondents each had a unique perspective of the quality management system, all were influenced by the shared norms and cultural context of the company. Deviating from quality procedures is not explicitly instructed nor openly condoned; however, there is a company culture of overlooking non-compliance, which creates and facilitates the context for deception.

Thirdly, deception was rationalised. The extent and impact of any deviation from quality procedures was minimised and justified as unimportant and minor issues. Many of the respondents stressed that life safety critical systems and checks were always carried out, and that the procedures which were exaggerated, backdated or fabricated, were unimportant.

## CONCLUSION

This study has demonstrated that the quality management system of the study organisation is not being implemented as prescribed, with most operatives doing the minimum required to maintain the appearance of compliance. This can be attributed to regulatory decoupling and a normalisation of deceptive practices. It could be argued that this approach wastes the opportunity to use the quality management system to maximise its benefit to the organisation. It is needed to maintain tender opportunities, while even basic maintenance of the system and certification is expensive and time consuming. If the operatives were to be consulted, the system could be rationalised, with superfluous procedures dropped. With operative 'buy-in,' non-compliance could be characterised as no longer socially or institutionally acceptable, with negative consequences for the offender. This new approach would require a change of attitude from senior management; however, the recoupling of the system, which the operatives do not currently prioritise, with the delivery of service, which the operatives care deeply about, could increase the efficiency and overall quality of the service within the organisation.

This pilot study comprises only five interviews with documentary examination and corroboration. Although the Quality Management Consultant commented that the behaviour observed in this case study is widespread, generalisable findings cannot be drawn from this size of sample; hence further research is required. However, the study does highlight some pertinent issues, for the follow up study and for any research probing a sensitive issue such as 'quality' in an organisation. Even with privileged access and a long-established trusting relationship with the organisation and interviewees, some evasive and dishonest answers were provided. Some respondents felt compelled to demonstrate conformance and deliver answers reflecting this premise. Interestingly, those who most fully embraced the ISO 9001 system were more willing to admit their own failings, and those of the system. Those who maintained only surface compliance were most likely to deny deviation from the system to foster the illusion of complete conformance.

Despite the trust that has been established with all interviewees, some felt unable to tell the complete truth regarding their opinion of, and compliance with, the quality management system. The researcher's assurances of anonymity and handling all responses with sensitivity were underpinned by long established trusting relationships. Undoubtedly this led to a more frank and honest discussion than otherwise would have been the case. This pilot study raises questions regarding the validity and reliability of responses given by individuals and organisations when examining similar sensitive topics, where no prior long-standing relationship exists.

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# TOWARDS IMPROVING PRODUCTIVITY ON REFURBISHMENT PROJECTS

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Refurbishment projects have shown a negative productivity development in the last decades. In the REVALUE research project one aim was to work towards a productivity benchmark for refurbishment projects. Further, it evaluated the productivity potential inherent in the processes. A case study was used to collect data through a work sampling study, comprising more than 2,200 data points. A lean perspective was adopted to estimate the share of time a construction crew spends on value adding and non-value adding activities. The crew installs pre-fabricated lightweight facade modules, and the data analysis showed that 31% of the time was spent on direct work, and 69% of the time was spent on indirect work and waste. The analysis combined with observations on-site documented potential improvements. In total, it was possible to reduce waste with 12% and to increase productivity with 27%. The impact was a relative reduction between 8% and 21% in direct labour costs for the contractor, which equals a 1% reduction in client costs. Thus, the potential gain from increasing productivity are relatively higher for the contractor than for the client. The process showed an improvement potential, and a relatively large productivity increase.

Keywords: lean, productivity, refurbishment, waste

## INTRODUCTION

Since the financial crisis in 2008, refurbishment has steadily increased its market share of the collected building activity. In 2017 refurbishment accounted for 35.8% of market in the Danish construction sector, making it 42% bigger than new build construction, at 25.2%. In addition, the government's climate goals require Denmark to be CO<sub>2</sub> neutral by 2050 (Danish Government, 2014). According to numbers from the Danish Government (2014) heating and running of equipment in Danish buildings account for 40% of the collected Danish energy consumption. Further it is estimated that most of the existing buildings today, will still be in use in 2050. Ravetz (2008) estimate that up to 75% of the present UK-building stock could be standing in 2050. Due to these circumstances, it is safe to assume that refurbishment will increase in the future, as the existing buildings must decrease their energy consumption to reach the ambitious climate goals. For the same reasons Kemmer and Koskela (2012) states "Refurbishment is one of the most important topics in the current research agenda in the UK", and that the research in the management of refurbishment projects is scarce.

Although very relevant, the productivity in refurbishment projects have been declining in the Danish construction sector since 1986, as the new build construction have shown a slightly increase (Tænketank for Bygningsrenovering, 2012). This productivity

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development results in less value and lower returns on investment in refurbishment. It also indicates that the prices increase faster than in other sectors. With rising demand for high quality refurbishment, the sector needs to find ways to reverse the negative productivity development. As the refurbishment sector grows, the need for more feasible and efficient solutions grows with it. This research will investigate the potential for improving productivity within the sector, by working towards a benchmark to hold future initiatives against.

### **Refurbishment**

Refurbishment is more complex and uncertain than new build construction. The extent of the work is rarely completely known until the work commences, there is a higher need for specialized workers, less space and more risky work conditions, and the end-users are often present during construction. Further, refurbishment projects contain work which is unique to refurbishment and different from new build (CIRIA, 1994; Egbu, 1994; Egbu, *et al.*, 1998).

Further the end-users of the refurbishment buildings are bound to be negatively influenced due to temporary nuisances like noise and dust (Holm and Bröchner, 2000). The process is therefore more valuable in refurbishment project as the contractors must work in suboptimal conditions to provide a service for the users (Sezer, 2014).

Kemmer and Koskela (2012) argues that lean theory is appropriate to handle the complex and uncertain nature inherent in refurbishment projects. Lean practiced on the Transformation-Flow-Value model, has shown superior project performance, especially in complex and uncertain conditions (Ibid.). Kemmer *et al.*, (2013) valid this in 6 case studies, showcasing lean in refurbishment. Despite this, the practical application of lean practices to refurbishment projects, is still limited (Kemmer and Koskela 2012). That refurbishment is already substantial bigger than new build construction, makes it even stranger that it has received so little attention in the existing literature, at least in the execution stage of construction.

### **Productivity Measurements**

Productivity can be calculated in different ways, but basically it describes the value of goods or services in a period of time of a production according to the usage of production factors. Productivity is difficult to measure because outputs and inputs are typically quite diverse and are themselves hard to measure.

Productivity can thus be difficult to compare across disciplines, and between different industries within the construction sector. This is due in part to difficulties in measuring inputs, and valuing outputs, especially in refurbishment projects, and because different professions have different production rates, and units of measurement, for example, concrete laid per hour (m<sup>3</sup>/hr) cannot readily be compared to other units or professions m<sup>2</sup>/hr finished surface.

The traditional measure of productivity can be very specific, and as Sezer (2014) argues as refurbishment is not pure production of goods, the physical measures of productivity such as concrete laid/m<sup>3</sup>, typical of new construction are insufficient. By itself it offers no suggestions as to how to improve the status quo, or information about the efficiency of the production. Instead another approach is chosen for this research, where the value generation is disregarded in the productivity measurements. The approach is called a work-sampling study (WS-study).

The advantage of a WS-study, is that it is relative regarding productivity. A work sampling study measures the time a worker spends on different activities, e.g. production, transport and waiting etc. A WS-study can thus be used as a crude estimate of the production efficiency (in this sense efficiency is understood as percentage of time spend on production, and on other activities). Two different professions, with different outputs, but roughly the same efficiency, will then have an equal relative productivity increase, if their productive time is increased in the same degree. WS-studies also provide clues to where improvements can be made to the process. These however, cannot be generalized, but used for optimization of each workplace.

## **METHOD**

A modular construction project was chosen based on the following argument. The work is carried out at a single workstation making it comparatively simple to follow all craftsmen at the same time. The method is well established and it is possible to make a clear work description. Two other case studies on new build projects installing pre-fabricated modules on new build project are available for comparison of method and results (Nielsen and Kristensen, 2001; Dirchsen and Gantriis, 2015).

### **Case Description**

The refurbishment case is a turnkey contract of DKK 320 million. It is a 3-year project from 2015-18, and is situated in Denmark. The refurbishment concerns 10 apartment buildings. It is primarily focused on making energy improvements through installing a new envelope and building service installations to improve indoor conditions. The project amounts to 23.700 m<sup>2</sup> rented property floor area spread across 297 apartments.

The main renovations are to the following extent: basement windows are replaced, and the basement walls are insulated externally down to one meter below terrain. The entrance facades of the buildings are dismantled and new light pre-fabricated modules are mounted with windows attached. New insulated gable elements are fitted, and six gable windows are constructed in each apartment building. Rooflines are adjusted to the new wall thicknesses. All entrances are fitted with storm plackets. All apartments should be inhabitable during construction, but residents are in fact moved to temporary pavilions in near vicinity.

### **Work Description**

The work performed in the study concerns the installation of light-weight pre-fabricated façade modules, from installation to finished surface. Prior to the installation, the building envelope is stripped to the naked concrete surface, and a new foundation for the self-carrying modules have been constructed. The installation process is as follows: Modules are delivered, released from restraints, and subsequently hoisted into place. The modules are mechanically fastened using metal bolts, drilled into the existing concrete slab. After all modules have been installed, all remaining gabs are insulated and sealed using wind plaster. The modules are then fitted with metal shins, and a surface layer of fibreboards. The installation process of 186 m<sup>2</sup> from start to finished surface took approximately 4 days, for 3 workers full time, with a crane operator present 40% of the time.

### **Planning**

The planning of the project is done using a mix of Location-Based Planning (LBP) and Last Planner System (LPS). The work is planned at a workshop with all sub-contractors present, and all the interdependencies between trades are found. There is no specific

look-ahead schedule, instead LBP is used. Weekly work plans are not made in a traditional sense, as fast meetings with 20 people is unrealistic (according to Project Manager), instead the Foreman contacts each team individually to find out status, and if anything is missing. Percent Planned Completed (PPC) is not used, neither is any explicit restraint analysis or continuous learning mechanisms.

**Data Collection and Validation**

The data collected in the study is based on a work-sampling study. It is a quantitative visual collection method based on observations (Terp *et al.*, 1987). WS-studies has been used for decades, and the key objective is to determine how time is being employed by the workforce, and in the 70'ies and 80'ies this was often wrongly refered to as productivity (Josephson and Björkman, 2013). Traditionally work would be divided into two categories, namely productive/value-adding and non-productive/wasteful. During the 90'ies especially Womack and Jones and Kaplan and Cooper promoted three categories, namely direct work, indirect work, and waste. As this tripartition seems to be grounded we apply this, but choose to sub divide indirect work into 3 categories (Conversation, Preparation, Transportation) and waste also into 3 categories (Walking, Gone, Waiting) in order to have better possibilities to analyse. These, in total, 7 categories were identified in advance and discussed with the workers, to ensure that they represented the performed work. The seven categories are presented below in table 1, with descriptions and examples.

*Table 1: Definition of observation categories*

| Category                   | Descriptions and examples  |
|----------------------------|--|
| Production/ Value-creation | Time used to work on modules or materials. Value is understood as a direct added value, but may also be in the form of adjusting a module; Processing materials, e.g. cutting facade panels; Crane yawing a module   |
| Conversation               | The time used to discuss drawings or work at hand. There is made no distinction between professional and private. Talking with crewmembers; Talking with resident; Talking on the cell phone; Talking with managers. |
| Preparation                | Non-value adding handling of materials and elements, adjustments, and cleaning of machines and tools. Looking for tools or materials; Releasing module from truck; Measuring and marking; Hooking a module.          |
| Transport                  | Workers carrying tools or materials from one place to another: Movement vertically in lifts between floors; Driving in a truck to retrieve materials; Crane yawing without a module.                                 |
| Walking                    | Walking to and from locations without carrying any materials or tools. Walking between workstations; Walking to and from breaks.   |
| Gone                       | Time away from the production site. Toilet visits; Other errands.  |
| Waiting                    | The time spent waiting for colleagues, materials or information  |

In practice, we shadowed a construction crew of 4 workers (three construction workers and one crane operator) over six days. At random intervals between 1 and 7 minutes (15 observations per hour in average), we note the 4 works current activity into one of 7 categories. An activity cannot fall between categories; hence the observer will decide immediately which category. If one observation should fall into a wrong category creating uncertainty, this is dealt with statistically due to the high number of observations.

**Measurement Uncertainties**

There is a delay or deviation from the chosen observation time, to when the actual observations are made. Ideally, each observation should be made instantaneously, and the activity should be unambiguously categorized with the predetermined frequency. In reality this is not possible, as it is impossible to correctly categorize all workers simultaneously. (Terp *et al.*, 1987). In addition, there are some uncertainties associated

with the categorization of activities. Some activities fall in between categories, and others may be out of category.

The repetition effect is considered to have no influence on the workers' productivity. They are experienced and have installed pre-fabricated modules earlier. The results will show that they have developed a routine. Further, the observations take place half way through the overall installation period, with this being the 6<sup>th</sup> building out of 10.

## RESULTS

Table 2 depicts the relative frequency of the categories from the WS-study along with the number of observations in each category. Note that Transport, Walking and Gone represent 33% of all time spend on site. The minimum and maximum values of the results, are based on statistical analysis of the 2221 observations. The maximum uncertainty is calculated at 2% and is confirmed by figure 2 that shows a steady distribution between the categories. Production (direct work) is therefore running 31% ±2% of the time, in the observation period.

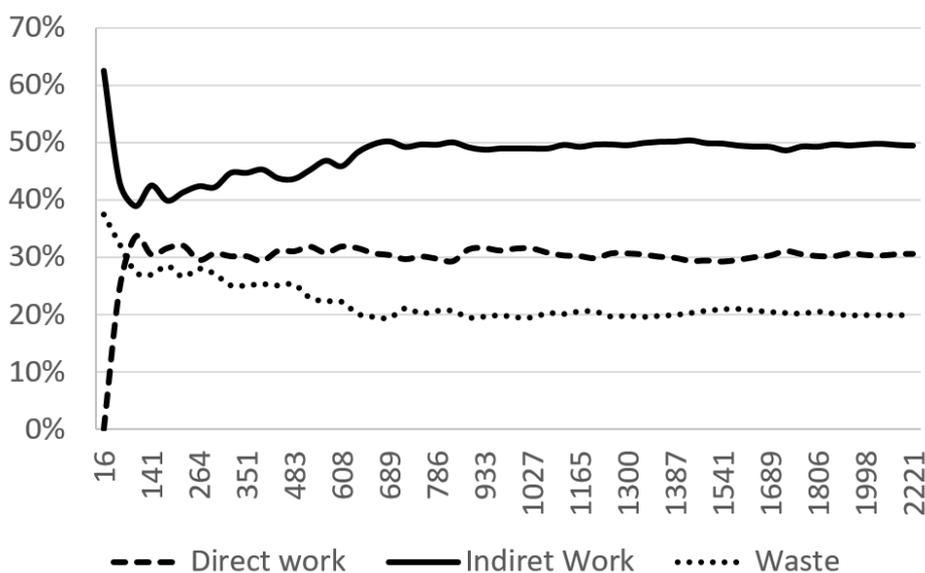


Figure 1: Relative frequency (RF) divided into categories.

Figure 1 shows how the relative frequency develops, as the number of observations increase in three categories: Direct work (production), Indirect work (Conversation, Preparation, Transportation), and Waste (Walking, Gone, Waiting). The relative frequencies settle around their respective averages, after 200 observations. The steadiness of the categories indicate that the team has experience and routine.

### Comparable studies

The results are similar to two other Danish case studies, in which the productive time was measured on two new build projects installing pre-fabricated modules.

Table 2: Results from the case-study. The actual frequency of each category lies within the spans, with a 95.5% certainty.

| Category: |     | Prod. | Talk. | Prep. | Trans. | Walk. | Gone | Wait |
|-----------|-----|-------|-------|-------|--------|-------|------|------|
| p_n       | (%) | 30.6  | 6.2   | 23.2  | 20.0   | 10.7  | 2.1  | 7.2  |
| n         |     | 680   | 138   | 516   | 445    | 237   | 460  | 159  |

|       |     |      |     |      |      |      |     |     |
|-------|-----|------|-----|------|------|------|-----|-----|
| s     | (%) | 1.0  | 0.5 | 0.9  | 0.8  | 0.7  | 0.3 | 0.5 |
| kn*s  | (%) | 2.0  | 1.0 | 1.8  | 1.7  | 1.3  | 0.6 | 1.1 |
| p_min | (%) | 28.7 | 5.2 | 21.4 | 18.3 | 9.4  | 1.5 | 6.1 |
| p_max | (%) | 32.  | 7.2 | 25.0 | 21.7 | 12.0 | 2.7 | 8.3 |

Where:  $s=(p_n(100*p_n/N)^{0.5}$ , for 95.5% certainty  $k_n=2$ ,  $p_{min,max}=p_n\pm k_n*s$  Method from (Terp, 1987)

Study 1 by Nielsen and Kristensen (2001) concluded that 29% of the time was direct work, based on 1,302 observations. Study 2 by Dirchsen and Gantriis (2015) found that 43% of the time was direct work, based on 1,138 observations. In a Swedish study (Björkman *et al.*, 2010), focusing on efficiency of HVAC instalment on a mix of refurbishment and new build projects, the researchers found that 13.3% of the total work time was direct work. The results were based on 18,374 observations from 8 construction sites. Björkman *et al.*, (2010) hypothesised that as construction moves towards modular construction, the share of time spend on actual production activities would decline, and the time spend on preparation and management would increase.

**Production Rate and Lead-Time**

To measure the actual relative productivity, the production rate of finished surface was calculated based on the progress of the construction workers. This is seen in table 3, and is based on four days’ work for 3-4 people. Figure 1 shows the work distribution without breaks. The production rate without breaks are therefore the most compatible with the relative frequencies in table 2.

Table 3: Average production rate for the crew, with and without breaks

| Production rate  | Area        | Man-hours |       |                    |
|------------------|-------------|-----------|-------|--------------------|
| Including breaks | 178.6 m2    | /         | 102.3 | = 1.8m2/h          |
| Excluding breaks | 178.6 m2    | /         | 86.7  | = 2.1m2/h          |
| Lead-time        | Crane-hours | # Modules |       |                    |
| Unadjusted       | 19.58       | /         | 52    | = 22.58 min/module |
| Adjusted*        | 16.76       | /         | 52    | = 19.34 min/module |

\*Adjusted lead time is withdrawn breaks, and 10 minutes for setup/takedown of mobile crane, on four separate days with varying number of modules.

The lead-time of a single module installation cycle was found by dividing the hours with a crane operator present, adjusted for breaks, and setup/takedown of the crane, with the number of installed modules. Again, the adjusted lead-time is more precise, as no data points was collected during breaks. The adjustment for setup/takedown was done, to consider a fluctuating number of modules being installed each day.

**Data Trends and Observations**

The individual categories were plotted throughout the day, to identify specific trends. The data was presented showing how the direct work production rate varied throughout the day. Based on data from five work days, and 1782 individual observations. The production rate was seen to be around 20% the first hour in the morning, after the first break, and again before closing time, relative to the average and peak production rates. Preparation (part of indirect work) was higher in the morning, steady between 20-30% in the afternoons, and then declined towards the end of the day. Movement (Transport, Walking and Gone) was high ~60% in the morning.

The following relevant wastes were observed during the observation period: Double handling of materials and tools, re-work, unnecessary movement, waiting.

## DISCUSSION

Based on the observation it is possible to identify improvements, i.e. time savings, which will result in improved productivity. These are based on observations from site, and a discussion with the crew. The potential savings are measured in minutes per day per worker and presented in table 4.

*Table 4: Potential time savings to increase productivity*

|            |  |
|------------|--|
| 9 minutes  | Increasing production-rate the first hour, from 20% to 35% would result in 9 minutes increased production each day. The crew suggested that toolboxes permanently on the lift would reduce the time spend on getting the workstations ready. Other improvements could be found using 5S or creating "best practices" and improving routines through continuous learning. |
| 14 minutes | Reducing lead time on the module installation by two minutes per module, ~10%, would on average could save 14 minutes per worker per day in the observation period. The crew suggested a smarter interlock system between modules. The authors suggest using VSM to locate and eliminate waste by improving the process.   |
| 12 minutes | Reducing movement categories by 10%, from 31% to 28%, would save 12 minutes per day. It is suggested to introduce routines and Kanban to reduce the number of forgotten tools, and improved communication between trades.  |

The suggestions were not implemented, as it was not in the scope of this research to identify barriers to these implementations.

### Impact

A workday consisted of 7 hours a day equal to 420 minutes. According to the frequencies calculated in table 3, this provides 130 minutes of production, and 290 minutes of waste each day. Reducing waste by 35 minutes per day, equals a 12% relative reduction of the waste category. The relative increase in productive time is however, equal to 27%.

Calculating the impact of these changes on an economic scale can be done in, at least, two ways. If the productivity is increased, as a result of increased direct work time, the output is increased by 27%, and the project is finished 21% earlier, thus saving 21% on labour costs. If the workers finish early, and does not capitalize on the time saved from waste reduction, the contractor saves 8% on labour costs. Economic impact for the GC is based on instalment of 185 m<sup>2</sup> façade, with actual wages of £ 8,205.

### Representativeness

A work sampling study does not show the productivity, but it shows the efficiency of a process with a given output. Because all workers have their own pace, it is not possible to measure the output of one worker based solely on his work sampling results. It is assumed that the workers will increase their hourly average production rate, calculated in table 3, as their hourly productive time increases in the ratio of 1:1. This is based on the observation that, all value creation is occurring in the measured productive periods, and none is happening in any other category. Thus, increasing the productive time, should increase the output accordingly.

The crew spends 31% percent of the time on value adding activities and 69% of the time on non-value adding activities from a Lean perspective. A change in this distribution creates relatively large productive gains. By reducing the wasteful activities 35 minutes per day, it is possible to achieve an increase in efficiency of 27%. This effect works both

ways and illustrates the importance of continuously shielding production from interruptions. Every time a piece of equipment is missing, and workers stops for 5 minutes, it equals four percent of daily productive time. If a work stops for 30 minutes, because of a delay in materials, it equals 23% of the daily productive time. The 30 minutes of stop is an example of why flow management and shielding activities by the planners is so important, and the 5 minutes stop is an example of deficient organization of the work at the workstation. This underlines the importance of efficient flow management and shielding activities using Last Planner System and/or Location-Based Planning, and illustrates how variation in flow and "small" delays have a relatively large negative impact on the productive time. In turn, proper organization of the work, with routines and "best practices" and will have the opposite - positive - effect on productive time and productivity. In the present case, several Lean tools are hypothesised to have a positive effect on reducing waste from table 1. These are mentioned here, but the underlying theory is not elaborated, and are based on observations from site: 5S, Kanban, Value Stream Mapping.

Some issues come to mind when generalizing based on results from 3-4 people. Does the 31% productive time represent every construction worker? Probably not. But it can be used as a rough estimate to calculate the effect or impact of delays or time savings made at the construction site. It puts delays into perspective, when compared to missed opportunity for progress, and it makes it possible to value small improvements, that could otherwise be forgotten. The results are in the middle, compared to the three other studies, but relatively higher than the larger study from Sweden showing 13.3%. The results are, therefore, considered rather conservative, but probably varies between professions. If the general productive time has a tendency to be lower, towards the Swedish study, the impact of improvements and delays would become more exaggerated, and the contractors would benefit even more from making improvements to their current practice. If the results in the present study are pessimistic, and the average workers time distribution has more productive time, suggested improvements would merely result in smaller productivity improvement, however still relevant, as it equals savings for the contractors expenses.

### **Does Work Sampling Studies Measure Productivity**

Work sampling studies does not measure productivity per say. It rather values the efficiency of production, by observing only if production is running or not. It is not possible to determine the output of a process based only on the results from a WS-study. Two workers can have the same distribution in the observation categories, and entirely different outputs. The production rate, i.e. actual productivity is not measured in a WS-study, and varies between the individual workers and different activities. It is however hypothesized, that each worker has an individual production rate in every activity, and increasing the time spend on actual production, will increase his output according to this rate. If production methods change, increasing the production rate enormously, the share of productive time would likely decrease, as logistics at a building site rarely allows a big supply of recourses at the location of installation.

## **CONCLUSION**

As refurbishment takes up increasing market shares, the focus is on higher productivity in the sector to create more value at less costs. Despite this, the productivity development in the construction sector as a whole, and in refurbishment in particular, is low. Refurbishment projects are more complex and uncertain than new build. Research is needed to document positive effects on productiveness in refurbishment projects. As

productivity can be difficult to measure and transfer from one case to another, this paper has conducted a relative measurement of productive time on a refurbishment project through a work-sampling study.

A benchmark of productivity on a refurbishment project have been presented in the form of a relative measurement of the time workers spend each day. On average, a worker spends  $31\pm 2\%$  of his daily time on production equal to 130 minutes daily. The rest is spent on activities that do not create value for the client. By reducing time spend on non-value adding activities, the impact on the daily productivity was calculated. In the present case, hypothetical time savings were collected. It was shown that decreasing waste by 12% per day per worker, increase efficiency by 27%. This would in in turn reduce the contractor's direct labour costs by 8-21%, depending on the calculation method. The results from this study, can be used to calculate relative productivity increases gained from waste reducing initiatives. The study has shown, the consequences of relatively small amounts of time waste on daily productive time. Five minutes of waste due to bad organisation at the workstation is equal to 4% reduction in daily productive time, and 30 minutes of delay due to bad planning, is equal to 23% reduction in productive time for the workers. It is hoped that this study can help increase the focus on waste and insufficient planning, by showing the relative impacts on production.

## ACKNOWLEDGEMENT

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# **COST OPTIMISATION FOR HIGH-RISE BUILDINGS CONSIDERING NUMBER OF LEVELS OF SHORES AND RESHORES**

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The cost of formwork shares a major part in the overall cost of high rise RC construction. Hence, it becomes necessary to optimise the cost of formwork to reduce the overall cost of construction. A MATLAB program has been developed to calculate load transmission between inter-connected slabs and levels of shores/reshores using the simplified method. Cost is optimised using genetic algorithm while ensuring the safety of construction. The study is carried out for 10-storey building for different grades of concrete from M20 to M50, with an increment of 5 N/mm<sup>2</sup>. The 50-50 combination of shore and reshore levels violate the safety requirement for lower grades of concrete. The study shows that a small difference in the total formwork levels can change the cost of construction to a greater extent. The program is further modified for 20, 40, and 60 storey building. This study is an attempt to explore the impact of shore/reshore levels combination on the cost of construction. Hence, it is suitable for designers and practitioners to decide the levels of shores and reshores for construction based on economy and safety parameters.

Keywords: factor of safety, formwork, genetic algorithm, reshores, shores

## **INTRODUCTION**

Multi-storey building construction is increasing exponentially as the shortage of land becomes a major problem. Hence to cater for the huge demand, the builders want to complete the building at a faster rate with as less investment as possible. In a multi-storey building construction, the time and cost both play important roles. The formwork shares 30-35% of the total cost of reinforced concrete construction (Jha 2011). Hence, it becomes necessary to lower the formwork cost to reduce the total cost of construction.

But while cutting down the cost, the safety of the structure during construction cannot be ignored. Early removal of the forms reduces the cost of the temporary structure, but it may affect the safety of construction. The removal of the formwork increases the load on the lower slabs and form levels. Hence the care should be taken while removing the forms. The transfer of construction loads between slabs and shore/reshore is studied based on a simplified method. The simplified method is proposed by Grundy and Kabaila (1963) for finding the loads on slab and shore/reshore at any time during construction. Since then many researchers worked on the slab-shore/reshore load transfer. Liu *et al.* (1988) discussed construction sequence using the simplified method that calculates the loads accurately. Azkune *et al.*, (2010) studied the shore removal pattern to check shore

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overloading. They showed that the overloads occurring due to early removal of shores could cause failure of the structure.

The cost reduction for the formwork becomes necessary to reduce the overall cost of the construction by maintaining certain safety factor. It shows that very little literature is available where the cost of the formwork is a part of the discussion. The researchers considered the total formwork cost as one of the components of the equation to minimize the total cost. But the study related to number of shore-reshore levels for the optimum cost of construction is not reported in the literature.

So this study aims to find the optimum number of levels of shores and reshores that should give the minimum cost of construction ensuring the safety of construction. A genetic algorithm is integrated with the MATLAB program to find the optimised cost for different combinations of levels of shores/reshores. The objective function consists of the concrete grade, number of shores, number of reshores, and overhead charges. These are defined as a function of cycle time to find the lowest cost.

## LITERATURE REVIEW

Grundy and Kabaila (1963) proposed simplified method to calculate load distribution among slabs, shores, and reshores. The strength gained by the slabs at any particular time of construction compared with the load applied on the slabs to check the safety of construction. Jha (2011) in his book gives ample illustrations about the use of one-level, two-levels, and three-levels of shores in multi-storey building construction. The analysis is carried out using simplified method to calculate loads on shores and slabs at different stages of construction.

Coello *et al.*, (1997) used a genetic algorithm for the design of reinforced concrete beams. The cost of the rectangular beam is minimised considering the cost of concrete, steel and shuttering. The optimisation equation consists of the costs of labour and material for concrete, reinforcement, and formwork. These parameters are examined by many researchers with different optimisation tools to minimise the total cost of construction (Sahab *et al.*, 2005). Similarly, the cost of concrete, steel, and formwork are minimised to lower the cost of a concrete beam (Rao 1973).

Senouci and Al-Ansari (1996) presented optimisation method for concrete slab forms. They minimised the cost while ensuring safe slab form design. The cost for sheathing, joist, stringer, shore, and labour are the terms used for the optimisation equation. They observed the cost reduction up to 21%. The same equation is used by other researchers (Kaveh and Shakouri Mahmud Abadi 2010, Kaveh and Behnam 2012; Al-Tabtabai 2000) to optimise the cost of a concrete slab formwork. Tabtabai *et al.*, (1999) designed slab formwork considering optimisation of cost. It uses the genetic algorithm as a tool for cost optimisation. The optimisation function is formed considering the cost for sheathing, joists, stringers, shores, and slab volume.

Literature review shows that the work has been carried out to understand the distribution of loads between interconnected slabs through shores/reshores. The cost of the slab is minimised considering the material cost. But the study to minimise the cost of RCC construction considering the levels of shores/reshores is not available. As formwork shares a substantial part of total cost of RCC construction (Jha, 2011), the reduction in the cost is possible if the levels of shores/reshores can reduce. Such a study is not available in the literature where the levels of shore/reshore are targeted for the cost minimisation. Hence this study aims to minimise the cost of RCC construction considering different levels of shores and reshores for a high-rise building using the genetic algorithm.

## MATHEMATICAL FORMULATION

A MATLAB program is developed to calculate the distribution of construction loads between slabs, shore, and reshore. This program is based on the construction sequence given by Liu *et al.*, (1988) for the calculation of load and strength of slabs at a different time during construction. The strength of the reinforced concrete slab at any time,  $t$  is calculated using the formula given by ACI Committee 209R (1992) as shown in Equation 1.

$$(f'_c)_t = \frac{t}{a + \beta t} (f'_c)_{28} \quad (1)$$

Where  $(f'_c)_t$  is the compressive strength of concrete at time  $t$  (in day) after casting;  $(f'_c)_{28}$  is the 28-day characteristic compressive strength of concrete;  $a$  and  $\beta$  are constants depending on the type of cement and curing method used. GA uses this program in MATLAB for optimising the cost using a genetic algorithm. The objective of this study is to reduce the cost of construction with respect to a number of levels of shoring/reshoring ensuring the safety of construction.

### Objective Function

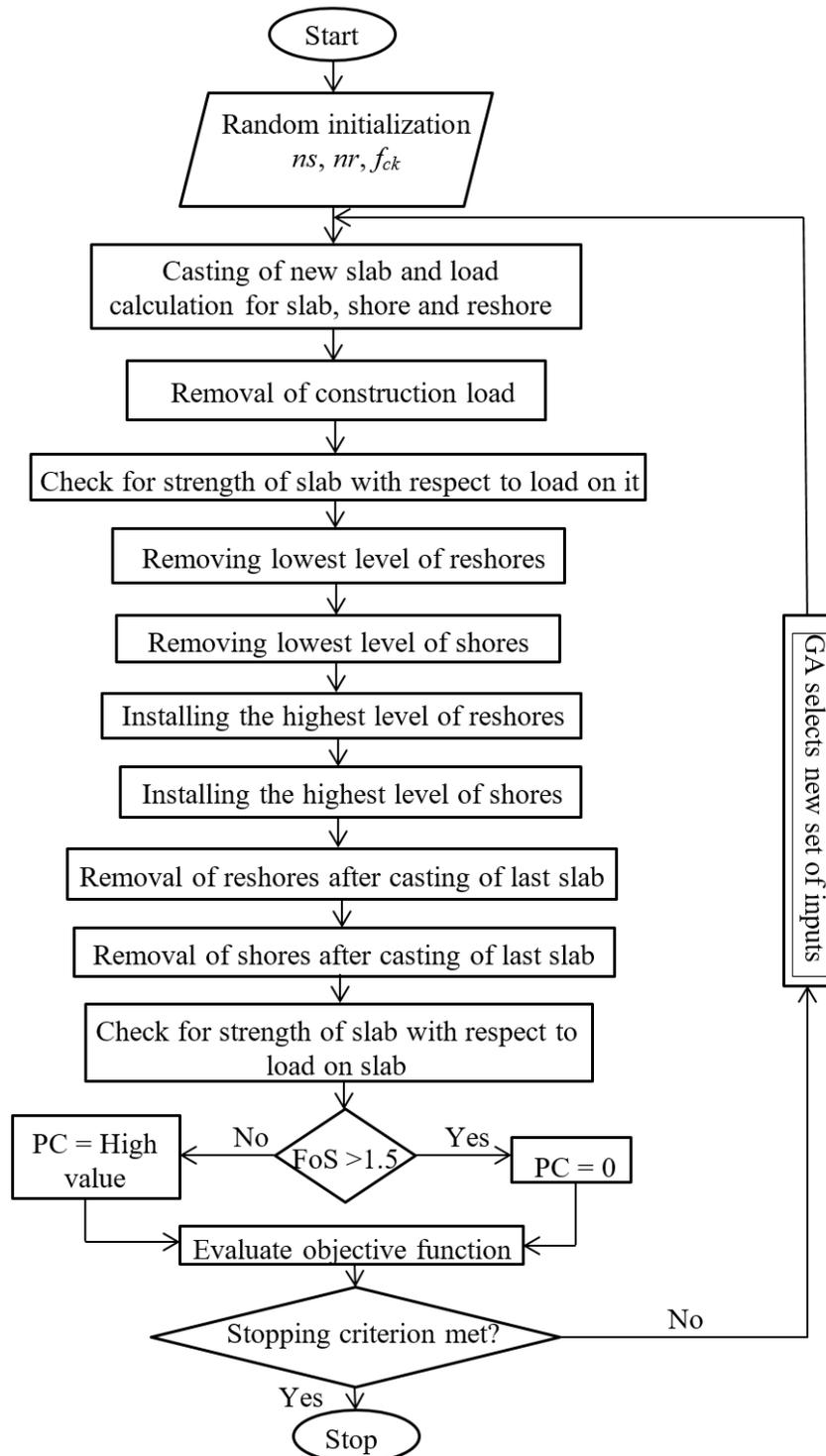
The objective function consists of the number of levels of shores, the number of levels of reshores, grade of concrete, and overhead charges as shown in Equation 2.

$$y = f(ns) + f(nr) + f(f_{ck}) + OC + PC \quad (2)$$

Where  $y$  is a fitness function value,  $ns$  is a number of levels of shores,  $nr$  is a number of levels of reshores,  $f_{ck}$  is the characteristic strength of concrete,  $OC$  is overhead charges during construction, and  $PC$  is the penalty cost. The cost of one level of shores is calculated based on the capacity of the shore. The cost of a level of reshores is same as 20% of the cost of one level of shores. The Delhi Schedule of Rates (DSR 2016) gives the cost for different grades of concrete. The cost of concrete includes the cost of material, labour, machinery, plant cost, and profit of contractor. The overhead charges are calculated from the salary of engineer, foreman, and charge hand required to execute the construction of the multi-storeyed building. The penalty cost is added to the total cost when it violates the factor of safety (FoS) condition. The FoS values lesser than 1.3 are unsafe (ACI 347.2R-05 2005). The expected FoS is 1.5 for the present study. The actual FoS obtained at each stage of construction is the ratio of the strength gained by the concrete slab to the load imposed on the slab at any particular time. When the actual FoS is less than 1.5, the total cost increases due to the addition of penalty cost. This equation is formulated for a 10-storey building having each slab of the same dimension. The area of one slab is 200 sq. m. with a thickness of 200 mm. Figure 1 shows the methodology used for optimising the cost of RCC construction. A MATLAB program calculates the load exerted on the slab at each stage of construction.

The strength gained by the slab is also calculated to check the safety of the construction which is part of the previous study conducted by the authors. This program is further modified to find the cost of RCC construction. A genetic algorithm is used to optimise the fitness function. Genetic algorithm does a parallel search of the solution and thus effectively explores many regions simultaneously. In a scenario where the formulation of problem solutions can be envisaged and defined as different possible numbers and a range of parameters, genetic algorithms can be used.

Figure 1: Methodology for cost optimisation



GA generates the solutions to optimisation problems using techniques inspired by natural evolution. Hence, this research problem uses the genetic algorithm as an optimisation tool. The individuals of next generation are selected based on the fitness value of the function with previously selected inputs. The same procedure continues to find the optimum value of the fitness function. The selection process continues till it reaches the stopping criterion.

### *Constraints*

The constraints for the objective function involve the range of variables. The constraints for the n-storey building are as follows:

1. The number of levels of shores (ns) varies from at least one level to one minus as many levels as the number of the storey ( $1 \leq ns \leq n-1$ ).
2. The number of levels of reshores (nr) varies from one level to one minus as many levels as the number of the storey ( $1 \leq nr \leq n-1$ ).
3. The sum of a number of shoring and reshoring levels can attain a maximum equal to the number of the storey. The minimum can be two as at least one level of shoring, and one level of reshoring is allowed ( $2 \leq ns + nr \leq n$ ).
4. The characteristic strength of concrete is taken in the range of 20 N/mm<sup>2</sup> to 50 N/mm<sup>2</sup> with an increment of 5 N/mm<sup>2</sup>.

The authors assume the installation time of three days with the considerations of only one shift of workers available for work. The cycle time (T) is the sum of stripping time and installation time. The maximum cycle time can be 30 days.

The program initializes the input parameters i.e. ns, nr, and fck randomly in the beginning through genetic algorithm code based on the n value. The MATLAB program evaluates these sets of values. The FoS is checked simultaneously for each level of construction, and the program decides the PC value at the same level. The objective function evaluates the set of chosen input values. The program repeats these steps until it reaches the stopping criterion.

## **RESULTS AND DISCUSSION**

The MATLAB program evaluates the cost for the 10-storey building. Table 1 shows the results for the given set of inputs. The program gives output for all the considered grades of concrete from M20 to M50. However, Table 1 shows the cost of different combinations of shoring/reshoring levels for M20, M25, and M30 grades of concrete only. Here a sample illustration of the cost for shore/reshore combination of M20 concrete is discussed.

The 1S-1R (one level of shore - one level of reshore) combination is unsafe as the FoS is less than 1.5 during construction. Hence, PC is added to the final value making it as an economically undesirable solution. So 1S-1R combination is economically undesirable condition. The calculation for the cost of 1S-3R combination with a cycle time of 26 days is included for better understanding. The cost of a shore level is a function of T, so the cost increases with the increase in T. The cost of one level of shores comes out to be Rs. 2,600 in this case. The cost of a level of reshores is 20% of the cost of the level of shores. So, here the cost of three levels of reshores is Rs. 1,560. The cost for M20 concrete is Rs. 23, 59,600. The overhead charges for 26 days are Rs. 390,000. The combination of 1S-8R gives the lowest cost as Rs. 25, 57,980 for M20 concrete with 13 days cycle time. All the combinations of shore/reshore levels violate the safety condition with the cycle time of six days for M20 concrete. Hence, these combinations give a very high cost.

Similarly, the program shows results for the M25 grade of concrete. The cost is lower when T is six days, as the overhead charge increases with cycle time. At the same time, the lesser number of shore levels gives minimum cost with six days cycle time. The 1S-9R combination gives the minimum cost of Rs. 24, 52,030 for the M25 grade of concrete with six days cycle time.

Table 1: Cost for different combinations of shore and reshore levels for M20, M25, and M30

| No. of shore levels (ns) | No. of reshore levels (nr) | M 20    |            | M 25    |            | M 30    |            |
|--------------------------|----------------------------|---------|------------|---------|------------|---------|------------|
|                          |                            | T (day) | Cost (Rs.) | T (day) | Cost (Rs.) | T (day) | Cost (Rs.) |
| 1                        | 1                          | -       | -          | 25      | 27,38,350  | 12      | 25,42,540  |
| 1                        | 3                          | 26      | 27,53,760  | 10      | 25,11,950  | 7       | 24,67,220  |
| 1                        | 4                          | 20      | 26,63,200  | 9       | 24,96,970  | 6       | 24,52,180  |
| 1                        | 5                          | -       | -          | 8       | 24,81,950  | 6       | 24,52,300  |
| 1                        | 6                          | 15      | 25,87,900  | 8       | 24,82,110  | 6       | 24,52,420  |
| 1                        | 7                          | 14      | 25,72,960  | 7       | 24,67,030  | -       | -          |
| 1                        | 8                          | 13      | 25,57,980  | 7       | 24,67,170  | 6       | 24,52,660  |
| 1                        | 9                          | -       | -          | 6       | 24,52,030  | -       | -          |
| 2                        | 8                          | -       | -          | 6       | 24,52,510  | 6       | 24,53,260  |
| 3                        | 3                          | -       | -          | -       | -          | 6       | 24,53,260  |
| 4                        | 5                          | -       | -          | -       | -          | 6       | 24,54,100  |
| 6                        | 1                          | -       | -          | -       | -          | 6       | 24,54,820  |
| 7                        | 3                          | -       | -          | 6       | 24,54,910  | 6       | 24,55,660  |
| 8                        | 1                          | -       | -          | 6       | 24,55,270  | 6       | 24,56,020  |
| 8                        | 2                          | -       | -          | 6       | 24,55,390  | 6       | 24,56,140  |
| 9                        | 1                          | -       | -          | 6       | 24,55,870  | 6       | 24,56,620  |

Table 1 shows that the combination of 1S-1R becomes safe with 12 days cycle time for an M30 grade of concrete. The lowest cost is Rs. 24, 52,180 for the combination of 1S-4R with six days cycle time. The combination of 5S-5R violates the safety condition for M20 to M30 grade of concrete with six days cycle time.

The relation between cycle time and the corresponding cost is shown in Figure 2 for M20 grade of concrete with a different combination of shore/reshore levels. The X-axis is the sum of shore and reshore levels. These are added to show the relationship between total formwork levels, cycle time, and cost so that, it becomes convenient to present four parameters in a single figure. As the cycle time increases, the cost of construction increases. The difference of one level of formwork (between 4 and 5) increases the cost by almost Rs. 1, 00,000 as the cycle time differs by six days. One can visualise the combination of formwork levels and cycle time from the figure for minimizing the cost of RCC construction. The engineers and practitioners can decide on the best combination of shore-reshore based on the priorities of the project.

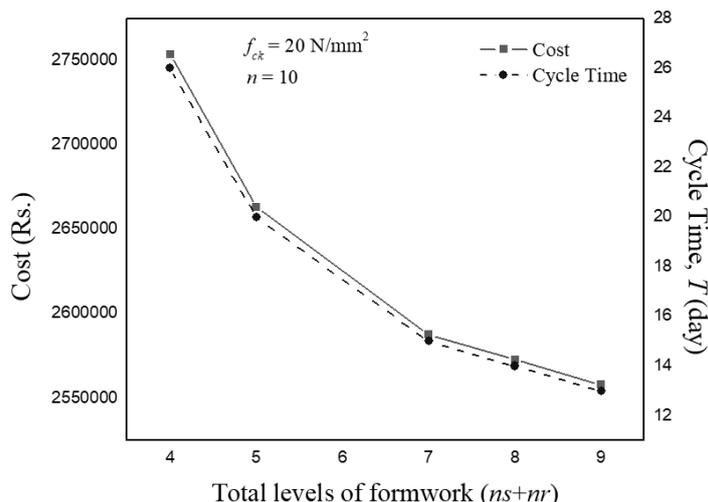


Figure 2: Cost and cycle time variation with total levels of formwork

Figure 3 shows the results for an M25 grade of concrete. The plot shows the combination of one level of shore with different possible combinations of levels of reshores. The figure shows the variation of cost with cycle time for the respective combination of shore/reshore levels. The cost increases by Rs.2, 26,400 when the level of reshore requirement changes from three levels to one level of reshore. The lowest cost is observed for maximum levels of reshores as the cycle time for this combination is the minimum i.e. six days.

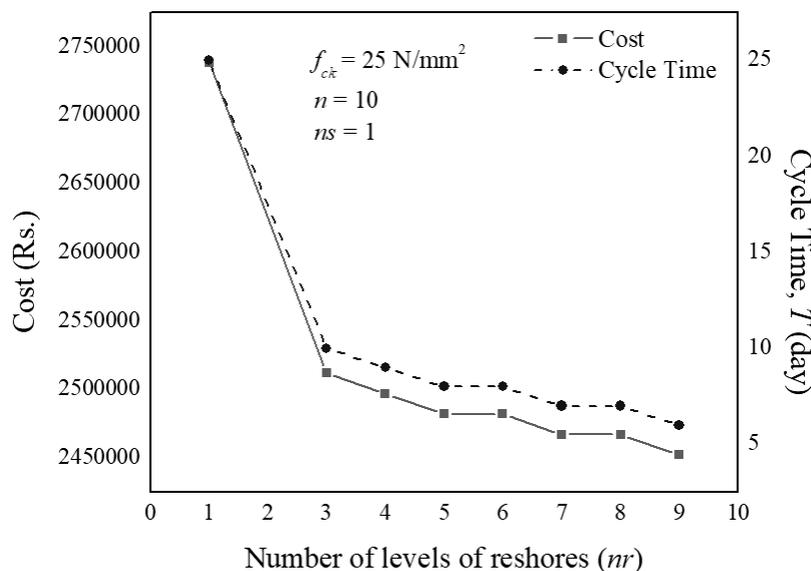


Figure 3: Cost and cycle time variation for one level of shores

Similarly, the program generates results for M35 to M50 grades of concrete in an excel sheet. The minimum cost for an M35 grade of concrete is Rs. 24, 52, 690 with six days cycle time for the 1S-2R combination. Similarly, the minimum cost for M40, M45, and M50 grades are Rs. 24, 53,320, Rs. 24, 54,070, and Rs. 24, 54,820 respectively with a 1S-1R combination and six days of cycle time. 5S-5R gives an economically desirable solution as the factor of safety condition is fulfilled.

Figure 4 shows the variation of cycle time for same shore/reshore combination with different FoS. The program gives the results for a 10-storey building with only one level

of shore and different possible levels of reshore for an M20 grade of concrete. The required cycle time increases with increase in FoS to ensure safety throughout the construction. The study considers the FoS values lesser than 1.3 (ACI 347.2R-05, 2005) as unsafe, and the values greater than 2.0 (IS 456:2000) as over safe (uneconomical). Hence the extreme safety conditions are checked for a 10-storey building. It shows that the cycle time is more for higher FoS, as the slab can gain desired strength with more number of level of shore/reshore in place.

The study gives the idea about the cost of construction with respect to shore/reshore levels combination for a 10-storey building.

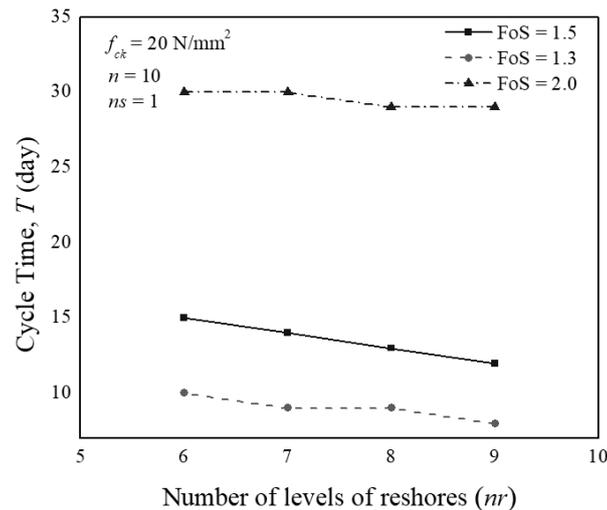


Figure 4: Cycle time variation for different factor of safety

It gives the clear picture of impact of safety consideration on the cost of construction according to cycle time. Hence, this helps the users and practitioners to choose the optimised cost model with respect to cycle time considering the desired safety of the construction.

## CONCLUSIONS

The analysis of cost is carried out for a 10-storey building considering the safety during construction. The slabs need to maintain a factor of safety of 1.5 to ensure the safety of the construction. The cycle time plays a major role in the cost calculation. All the combinations of shore/reshore levels violate the safety condition with the cycle time of six days for M20 concrete hence give a very high cost. Whereas, all other grades i.e. M25 to M50, give minimum cost in six days cycle time. The combination of five levels of shores and five levels of reshores violates the safety condition for M20 to M30 grade of concrete with six days cycle time. The cycle time increases with increase in the required factor of safety. A small difference in the total formwork levels can change the cost of construction to a greater extent. The program can be easily modified for any storey with the required FoS to generate the results for cost of construction. This study is an attempt to explore the impact of shore/reshore levels combination on the cost of construction. Hence, it is suitable for the designers and practitioners to decide levels of shores and reshores for economical construction without compromising the safety.

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# A METHOD FOR TENANT SELECTION OF CHINA'S CONSTRUCTION INDUSTRIAL PARKS THROUGH INDUSTRIAL SYMBIOSIS

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Offsite construction is an innovative alternative to conventional site-based construction. It requires building components to be fabricated before installing into their final locations. Construction industrial parks (CIPs), clusters of offsite construction companies, provide a common platform for above industrial activities to improve plant efficiency and achieve sustainable development. Even though a lot of CIPs already exist in China, several ecologic proposals of CIPs are still in progress but not achieved. The concept of industrial symbiosis (IS) can be applied to the existing CIPs to obtain environmental and economic benefits by sharing resources and information. Furthermore, strategy of designing a symbiosis network between companies in a CIP involves tenant selection to complement existing offsite construction companies. However, literature review shows that the eco-design of Chinese CIPs considering the potential integration of tenants in an eco-industrial parks (EIPs) framework is still lack in research. In this study, an access indicator system and a linear programming model are established to select tenants in a CIP. The access indicator system, proposed from the perspective of park-based level, comprises three primary indicators and fifteen secondary indicators. The linear programming model is proposed to assess the satisfactoriness of all indicators and can achieve multiple enterprises selection.

Keywords: China, industrial symbiosis, offsite construction, tenant selection

## INTRODUCTION

China is construction dependent, the construction industry has also developing rapidly, creating many problems including low utilization efficiency of recourses and environmental disruption (Zhang 2014). Traditional construction methods are dominated by labour-intensive approaches involving the use of considerable onsite labour. Recent labour shortages in the industry have resulted in insufficient workers being available to undertake traditional construction projects, with resulting delays in production and delivery (Nawi, Lee and Nor 2011). These problems have unavoidably led to negative effects in the development of China's society and economy. Therefore, how to revolutionize construction activities more effectively and cleanly has recently attracted an increasing interest from both the practitioners and academia. Offsite construction is an inventive manner with extensive advantages, challenging the anterior filed-construction (Pan and Sidwell 2011). Benefits from using such technologies have been widely studied and they mainly include reductions in cost, time, defects, health and safety risks, and

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environmental impact and a consequent increase in predictability, whole life performance and profits (Pan and Sidwell 2011). In recent years, with the development of offsite construction, clustering of construction companies into construction industrial parks (CIPs) was adopted in China, such as Tiexi construction industrial park in Shenyang (Dai 2010). CIPs means that companies assemble collections of construction manufacturing and service business, and then put them together on a common property. The activities of CIPs involve the manufacture and pre-assembly of building components, elements or modules before installation into their final locations.

The scientific development of industries is often closely related to nature. The efficient and perfect food chain and the cycles of natural ecology have become aspirational subjects for research (Zhou *et al.*, 2012). Industrial ecology (IE) is an emerging and multidisciplinary research field based on an analogy between industrial systems and ecological systems (Taddeo *et al.*, 2012). IE brings the idea of resource cycling in natural systems to the current industrial clusters to achieve industrial symbiosis (IS) (Cote and Cohen-Rosenthal 1998) and supports sustainable local industrial development or redevelopment through the promotion and implementation of eco-industrial parks (EIPs) (Taddeo *et al.*, 2012).

An EIP can result in the creation of a new industrial site or in the involvement of production plants already present in a given region (Taddeo *et al.* 2012). Given this, the basic principles of EIPs (Zhou *et al.*, 2012), including industrial symbiosis, resource coupling, waste recycling, and pollution control, which can be applied to the CIPs to achieve maximal utilization of resources, maximal economic benefit, and minimal environmental pollution. An EIP has great stability and systematic efficiency when each member enterprise is suitable and compatible (Zhu *et al.*, 2010). Therefore, the selection of suitable member enterprises plays an important role for the early planning and design of an EIP. A typical EIP consists of previously established anchor tenants and support tenants to follow (Ubando *et al.*, 2016). The anchor tenants represent staple industry of the EIP, which serves to attract other enterprises to join the EIP. These new enterprises are known as candidate tenants act as either supplier or customer of these anchor tenants, whose entry creates new opportunities for integration. In considering the candidates for support tenants, a planning committee may be formed to assess the compatibility of the candidate tenants in the EIP (Lowe 1997). However, many local governments introduced EIP businesses to enhance economic growth regardless of the form of the eco-chains and networks of enterprise (Zhu *et al.*, 2010).

The offsite construction-based firms, as the heart of the CIP, acts as the anchor tenants and provides synergistic collaborative network between various industries on specific by-product streams. A valuable method of quantitative evaluation for candidate tenants can effectively reduce negative environmental impacts on the CIP system. Literature review shows that the eco-design of Chinese CIPs considering the potential integration of candidate tenants in an EIP framework is still lack in research. Hence, in view of the importance of selection of suitable member enterprises for CIP programs, this study is aim to establish an evaluation model which provides a practice tool for optimal design CIPs in China. To be more specific, the objectives are (i) to establish an access indicator system for candidate tenants of CIPs; (ii) to provide a quantitative method for evaluating the suitability of an enterprise integrating into a CIP. This method is applicable to the CIPs towards ecological industry development.

## Optimization Method of CIPs

### Access Indicator System for Selecting Candidate Tenants on CIPs

#### *Criteria for selecting indicators*

Since the characteristics and the goals of EIPs vary, researchers have different opinions in the criteria for selecting indicators. To achieve the goal of selecting indicators to control member enterprises access to a CIP, this new criterion set is proposed combining the criteria described by Zhu (2010) and Valenzuela-Venegas (2016). It is worth noting that the indicators proposed by Zhu (2010) to evaluate new members in an EIP can be defined at enterprise-based level and park-based level respectively. The proposed CIP access indicator system does not include enterprise-based indicators, for the reason that the authors consider all the tenants are qualified with regard to national and local industrial policy, industrial planning and environmental requirements. Therefore, the criterion called boundary shows that the study only select the park-based indicators. The criteria the study adopt for selecting indicators and their description are shown in Table 1.

*Table 1: Criteria for indicators choice and their description*

| Criterion    | Description   |
|--------------|---|
| Practicality | Indicators must be measurable and address calculation.  |
| Relevance    | Indicators must be relevant to the goal of CIP development and the long-term strategy of participating companies. |
| Boundary     | Indicators must be set from the perspective of the park-based level.  |

#### *The access indicator system*

A variety of indicators is available for assessing CIPs. A literature search in ISI Web of Science's database is presented by Valenzuela-Venegas *et al.*, (2016) to explore feasible sustainability indicators. As a result, the definition of 249 indicators is provided in a list. The authors filter the 249 indicators and other sustainability indicators that proposed by relevant research based upon the three criteria listed in the previous section, and propose an access indicator system (Table 2) for enterprises into a CIP. The fifteen indicators are filtered and classified as three primary indicators including industrial symbiosis, environment performance and economic benefit, according to the IS principles and the three dimensions of sustainability (environment, economic and social dimensions). The authors classify those indicators related to the social aspect as economic because they are also related to the economic performance. Because the type of the measure indicators has vital effects on the selection of correlation functions, the indicators should be classed according to certain principles. The authors classify these indicators into two categories based on their indicative function: positive indicator (P) and negative indicator (N). The positive indicator is the one that increases with its value; the negative indicator is the one that decreases with its value.

#### *Identification of indicators*

Park-based indicators include three primary indexes from F1 to F3 and fifteen measure indicators from I1 to I15. These categories and subcategories represent the requirements from a CIP.

5. F1: Industrial symbiosis. Lowe (1997) argues that the nature of an EIP is the interaction between enterprises and the environment. The authors second their point and consider interaction as a key factor to consider when selecting the member firms. Five measure indicators are set as follows:

- I1: Quantity of metabolic connectivity  
It measures the role of the tenant in improving existing CIP member businesses linkage through supplies or demands. The greater number of metabolic direct flows with the new member firm, the higher the score is.
- I2: Degree of metabolic connectivity  
The indicator is to measure the degree of the connectivity among the enterprises or factories in a CIP after introduction of the tenant. The formula calculates as follows:

$$C = \frac{L}{S(S-1)/2} \quad (1)$$

Where C is the degree of metabolic connectivity of the CIP; S is the number of member enterprises in the web; and L is the number of links after introduction of the new candidate tenant.

- I3: Geographical distribution of resource acquisition  
It measures the geographical distribution of obtaining main materials or resources from local clubs. The shorter the distance, the higher the score is.
- I4: Recycling rate of industrial water  
This indicator is used to evaluate the proportion of industrial water recycled in the tenant. The formula calculates as follows:

$$C(\%) = \frac{Q_1}{Q_1+Q_2} \quad (2)$$

Where C is the recycling rate of industrial water; Q1 is the total annual recycling industrial water used by the tenant; and Q2 is the total annual fresh water used by the tenant.

- I5: Recycling rate of by-product and solid wastes  
This indicator reflects the proportion of by-product or solid wastes reused and recycled in the tenant. The formula calculates as follows:

$$C(\%) = \frac{Q_1+Q_2}{Q_1+Q_2+Q_3} \quad (3)$$

Where C is the recycling rate of by-product or solid wastes; Q1 is the total annual recycling by-product or solid wastes produced by the tenant; Q2 is the total annual recycling by-product or solid wastes produced by the other member enterprises in the park and used by the tenant; and Q3 is the total annual raw materials used by the tenant.

6. F2: Environment performance. The goal of introducing new businesses into an EIP is to improve the industrial symbiosis and systematic efficiency. The environmental performance is expected to be improved after the entry of new members. Therefore, this is a key factor to consider. There are five measure indicators under the primary index.

The indicators I6 to I10 measure the contribution of new business to the pollutants production of COD, air pollutants, CO<sub>2</sub>, wastewater and solid wastes in the park after the introduction of the candidate tenant. The calculation is as follows:

$$C(\%) = \frac{Q_1-Q_0}{Q_0} \quad (4)$$

Where C is the change rate of park COD, air pollutants, CO<sub>2</sub>, wastewater and solid wastes production respectively; Q0 is the park COD, air pollutants, CO<sub>2</sub>, wastewater and solid wastes production per year before the introduction of the candidate tenant; Q1 is the park COD, air pollutants, CO<sub>2</sub>, wastewater and solid wastes production per year after the introduction of the candidate tenant.

7. F3: Economic benefit. Economic benefit is the one key considered by both CIP developers and enterprise managers. There are many measures, but the authors select only the five applicable ones as follows:

- I11: Proportion of gross industrial output value  
It measures the contribution of new business to the gross industrial output value of the park after the introduction of the candidate tenant. The value is the ratio of the annual gross industrial output value of the tenant to the annual gross industrial output value of the whole park.
- I12: Industrial value-added per unit fresh water consumption  
This indicator measures the efficiency of water use in production as well as the level of technology and equipment. The value of the indicator is the ratio of the annual industrial value-added of the tenant to the annual fresh water consumption of the tenant. The unit is usually 10000 Yuan / m<sup>3</sup>.
- I13: Industrial value-added per unit energy consumption  
It measures the energy efficiency. The consumption of all the energy is calculated and converted to the number of standard coal using means conversion coefficients. The value is the ratio of the annual industrial value-added of the tenant to the total energy consumption of the tenant. The unit of this index is 10000Yuan/per unit t standard coal.
- I14: Industrial value-added per unit land consumption  
The indicator is to measure the efficiency of land use of the tenant. The value is the ratio of the annual industrial value-added of the tenant to its total land demand. Given the land supply is limited, the lower the ratio, the higher the score is. The unit of this index is per IVA/m<sup>2</sup>.
- I15: Employment contribution  
It measures new job created by the tenant. The greater number of job creation after the establishment of CIP cooperative network, the higher the score is.

### Optimal Method for Selecting Candidate Tenants on CIPS

#### *Problem statement*

In designing a CIP and employing the concept of IS, the challenge is to select candidate tenants while satisfying the overall objective of the CIP. Firstly, the degree of industrial symbiosis of the CIP is maximized. Secondly, the environmental impact of the CIP is minimized. Lastly, the economic benefit improvement of CIP is maximized. In the research, the authors try to select the candidate tenants that meet the requirements of CIP development through the optimization methods. The following 0-1 variables were used to describe the selection of the tenants.

$$x_i = \begin{cases} 1 & \text{Enterprise } i \text{ is selected} \\ 0 & \text{Enterprise } i \text{ is not selected} \end{cases} \quad (5)$$

Where  $x_i$  is the tenant selection vector,  $i=1, 2, 3, \dots, m$ . A  $x_i$ -value of 1 indicates the enterprise  $i$  was selected. A  $x_i$ -value of 0 represents an unacceptable value of the enterprise  $i$ .

#### *Evaluation method*

The general process of the evaluation method is constructing an evaluation indicator system, confirming the weighting coefficients, establishing conjunction function and calculating. The practicability-oriented model should be as simple as possible and can be easily understood and operated by practitioners.

- Indicator weights assignment

Each indicator is of different importance to an overall goal. Therefore, different weights should be assigned. The aforementioned fifteen measure indicators are assigned weights based upon the widely used Analytic Hierarchy Process (AHP). The weight of the fifteen indicators and its normalized set are denoted as  $\omega_j$ , where  $j=1,2,\dots,15$ . 2)

- Normalization of values of the indicators

In order to achieve an overall evaluation result, the result of various indicators need to be combined together (Zhou *et al.*, 2012). As the units and magnitude of selected indicators are different, they need to be normalized first.

For those indicators for which larger results are better,

$$k'_{ij} = \frac{k_{ij} - \min(k_{ij})}{\max(k_{ij}) - \min(k_{ij})} \tag{6}$$

For those indicators for which smaller results are better,

$$k'_{ij} = \frac{\max(k_{ij}) - k_{ij}}{\max(k_{ij}) - \min(k_{ij})} \tag{7}$$

Where  $k'_{ij}$  is the normalized value of the indicator  $j$  of enterprise  $i$ ,  $k_{ij}$  is the calculated value of this indicator, and  $\max(k_{ij})$  or  $\min(k_{ij})$  are the calculated maximum or minimum value of this indicator among all candidate tenants.

- Objective function

The object  $Z$  of park total benefit is calculated using the following equation.

$$\max(Z) = \sum_{j=1}^{15} \sum_{i=1}^m \omega_j k'_{ij} x_i \tag{8}$$

The rule of evaluation is that an object is better by the access criteria if the value of its optimal degree is greater. Namely, the enterprises make maximal optimal degree for the park are the best candidates to be integrated with existing industrial chains in a CIP.

- Constrains

Constrains here refers to the limited supplies of land, water and energy in the park (Zhu *et al.*, 2010). The amount of land, water and energy used for tenants should be less than the total amount provided by the park. Thus new businesses can be admitted into the CIP only if their demand of the above resources does not exceed park carrying capacity. So three inequality constraints are proposed as follows:

$$\alpha_1 x_1 + \alpha_2 x_2 + \dots + \alpha_m x_m \leq A \tag{9}$$

$$\beta_1 x_1 + \beta_2 x_2 + \dots + \beta_m x_m \leq B \tag{10}$$

$$\gamma_1 x_1 + \gamma_2 x_2 + \dots + \gamma_m x_m \leq C \tag{11}$$

Where  $\alpha_i$ ,  $\beta_i$  and  $\gamma_i$  are the annual demand of land, water and energy of candidate enterprise  $i$  respectively;  $A$ ,  $B$  and  $C$  represent the total amount of land, water and energy provided by the park respectively.

## DISCUSSION

### Access Indicator System

The access indicator system provides straightforward evaluation items for the CIP developers and administrators. A remarkable feature of a real EIP is industrial symbiosis. The study design fifteen park-based indicators through the implementation of EIP, which are lacking in the previous studies to select candidate tenants. However, the measure indicators are not new. They have been used in some evaluation indicator systems of sustainability.

Table 2: Access indicator system for control of entry of enterprises into a CIP

| Primary indicator           | Secondary indicator  | Unit                         | Reference   |
|-----------------------------|--|------------------------------|---|
| F1: Industrial symbiosis    | I1: Quantity of metabolic connectivity (P)                       | -                            | SNDEP; Zhu <i>et al.</i> , (2010); Dai <i>et al.</i> , (2010); Phillips <i>et al.</i> , (2006); Lu <i>et al.</i> , (2012); Ohnishi <i>et al.</i> , (2012)   |
|                             | I2: Degree of metabolic connectivity (P)                         | -                            | Zhu <i>et al.</i> , (2010); Dai (2010); Phillips <i>et al.</i> , (2006); Lu <i>et al.</i> , (2012); Ohnishi <i>et al.</i> , (2012)  |
|                             | I3: Geographical distribution of resource acquisition (N)        | -                            | Phillips <i>et al.</i> , (2006); Song <i>et al.</i> , (2014)  |
|                             | I4: Recycling rate of industrial water (P)                       | %                            | SNDEP; Zhu <i>et al.</i> , (2010); Song <i>et al.</i> , (2014); Dai <i>et al.</i> , (2010); Su <i>et al.</i> , (2013); Phillips <i>et al.</i> , (2006); Geng <i>et al.</i> , (2009)                         |
|                             | I5: Recycling rate of by-product and solid wastes (P)            | %                            | SNDEP; Zhu <i>et al.</i> , (2010); Song <i>et al.</i> , (2014); Dai <i>et al.</i> , (2010); Su <i>et al.</i> , (2013); Phillips <i>et al.</i> , (2006); Bai <i>et al.</i> , (2014)                          |
| F2: Environment performance | I6: Change rate of COD emission (N)                              | %                            | Zhu <i>et al.</i> , (2010); Song <i>et al.</i> , (2014); Geng <i>et al.</i> , (2009); Bai <i>et al.</i> , (2014); Pakarinen <i>et al.</i> , (2010); Azapagic and Perdan (2000)                              |
|                             | I7: Change rate of air pollutants emission (N)                   | %                            | Chen <i>et al.</i> , (2012); Pakarinen <i>et al.</i> , (2010); Behera <i>et al.</i> , (2012);   |
|                             | I8: Change rate of CO2 emission (N)                              | %                            | Park and Behera (2014); Pakarinen <i>et al.</i> , (2010); Eckelman and Chertow (2013);  |
|                             | I9: Change rate of wastewater generation (N)                     | %                            | SNDEP; Zhu <i>et al.</i> , (2010); Su <i>et al.</i> , (2013); Phillips <i>et al.</i> , (2006); Geng <i>et al.</i> , (2009); Bai <i>et al.</i> , (2014); Chen <i>et al.</i> , (2012);                        |
|                             | I10: Change rate of solid wastes generation (N)                  | %                            | SNDEP; Zhu <i>et al.</i> , (2010); Song and Shen (2014); Su <i>et al.</i> , (2013); Phillips <i>et al.</i> , (2006); Geng <i>et al.</i> , (2009)  |
| F3: Economic benefit        | I11: Proportion of gross industrial output value (P)             | %                            | SNDEP; Zhu <i>et al.</i> , (2010); Song and Shen (2014); Geng <i>et al.</i> , (2009); Bai <i>et al.</i> , (2014); Park and Behera (2014)  |
|                             | I12: Industrial value-added per unit fresh water consumption (P) | 10000 Yuan / m <sup>3</sup>  | SNDEP; Zhu <i>et al.</i> , (2010); Song and Shen (2014); Su <i>et al.</i> , (2013); Phillips <i>et al.</i> , (2006); Geng <i>et al.</i> , (2009)  |
|                             | I13: Industrial value-added per unit energy consumption (P)      | 10000 Yuan / t standard coal | SNDEP; Zhu <i>et al.</i> , (2010); Song and Shen (2014); Phillips <i>et al.</i> , (2006); Geng <i>et al.</i> , (2009); Bai <i>et al.</i> , (2014); Park and Behera (2014); Pakarinen <i>et al.</i> , (2010) |
|                             | I14: Industrial value-added per unit land consumption (P)        | m <sup>2</sup> /per IVA      | Zhu <i>et al.</i> , (2010); Azapagic and Perdan (2000)  |
|                             | I15: Employment contribution (P)                                 | -                            | Phillips <i>et al.</i> , (2006); Azapagic and Perdan (2000)   |

SNDEP= Standard for National Demonstration Eco-industrial Parks. COD=chemical oxygen demand. Standard coal is the coal whose net calorific value as received is 29.27 MJ. IVA=industrial value-added.

These indicators are also necessary for constructing an overall access indicator set in this study. For the selection of measure indicators, theoretically, the more indicators there are, the better it is to evaluate the candidate enterprises. However, considering practicality, it is easy to operate only when the number of indicator measures is small. In

the indicator system, the most important indicators are the quantity and degree of metabolic connectivity because it measures the enhancement of industrial symbiosis.

In other word, even if an enterprise succeeds in clean production, it may not be the best candidate from the perspective of the industrial chains construction. The idea is similar to the access indicator system of EIP proposed by Zhu *et al.*, (2010) where the starting point for developing an EIP by ranking plenty of candidate enterprises to match with existing industrial chains. However, there are some differences on criteria for selecting indicators. Firstly, indicators must be set from the perspective of the park-based level. The access indicator system focuses on how much candidate enterprises can improve sustainable development of the whole CIP, so enterprise-based indicators related to environmental requirements are not included. Secondly, indicators of the system must be measurable and the values of all indicators are quantifiable. The assignment of the value for an indicator is often influenced by subjective factors such as personal preference and professional knowledge. A valuable approach of quantitative evaluation for candidate enterprises can partly reduce the deviation.

### **Evaluation Method**

The study have introduced the linear programming method to establish an evaluation model for CIPs. The selection of candidate enterprises for CIPs is typically a multi-objective problem. Even though plenty of research related to this work, only a few consider several objective selection. However, what gives concern is to formulate a function that can be take into account in the evaluation of multiple candidate tenants for eco-design of CIPs. Compared with the previous research, the improvement of our evaluation method is reflected in the realization of multi-objective selection. Specifically, those enterprises with top scores may be not the best choices for the park because of limited supplies of land, water and energy in the park. By contrast, the combination of multiple enterprises is sometimes more suitable for the park than a single high-score enterprise. In other word, the method can provide a result of combination of several candidate enterprises, which can be integrated into a CIP to enhance its systematic efficiency. In addition, the method of AHP is used widely to determine weights of indicators. The reason why the study do not discuss in detail here is that their own importance to the total goal varies with the location of CIPs.

### **CONCLUSIONS**

It is a challenge for the developers and management teams of a CIP to select suitable tenants into the existing industrial chains among candidates, which all have advantages and disadvantages simultaneously. This study provides a quantitative method for selecting member tenants, which involves the establishment of both the access indicator system and the evaluation model.

The access indicator system is proposed from the perspective of park-based level, which includes three primary indicators and fifteen secondary indicators. The categories and subcategories are selected according to the principles of practicality, relevance and boundary. Although some indicators are also used in other indicator systems, it is a new idea to combine them together with to construct a comprehensive access indicator system as a control tool for candidate tenants of CIPs. The evaluation model of linear programming method has been applied to establish a way to control enterprises' access to a CIP. The study have made some improvements on the evaluation model, which can achieve multiple tenants' selection.

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# **POLICY AND MACRO PERSPECTIVES**

# COMPETITIVE STRATEGY AND THE ROLE OF NARRATIVE INFRASTRUCTURE: THE CASE OF TURKISH CONTRACTORS

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This paper is about competitive strategy in the international construction sector. Drawing on the ‘narrative turn’ in organisation studies, it emphasises the temporal and discursively constructed nature of competitive strategy. Competitive strategy narratives are seen to provide a means of understanding the formation and enactment of strategy. The empirical analysis focuses on the narrative infrastructure as produced by the Turkish Contractors Association (TCA). The findings highlight the multi-actor and multi-level processes of strategy making. They further illustrate the way in which narrative building blocks that are continuously mobilized as part of the on-going progress of strategizing on the sectorial level. The nuances of the identified narrative building blocks are seen to reflect the complexity and diversity across individual accounts of strategy making.

Keywords: competitive strategy, narrative, Turkish contractors, narrative analysis

## INTRODUCTION

Traditionally, strategy research has been informed by Porter’s (1985) industry-level analysis of strategic positioning. More recently the emphasis shifted towards the level of the firm, initially on the basis of Barney’s (1991) resource based view thereafter extending to Teece *et al.*’s (1997) concept of dynamic capabilities. A more grounded, empirical approach has since emerged under the label of strategy-as-practice (SaP) whereby the *doing* of strategy becomes the point of attention (Whittington, 2006). The current research bridges the strategy-as-practice perspective and the so-called the ‘narrative turn’. The adopted narrative perspective emphasises the socially constructed, discursive and temporal nature of competitive strategy. The central argument of the narrative turn is that individuals make sense of the world by telling stories. More importantly, narratives and stories are seen to be constitutive of organisational activity rather than simply representative (Czarniawska, 2004). The current paper views competitive strategy from a narrative perspective. It is notable that the potential of narrative methods remains relatively unexplored in the context of construction management research. The study is based on the premise that competitive strategy narratives constitute the temporal realities of strategy making which play a pivotal role in shaping future organizational actions (Fenton and Langley, 2011). Drawing on the concepts of *narrative infrastructure* and *narrative building blocks* (Deuten and Rip, 2000), this paper focuses on the analysis of a formalized sectorial narrative derived from the grey literature. The analysis extends previous empirical research, which the formal

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narrative of Turkish contractors in 1970s deconstructed to its constituent elements in terms of actors, actions, events and contextual setting (Duman *et al.*, 2017). The source in question is a quasi-historical account of the Turkish international contracting sector's development with the explicit stated purpose of creating a common memory and point of reference for subsequent generations (Tayanç, 2011). Entitled 'Geographies of Contractors', the text was published as an online book on the TCA's web page. The empirical value of the selected source lies in the way in which it includes narrative fragments from a combination of institutional reports, media articles and direct quotations from senior managers within Turkish firms. Such fragments are embedded within TCA's institutional over-script. The narrators of the fragments describe the details of Turkish contractors' overseas expansion from their subjective viewpoints. Such multi-level and multi-author narrative fragments highlight the essential temporality of strategy narratives even within a formalized narrative. The findings provide insights into the formulation and enactment of Turkish contractors' strategy in respect of international markets.

## **TURKISH CONTRACTORS IN INTERNATIONAL MARKETS**

The end of Second World War saw a dramatic expansion of international contracting (Linder, 1994). The post-war period was characterized by large-scale construction activity in Europe funded through the Marshall Plan. Also important were the increasing aid programmes and development loans from international institutions to boost construction in Third World countries. The oil boom of the 1970s subsequently created a massive construction market in the Middle East and North Africa (MENA). Construction companies from the US, Europe and Japan dominated international market in this period, with the involvement of firms from emerging economies such as Turkey and Korea as sub-contractors (Raftery *et al.*, 1998). However, the social, political and economic instabilities throughout MENA in the 1980s led Western contractors to withdraw from these markets and focus on relatively stable markets of the West (cf. Crosthwaite, 2000). Turkish contractors in contrast followed a different trajectory by demonstrating a high propensity for risk in post-conflict zones. They increased their turnover in MENA countries progressively throughout the 1980s. International activity of Turkish contractors reached another level in the 1990s through their successful involvement in the CIS region following the dissolution of the Soviet Union (USSR). The first two decades of international contracting was seen a learning process for Turkish contractors that they gained experience and developed their capabilities (Tayanç, 2011). Then, the 1990s were characterized by market and product differentiation, which subsequently led to market embeddedness, especially within the former republics along the southern fringe of the USSR. The favoured markets of Turkish contractors have often been characterised by continuous social, economic and political instability. In contrast to their international competitors, Turkish contractors tend to perceive such conditions as opportunities to expand their market share. The sectorial-level narrative of TCA presents the trajectory of Turkish contractors as an *epic story*, in which founder managers are depicted as *quasi-heroic* characters striving to establish their firms in emerging markets. It is argued that the story fragments presented within the sectorial-level narrative of TCA provide a rich empirical source to understand the enactment of strategies by Turkish contractors.

## **ACADEMIC NARRATIVES OF COMPETITIVE STRATEGY**

### *Assumptions of Stability and Predictability*

Theories of competitive strategy have changed considerably since the initial highpoint of strategic planning in the immediate aftermath of World War II. Initial models of strategy were developed in conditions of certainty with the assumption that strategies are planned

and executed through a rational, top-down and linear process (i.e. Chandler, 1962; Ansoff, 1965). The assumption of a stable world continued to dominate the mainstream literature until the latter 1980s. Porter's (1985) seminal contribution has provided the key building blocks for a series of studies of competitive strategy in construction (i.e. Oz, 2001; Ofori, 2003; Mesner and Korkmaz, 2008). The common tendency is for competitive strategy to be reified as a stable entity which can be defined, measured and (allegedly) improved. However, the increasing uncertainty initiated by the oil crises of the 1970s challenged the assumed expansion and hegemony of the pre-existing notions of strategizing. Such market uncertainties gave rise to the emergence of new perspectives, which recognise the complexities of strategy-making-in-practice (i.e. Mintzberg, 1987). These approaches highlighted the inherent political and culturally embedded nature of strategy making (Pettigrew, 1987). Organization studies started to emerge as a distinct discipline with a strong focus on the routines and resources that enabled firms to respond to external change. Barney's (1991) resource-based view and Prahalad and Hamel's (1990) core competencies approach have since become key points of reference in strategy studies. Empirical studies have hence subsequently emphasised the importance of unique resources, organizational competencies and the shaping effects of path dependency (Phua *et al.*, 2006; Wethyavivorn *et al.*, 2009).

#### *Towards the Recognition of Process*

The 1990s comprised a further age of disruption with the end of the geo-political certainties of the Cold War. Globalization, technology and continuous change became the new mantra of competitive strategy studies. The dynamic capabilities view was developed in recognition of such an increasingly dynamic world and promoted the requirement for firms to adapt to the constant flux in the business environment (Teece *et al.*, 1997). The focal point of the competitive strategy discussion shifted to the ability of firms to transform and reconfigure their resources and operating routines. However, such studies consistently ignore the changing geo-political contexts within which organizations operate. The so-called 'process school' has emerged from this critique and emphasized the embedded nature of the strategy making process and the importance capturing 'reality in flight' (Pettigrew, 1997). Longitudinal analysis of the broader context and interaction between multiple parameters hence becomes the key focus of empirical analysis. However, the emphasis on linking the context, process and outcomes risks degrading all three to a set of variables that supposedly shapes the eventual outcome (i.e. Langley, 2007). Besides, only few empirical studies attempt to capture the reality in flight of strategy making within the context of highly unstable and unpredictable of construction sector (cf. Green *et al.*, 2008).

#### *Competitive Strategy as Practice*

Developed as an extension of the above, the strategy-as-practice (SaP) approach contends that strategy is not something that is possessed but something that is practiced. Hence competitiveness must be theorised as a situated socially accomplished activity (Whittington, 2006). Recent research within the SaP tradition has focused on the important role of narratives as the medium through which strategy is enacted. Löwstedt and Räisänen (2012) drew on a narrative perspective to understand 20 years of change process in a Swedish construction company. They sought to compare the formal narratives stated by company documents and individual spoken narratives of middle managers and describe the differentiation between two levels of narrative.

#### *Narratives of Competitive Strategy*

The 'narrative turn' in organisation studies sees organizations as discursive spaces within which the narratives of different actors and interest groups compete as sense-making

mechanisms (Fenton and Langley, 2011). Deuten and Rip (2000) further argue that multi-authored and heterogeneous narratives aggregate and interact over time in their social and material settings and progressively constitute a *narrative infrastructure*. The concept of a narrative infrastructure helps explain how coherent strategies can emerge from complex and contested contexts. More importantly, the narrative infrastructure is depicted as a key concept not only in informing present day decision-making, but also in generating possibilities for further strategic actions (Fenton and Langley, 2011). The construction of the narrative infrastructure is seen to follow a dynamic process of interaction with specific *narrative building blocks* (Deuten and Rip, 2000). The term *narrative building block* is used to refer to commonly accepted discursive resources that are used to give meaning to emerging occurrences. Narrative building blocks could be grand narratives such as globalization, regionalization, climate change etc. (cf. Vaara, 2002), or alternative discourses of competitive strategy such as positioning, unique resources, dynamic capabilities, etc. (cf. Green *et al.*, 2008). It is important to emphasize that the processes of contestation are continuous. The narrative infrastructure is hence continuously re-constructed over time. The analysis of narrative infrastructure and the narrative building blocks from which it draws thereby provides potential insights into the ways in which competitive strategies are negotiated and enacted.

## RESEARCH METHOD

The adopted approach follows the tradition of interpretive research which assumes that people create their own subjective and inter-subjective meanings as they interact with the world around them (Orlikowski and Baroudi, 1991). Narrative research is hence firmly positioned within the interpretive tradition (Rhodes and Brown, 2005). Of central importance are the multiple realities projected by individuals and the ways in which different narrative building blocks interact with the broader social context and create the narrative infrastructure. Since social reality is seen as a process of continuous construction, the search for *objective truth* is replaced by a quest to understand how *a given version of the world is constructed* (Czarniawska, 2004). Hence the research focuses on the *narrative infrastructure* relating to the competitive strategy of Turkish contractors. As a caveat, it is important to note that the international markets within which Turkish contractors operate can be characterised in part by a range of quasi-objective criteria, not least in terms of economics and geopolitics. But such criteria are of course always subject to interpretation as any series of historical events can be narrated in a plurality of ways. The empirical study started with a structural analysis of the TCA narrative entitled 'Geographies of Contractors'. The story fragments within the TCA narrative were deconstructed to their constituent elements. A coding structure based on the structural analysis models described in narrative literature (Duman *et al.*, 2017). The important narrative elements were defined as actors, actions, events, time and contextual parameters that are linked by certain plot structures. By cross-referencing with relevant literature an iterative reading process enabled the identification of six common and recurring themes across narrative fragments. Such common themes are labelled as the *narrative building blocks* from which the *narrative infrastructure of TCA* is constructed. According to Greimas (1987) all narratives focus on a subject (or 'hero'), who follows a journey to reach an object (otherwise construed as an 'end-goal'). Each journey routinely describes how the subject interacts with a series of characters at different stages of the process. The same characters may be presented as heroes or opponents at different times. Many narratives build particular plot lines around the tendencies of helpers to subsequently turn into opponents, and vice versa (Czarniawska, 2004). By demonstrating such temporal and dynamic connections across an extended timeline, the empirical

analysis provides a means of understanding the essential temporality associated with the negotiation and enactment of strategy.

## FINDINGS AND DISCUSSION

The 'Geographies of Contractors' can be seen to comprise a narrative infrastructure that is constructed by compiling several narrative fragments derived from interviews with company managers, media documents and sectorial reports prepared by different institutions (i.e. IBRD<sup>1</sup>, TUDIAD<sup>2</sup>).<sup>2</sup> Such narrative fragments draw temporally from alternative narrative building blocks while presenting particular interpretations of Turkish contractors' stance in international markets. However, the emergent pattern is not only about the temporality between narrative building blocks, it is also the different roles ascribed to the actors as helpers or opponents within narrative fragments. Such narrative fragments present an interpretation of the actions of supposed heroes in overcoming the barriers presented by particular markets. The analysis below presents the building blocks from which the narrative infrastructure has been created on an epic plot structure. It further discusses the changing roles ascribed to the actors, actions and events within narrative fragments.

### *Narrative Building Block 1: Turkey's Push*

The formalized narrative of TCA highlights the recurrent political and economic instabilities in Turkey as the key reason at the starting point of the epic trajectory of Turkish contractors. The successive economic crises and the associated stagnation of construction projects are named as '*push factors*', whereby the government emerges as the initiator of the action. In the words of managers:

As you know there has been a decrease in the domestic investments in Turkey lately, as a result, contractors speed up international contracting as previously happened in 1980s, 1970s...(Company manager, 2009)

It is important to note that such '*push factors*' have not shaped the trajectory of Turkish contractors in isolation but have interacted with several other events. Examples include high construction demand in Libya in the 1970s, in MENA more broadly in the 1980s and across the former republics of the Soviet Union in the 1990s. Several story fragments emphasise that '*it was the time that Turkey pushed, but Libya/Russia pulled us*'. Besides, some narrative building blocks emphasize the company owners' visions as being more important than Turkey's push narrative. The owners' visions tended to dominate the narrative fragments emphasized by the companies who had reached certain level technical, managerial and financial maturity. In these cases, the founder of the company is depicted as the visionary hero moving from one market to another to create an opportunity. Such story fragments serve to emphasise a temporal daily coping process in response to emergent contextual parameters as discussed in SaP. More importantly, presenting a heroic character seems to generate a point of reference and motivation for new generation of managers.

### *Narrative Building Block 2: Inadequate Financial Capabilities*

Limited financial capabilities of Turkish contractors emerge as a key narrative building block. The problem of 'letters of guarantee' is especially highlighted as the key opponent that inhibits the success of Turkish contractors. The common tendency is to accuse the banking sector in Turkey. The narrators complained about the failure of Turkish banks to pay back the deposits during the Libyan crises of the 1980s and the '2001 Economic

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<sup>1</sup>International Bank of Reconstruction and Development, <sup>2</sup>Turkish Industry and Business Association

Crises' in the domestic market. The argument made is that as Turkish banks lost their credits in international markets, Turkish contractors' lost their financial strength in the tenders of mega projects. Some narrators emphasize that the difficulties of convincing Western banks to give letters of guarantee to Turkish firms has worsened their chance to enter some tenders. In the words of managers:

The biggest problem of Turkish firms is the letters of guarantees... If you undertake a 700 billion US \$ project, you need a security deposit at least 25% to 30% of this value... It is impossible to provide these from Turkish banks, even if you managed to get it once you get nothing on the next one... (Chief executive, 2009)

The narrative fragments refer to some critical actions taken by the contractors to overcome such financial struggles. These actions can easily be labelled as 'enacted strategies'. According to the TCA's narrative, some companies have established local subsidiaries in the markets that they aim to work in. They then seek to access finance through local banks within these markets through their local subsidiaries. The other action has been underlined as working in partnership with a Western contractor and benefiting from Western finance as a joint venture (JV). Although rarely mentioned, the third action is defined as benefiting from government lobbying to get acceptance of the guarantee of letters given by Turkish banks. Lastly, setting up JVs among Turkish companies has been emphasized as the key action to increase the financial strength in different periods. Such interpretations underlie the critical importance of financial capabilities to compete in international contracting. More importantly, detailed explanations of how the heroes have found different solutions to overcome the financial difficulties create a sense of direction and inform prospective actions.

### *Narrative Building Block 3: Government Lobbying*

Government support emerges as a key narrative building block emphasized in several narrative fragments. Official government visits to other countries with contractors, active role of ambassadors and Foreign Ministry as a network provider emerge as the key actions underlined in several story fragments. The narrative infrastructure created by TCA indicates a very close relationship between foreign diplomacy and market entry into different countries. For several narrators, especially important are the foreign country visits of government officials, in which contractors are part of the accompanying trade delegation. In such trips, the owner-managers of the contracting companies had the chance to set up government level networks which enabled them to invest not only in contracting but also in other sectors. Lobbying by the Turkish government seems to have played a very active role in activating the historical and geographical ties and facilitating Turkish contractors' entry into different markets. Another key action emerges as the sod-turning ceremonies, in which the government-level representatives of both countries meet at the construction site. Such ceremonies organized by contracting companies are highlighted as key activities to guarantee subsequent projects. Several story fragments argue that lobbying by government is a common strategic action in the agenda of other countries, France being the most frequently cited example. Most notably, winning the tender for a mega-project is routinely represented as a victory for one country over another. In such narrative fragments the subject of the narrative shifts from the role played by company leaders to that of Turkish government whereby presidents and diplomats are underlined as the key helpers. From a quotation of a Turkish newspaper in 2005 'Foreign Minister, Gul won his second victory over French President, Chirac in international tenders (Newspaper, 2005). However, such an emphasis on the role of the government changes according to the situation. For example, when the discussion comes to the financial problems that Turkish contractors face in terms of getting project credits,

letters of guarantee or inefficient auditing systems for the approval of compliance certificate of contractors, then the narrative fragments emphasize the government as the key opponent in the successful expansion of Turkish contractors. This reflects the dynamism and temporality of the roles assigned to the actors in the narrative fragments.

*Narrative Building Block 4: Combining Powers*

Several narrators see the failure of Turkish firms' cooperation between each other as a key problem inhibiting Turkish contractors' competitiveness as measured against their foreign competitors. More importantly, Turkish contractors are seen as the opponents of themselves as they compete with each other through low-cost tenders, especially in the 1970s Libya market. A quote from Middle East Economic Digest highlights:

Turks turn the tenders into a nightmare: As a result of the increase in the number of contractors who bids for the decreasing number of projects in Middle East, bidding becomes a nightmare for many contractors... (Middle East Economic Digest, 1983)

The TCA's narrative highlights that the short-term JVs set up to bid for the projects in Soviet Union in late 1980s and early 1990s paved the way for the initial foothold in post-Soviet states. Such a narrative seems to give a clear message about the need to avoid needless competition between Turkish contractors. When the narrative fragments refer to the 2000s, the narrators again start mentioning successful cooperation examples. Hence it could be argued that learning to work together has taken time for the Turkish contractors despite the recognition of its benefits since 1980s. The following quotation indicates the importance of the consolidation:

This is first time that we bring our powers together without any foreign company... We prevent unfair competition... We had a bad experience in Libya that firms compete on lowest costs (Company manager, 2009)

An alternative narrative underlies working with foreigners as a key strategic action to win tenders. Such narrative fragments emphasize the importance of the track records, or networks developed by working as project partners with foreign companies in the past as the way to set up JVs with foreign companies. Several story fragments highlight how both sides of a partnership help the other to secure significant projects:

...It was a huge project ...It is not possible for a Turkish company to take this project... (Japanese) are the giant companies working all over the world. We had a work experience with them in Turkey... They...know the experience... the capabilities of Turkish contractors and possible economic benefits that we could bring...it is very easy for a Turkish minister or a Turkish bank to talk (with the client)...understanding the client...it is almost impossible for a Japanese firm... As they thought we would bring benefit to them, as they know us, we set up a JV (Company manager, 2009)

Similarly, setting up long-term JV with US based contractors or asserting their identity as 'NATO contractors' provide alternative narrative building blocks for the purposes of breaking into the European and African markets. Considering the sustained efforts to increase market share in Europe and Africa as target markets, Turkish contractors seem to use working in partnerships as a strategic action.

*Narrative Building Block 5: We Love To (Have To) Work in High-Risk Markets*

Several narrators emphasise the adventurous and risk lover nature of Turkish people. However, the actual reason which emerges is that the risky markets have traditionally been the only option to create a market for Turkish international contracting given that other markets were already dominated by Western companies. But, shaping the story with assigning a heroic stance seems more helpful than describing the actual facts. More importantly, such risky markets were seen as a chance to move into new markets. Two quotations demonstrated below provides example for both perspectives:

(i) I have no expectation that somebody will deliver a project to me in Champs Elysees, I know that I need to go tough countries (Company owner, 2001)” / (ii) “I don’t expect that Western companies pay attention to Afghan market, because the conditions are very difficult...As it will be a door to open other global markets, it is very important for Turkish firms (Company owner, 2002)

It seems that developing capabilities by working in such risky markets over time builds the necessary resilience to operate successfully in hostile environments. And, as ‘instability’ and ‘disruption’ are the key mantras of today’s international contracting sector, such capabilities could serve as a point of departure for Turkish contractors in seeking to enter markets dominated by others. More importantly, considering the constitutive role of narratives and creation of an account that *we love to take risks*, the contractors become active players within the success story they create.

### *Narrative Building Block 6: Building Brand Recognition*

Several narrators emphasize the importance of creating a brand image to become embedded in different markets. Although there are slight differences within the narrative fragments, building brand recognition is linked to (i) early project completion, (ii) quality of work, and (iii) conflict adverse attitude. Such actions are seen as the way to undertake successive projects to the same client, or create market embeddedness. In the words of a company owners:

...the Chinese were working in front of us; and the Indians were working behind us. Everyone saw that we did the most successful work; we did it very well before than the expected time... So we are recognized in India... (Company owner, 2010)

Several narrative fragments emphasize the number of days won by the early completion. It especially becomes a key point of reference in power and built-operate-transfer projects with a specific emphasis on the cost advantages gained by early start-up. Another important action related to the brand recognition is underlined as the involvement in approved contractors list of international institutions. It seems especially important to overcome the financial difficulties to win mega projects.

## CONCLUSIONS

This paper has considered how the 'narrative turn' might contribute to a better understanding of competitive strategy in the international contracting sector. The empirical work comprised an analysis of the narrative infrastructure created by the Turkish Contractors Association (TCA). The TCA narrative consists of story fragments derived from key individuals and written documents. It hence provides a multi-authored and multi-level discussion on the competitive strategies applied by Turkish contractors. The analysis demonstrates the continuous reconstruction of narrative infrastructure through the mobilization of different narrative building blocks over time. Such building blocks seem to become the common point of reference for the narrators although the roles assigned to the narrative elements frequently change over time. While an actor is positioned as a key helper in one case, he/she could easily be presented as an opponent in another. The analysis of narrative fragments further illustrates the temporal connections made between the actors, the actions that they take, and the events that are initiated by external parties. The connections are presented from the perspective of the narrators for the purposes of making a particular argument. Such connections provide the basis for understanding how different actions are taken in different situations, and how they may subsequently be interpreted as strategy. The findings support the argument that strategic practices can only be understood in their embedded context and time as discussed in process studies (cf. Pettigrew, 1997). More importantly, the narrative fragments reflect the interaction of multiple realities and signify the complexity and diversity across

individual accounts of strategy making. The findings point to the requirement for a post hoc rationalization to specify and label some actions, and decisions as strategic. This proposition offers a contrary argument to the dominant thinking within mainstream competitive strategy theories, although it certainly chimes with the ideas of SaP (cf. Whittington, 2006).

In conclusion, it is argued that actors create narrative fragments. The recipients of these stories subsequently build on these fragments, or present contrasting stories. Such interactions generates a multi-voice and multi-level mosaic of stories whereby the above listed narrative building blocks emerge as common set of discursive resources. The temporal interactions and evolving aggregation of such narrative fragments and narrative building blocks constitute an evolving narrative infrastructure for the Turkish international contracting sector (cf. Deuten and Rip, 2000). Such a narrative infrastructure enables a strong point of reference for the generation of further narratives, which constitutes the actions of Turkish contractors. More importantly, portraying the Turkish contractors as heroes of international construction sector within retrospective accounts, TCA creates a narrative infrastructure for the purpose of achieving an expressed end goal, namely the increased penetration of international markets by Turkish contractors.

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# UNDERSTANDING RADICAL INNOVATION: A CASE EXAMPLE FROM THE TURKISH HOUSING MARKET

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Product differentiation is amongst the essentials of meeting customer needs and gaining competitive advantage over the rivals in highly dynamic markets, while efficient management of the resources in accordance with corporate strategies is key to successful outcomes. This paper focuses on the innovative business and design initiative of a Turkish company, NEF, which introduced the concept of Foldhome to the housing market. NEF describes this patented concept as “ensuring the inclusion of all rooms, which cannot fit into one house, by means of folding.” Foldhome allows the users and their guests to access various spaces and facilities on a ‘pay-per-use’ basis, in addition to using their standard accommodation units. Foldhome's radical departure from the status quo in a conservative industry, along with its attractive potential for further innovation suggests that it can be classified as a radical design and business innovation in the housing sector. The paper presents the story of Foldhome as part of an integrated innovation process and calls for a wider lens to look at innovation in the building industry. The resource based view of the company (RBV), combined with strategic entrepreneurship perspective, provide the theoretical framework of the analysis.

Keywords: strategic entrepreneurship, Turkish housing sector, Foldhome

## INTRODUCTION

A Turkish company, NEF, established in 2010 by a 28-year-old entrepreneur, Erden Timur, introduced the innovative Foldhome concept into the housing sector, which is characterized as 'conservative' based on its risk-averse suppliers and clients, often seeking the "tried and true" (Koebel *et al.*, 2003). The idea behind the Foldhome was described by NEF as "including various rooms which cannot fit into one house by means of folding," where the users, on the basis of a 'pay-per-use' system, can benefit from various social facilities as if these spaces are part of their own accommodation units. No payment is charged for any facility, if it is not used. When facilities require repair works, expenses are compensated from depreciation (Nef, 2015a). Foldhome was the origin of a series of NEF's other innovative concepts such as Foldcity, Foldworld, Foldvillage, Foldoffice and Foldfarm (Timur, 2015:35). Foldhome was welcomed in the market and gained a significant commercial success, as evidenced by NEF's turnover of about 1.3 billion US Dollars in 2016, and more than 50 domestic and international awards, including the 'The ELITE Award for Growth Strategy of the Year' in Europe.

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Foldhome can be described as a radical innovation, due to its visible potential to change the dynamics of a market and affect the economic activities of firms. Although it has drawn transnational attention and become subject to leading business journals such as *The Harvard Business Review* (Timur, 2016a), Foldhome is yet a black box from an academic point of view and deserves a systematic analysis since it offers a valuable opportunity to observe the relationships between alternative theoretical perspectives on competition, innovation and entrepreneurship, apart from the its attractive potential to help decipher the dynamics behind radical innovations, which typically deviate from the status quo. Available evidence suggests that the commercial success of the Foldhome appears to be rooted in the strategic capabilities of a company for managing its resources efficiently, through the guidance of a powerful entrepreneurship style. The Foldhome experience might be of interest for the practitioners who aim to understand the drivers behind the development of a radical innovation in relation to corporate strategies.

## **INNOVATION IN THE AEC INDUSTRY**

A quick review of the literature will reveal two conflicting views of innovation in the AEC field. The prevailing perspective is quite pessimistic: the industry, especially the housing segment, is laggard due to numerous impediments; both the builders and buyers are risk-averse and conservative; little attention is paid for research and innovation, and so on. In contrast, relatively a smaller group of researchers, who are more optimistic about the innovation performance of the industry, tend to focus on the cultural and managerial characteristics of innovative and creative companies (see Koebel *et al.*, 2003 for a comprehensive review of innovation in the residential building sector). Both streams of research appear to acknowledge that innovation is essential for the market success of construction companies due to both the push of competitive advantage and the pull of increasing complexity of demand for built products (Koebel *et al.*, 2003:9). However, similar to the management science literature, available body of knowledge in the AEC field is far from uncovering the linkages amongst competitiveness, innovation and entrepreneurship.

### **Competitiveness, Entrepreneurship and Innovation**

Available theoretical models of competition in the strategic management field are under the umbrella of two major perspectives market driven view (MDV) and the resource-based view (RBV). MDV postulates that the industry structure sets the competitive rules and influences the strategies that are available to a company. To the extent that the resources of a company fit to this external environment and support particular strategies, they provide competitive advantage. However, the fact that MDV tend to disregard the role of internal environment led to the development of alternative views (Breznik and Hisrich, 2014:368).

The RBV conceptualizes the sources of a company as 'inherently valuable' and contend that any company should formulate its corporate strategies according to its unique resources (Rivard *et al.*, 2006:30). RBV asserts that companies are heterogeneous in terms of the strategic sources they own and their awareness about the valuable, costly to imitate and non-substitutable resources and their organizational capabilities to configure internal or external resources will eventually result in a sustained competitive advantage (Kostopoulos *et al.*, 2002:4; Penrose and Pitelis, 2009). Resource immobility, the other fundamental assertion of RBV, is based on the assumption that intangible resources such as know-how, brand equity or intellectual property are not mobile and do not move from company to company; accordingly, companies cannot replicate competitors' resources and strategies (Kostopoulos *et al.*, 2002:6). A common distinction in the RBV literature

is between the tangible and intangible resources. While the former refers to the financial and physical resources, the latter refers to components such as organization culture; design and engineering know-how and intellectual property, in addition to the human resources. An organization's capabilities to transform these resources into strategies determine its market success, since the resources alone do not lead to competitive advantage.

An organizational capability is defined as "a firm's capacity to deploy resources for a desired end result" (Grant, 2010:131). Organizational capabilities might be related to the different functional areas of a company such as corporate management (e.g. finance management; strategic management; strategic innovation; acquisition; and international business) and the associated management information systems to support decision making; research and development (e.g. new and fast-cycle product development); operations (e.g. Efficiency in volume manufacturing; continuing improvement in operations; and the flexibility and speed of response); product design (e.g. design capability); marketing (e.g. brand management; promoting reputation for quality; and responsiveness to market trends); and the sales and distribution (e.g. effective sales and promotion; efficiency and speed of order processing; speed of distribution; and the quality and effectiveness of customer service) (Grant, 2010:132). According to Breznik and Hisrich (2014:374), innovation capability can be seen as a 'synthesis of capabilities,' referring to a company's capacity to transform its knowledge and ideas into innovative solutions.

RBV, however, "lacks a story" about the creation of competitive advantage (Foss, 2011:15-19): Entrepreneurship literature treats the "process of combining and organizing resources" also as a resource, which is difficult-to-imitate and immobile. The central idea of strategic entrepreneurship, a fairly new discipline, is that "opportunity-seeking and advantage-seeking- the former the central subject of entrepreneurship, the latter the central subject of the strategic management field- are processes that are to be considered jointly." Strategic entrepreneurship is defined as "the use and/or stimulation of entrepreneurial activity to achieve strategic goals" (Kuratko *et al.*, 2009).

Entrepreneurs function as business leaders who inspire organizational members "not only to substitute organizational goals for their own personal goals, but-equally importantly-to subordinate their personal preferences, principles and prejudices to team collaboration" (Grant, 2010:157). Entrepreneurship literature places a considerable emphasis on the personal and psychological characteristics of these leaders, which differentiate them from other people, such as being better informed than others to seek and exploit opportunities (Foss 2011:1; Ireland *et al.*, 2003:968), even when the situations are ambiguous and fragmented (Ireland *et al.*, 2003:968); being bold, imaginative and creative (Foss 2011:13); and acknowledges entrepreneurs' special ability to invent and commercialize new products and services (Hitt *et al.*, 2001:484), by managing their resources strategically and creating an entrepreneurial culture in their organizations.

Innovation is seen as the primary activity of entrepreneurship (Ireland *et al.*, 2003:971). As many scholars highlight, however, strategic management and entrepreneurship, two complementary fields, have surprisingly little contact, although establishing a link between advantage-seeking and opportunity seeking behavior can be especially critical in dynamic business environments, where competitive advantages are short-lived (see Foss, 2011:15-18; Ireland *et al.*, 2003,965). Little empirical evidence exists on how the entrepreneurial leaders manage resources strategically and "bundle resources into capabilities" to create competitive advantage and wealth (Ireland, 2003:983). Figure 1

shows a summary of the overall framework, where the strategic management of resources led to competitive advantage through the guidance of entrepreneurship.

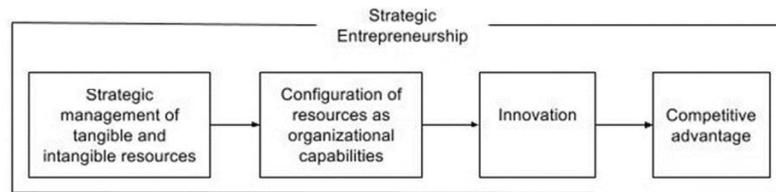


Figure 1: A model of strategic innovation (Adapted from Ireland et al., 2003)

**The Foldhome**

The Foldhome concept is based on the addition of a set of social facilities to a core accommodation unit which includes a bedroom, a living space and the wet spaces. This core unit, size of which vary to meet user needs, is "folded" by various tailor-made areas which are also configured according to client/user needs (Figure 2). Any user with a digital access card can benefit from such facilities on a pay-per-use basis, without any additional payment, apart from the standard subscription fee. Damage due to wear and tear is compensated from depreciation. Audio-visual materials about Foldhome are accessible from the company web site (Nef, 2015) and its Facebook page (Nef, 2017).

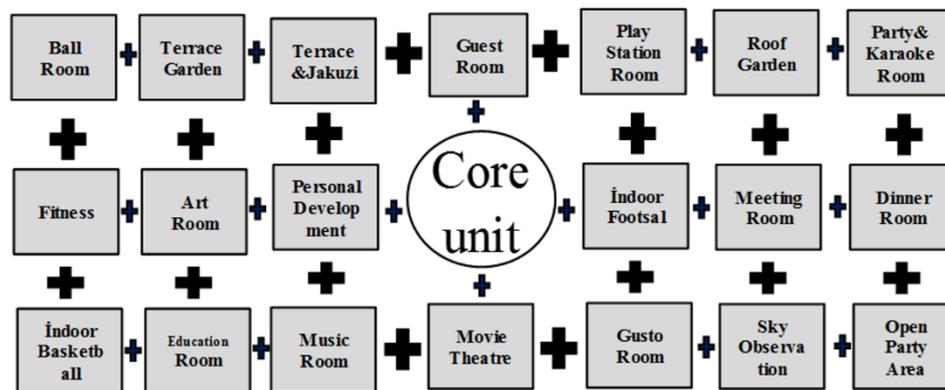


Figure 2: The concept of Foldhome

**METHOD**

Considering the knowledge gap in both the management science and AEC literature regarding the linkages amongst strategic management, innovation and entrepreneurship, a research project was started to achieve an in-depth analysis of the Foldhome, due to its attractive potential to contribute to a better understanding of such theoretical linkages and the dynamics behind a radical innovation, which have already proved its commercial success. In accordance with the model in Figure 1, the authors aim to understand how the tangible and intangible resources of a company are managed strategically to create organizational capabilities which lead to innovation and an explicit competitive advantage in a highly conservative market segment.

Considering the uniqueness of Foldhome in the Turkish market, a qualitative research strategy (single-case study research) was adopted as it would allow the triangulation of data from different sources such as the interviews with the entrepreneur, functional managers, project managers, employees, and the end users, in addition to numerous documents such as the strategic reports, progress reports, and user satisfaction surveys; and the digital resources such as the corporate web site, mass and social media platforms,

which promise a significant amount of data about the Foldhome. Additionally, the first author of this paper worked as the NEF's design manager for 2 years, from 2014 to 2016, which allowed her to be part of the Foldhome experience. Following a literature review, the authors drafted a case study protocol, which later saw small updates due to feedbacks from the ongoing field study. Due to the nature of qualitative research strategy, this protocol is being updated regularly following the analysis of new data from the field (e.g. in addition to the analysis of secondary data, three functional managers have been interviewed so far).

Since the entrepreneurship literature put a significant emphasis on the relationship between innovation and the personality characteristics of entrepreneurs, the 'leader' behind the Foldhome was considered as an essential and initial part of these analyses. This paper reports the outputs from the analyses of secondary data from the mass media (i.e. the interviews with the entrepreneur -Erden Timur- and the news about the Foldhome), NEF's corporate web site, and the other digital resources such as the corporate Facebook group. Understanding the entrepreneurial discourse is a critical step for understanding Foldhome, if innovation is seen as the primary activity of entrepreneurship. The following section includes a short summary of NEF and the entrepreneur behind the Foldhome, before presenting the results of a preliminary analysis, which aimed to understand the organizational capabilities of NEF from the entrepreneur's perspective. In particular, the organizational capabilities which led to the Foldhome was the focus on interest. Since the presented analysis is based on secondary resources at this stage, only the capabilities about which relatively sufficient information was available were included in the analysis. These organizational capabilities include strategic management, strategic innovation; finance management, product design; research and development; and marketing.

### **The Company and the Entrepreneur behind Foldhome**

NEF was founded in 2010 by a then-28-year-old entrepreneur, Erden Timur, as a brand of Timur Holding, which carries out business operations in a variety of sectors including iron-steel, fuel oil and real estate development. NEF defines its vision, on its corporate web pages, as being "known as a best practice company in the sector," and its mission as "designing and offering attainable living spaces which meet undiscovered expectations, and spreading happiness". Contributing to society; continuing improvement, creating added value and the happiness of stakeholders are declared as the company values. The company currently has about 350 employees in total, including both the corporate and project-level operations. The human resources structure in NEF is quite dynamic: about half of the employees have been working for NEF for less than a year, while those with 3-4 years of experience account for about 20 per cent of the total workforce. The company recently declared that its strategic goal is to rank among the top five companies in Turkey and expand its business operations to the major European and American cities to become a global brand (Emlakkulisi.com, 2016a).

Erden Timur, the Chief Executive Officer (CEO) of NEF is the entrepreneur behind the success of the company. Timur's story, in his own words, has been widely circulated through several business journals and newspapers (Milliyet, 2011): "I was a graduate student at London School of Economics. I was 22 years old when I went back to Mersin [his hometown, a city on the Mediterranean coast of Southern Turkey] when I learned of my father's illness. We were working on a land development project [in Mersin]. I had a law degree, but I had long wanted to start a venture capital company and to work in the business development field. This is my favorite stuff...say a hobby. Suppose you give

me a salt cellar; I immediately start to imagine changes on it like adding a thing to this or that side, or remove this or that part. After all, this is how innovative ideas show up. So I had planned to deal with the visioning part of our then ongoing development project. It was a short-term endeavor for me. We owned a holding, running operations in the energy, logistics and real estate development fields. So I was able to raise the capital for construction business."

### **Analysis of Foldhome as a Radical Innovation**

Following a preliminary analysis of the secondary sources, the organizational capabilities of NEF are illustrated below according to various functional areas including strategic management; strategic innovation, finance management; product design, research and development; and marketing.

#### **Strategic Management**

The strategic plan of NEF, formulated by Erden Timur in 2010, has three-phases, each covering 5-year periods. 2010 to 2015 period comprised the development of business concept and the marketing strategy, where NEF invested in its brand, established partnerships with financial institutions and leading designers. 2015 to 2020 was formulated as a growth and business scaling phase, to be able to plan sustainable growth models, continue branding investments, establish new partnerships and protect the company's financial power. Timur argues that learning how to "stay focused" is one of the most critical assets in his business life (Emlakkulisi.com, 2016b), which allowed NEF to achieve an efficient acquisition management and grow in a healthy way. The last phase of the strategic plan, from 2020 to 2025, is the period where NEF aims to position itself as a global real estate brand and expand business operations to the major cities in the United States of America (USA) and Europe (Ekoyapıdergisi, 2015).

Location strategy and land investments are critical elements of strategic management for any real estate company. Financial power of NEF allows the company to invest in land for future Foldhome (and other) projects both in the European and Anatolian parts of Istanbul. The fact that Istanbul is the middle of a large-scale urban regeneration process, as part of governmental policies come to mean business opportunities for NEF, which has signed about 4,000 contracts with individual property owners (Emlakkulisi.com, 2016c). According to Selçuk Çelik, the Sales and Marketing Director of NEF, appropriate selection of project locations are among the major factors that led to the company's success in the market (Ekoyapıdergisi, 2015).

NEF formulates its human resources management (HRM) strategy to support its corporate goals and describes its HRM mission on its corporate web site as "being the most preferred and appreciated brand by top-calibre employees" (Nef, 2015b). HRM tools to support this mission include, but are limited to (Dalan, 2016): working from home after childbirth; provision of nappy and baby food, support for parental education; flexible work hours, casual dress code policy; holiday packages, financial support for private school payments, summer schools and various scholarships for children. Timur argues that they want to be a model for the business world (Ibid.).

#### **Strategic Innovation**

The strategic innovation behind Foldhome is targeted at changing the traditional form of home ownership. According to Timur, reconfiguration of the ownership concept opened up new possibilities for his company in a conservative market (Timur, 2015, 34):

...House came to mean a few rooms and salon [for many]. Once you bought it, you could make little changes on it, except for small aesthetic touches. On the other hand, your needs were changing. You were getting married, having kids. The product was static, allowing little opportunity to for scaling...We listened to people; asked them 'If you had a big house, what would you like to have in it?' We realized their desires. Our projects include facilities...which are missing even in the million-Dollar worth houses...we describe this as 'accessible freedom.'

What Timur calls 'accessible freedom' gave new insights to NEF to start other innovative initiatives such as the Foldcity and Foldworld. While the former concept is based on the idea that Foldhome users can benefit from any other Foldhome project in Istanbul, the Foldworld© concept aims to extend this "freedom" to a global level. Another major aspect of NEF's strategic innovation is the concept of social innovation, which essentially includes the efforts to seek on novel solutions to social problems in effective, efficient and sustainable ways. Timur (Timur, 2016b) argues that companies such as Uber and Airbnb, which focus on creating social influence, rather than being merely motivated by short-term profit maximization, are more likely be remunerated by the society, as evidenced by their market values. Only the companies which incorporate social innovation into their business strategies will be able to address the markets of future which will be shaped by ethical, social and ecological concerns and expectations. Timur believes that the Foldhome, as an output of a social innovation perspective, brought "democratization" to the real estate sector (Timur, 2016b).

### **Finance Management**

NEF establishes strong partnerships with the leading local and international financial players to realize its innovative projects. İş GYO (a local real estate investment trust); Abdi Ibrahim (a local pharmaceutical company); European Bank for Reconstruction and Development (EBRD); and Amstar Global Real Estate Investments from USA are to name a few (Alagöz, 2015; Hurriyet, 2016; Milliyet, 2017). Concurrently with the Foldhome concept, NEF developed various investment instruments to support its strategies. For example, the 'guaranteed project' concept aims to bring down the investment risk to zero and guarantee the delivery of a project before the construction started. After the feasibility study by an independent body, "...whole cost of a project is held in bank from the first day...All the expenses of the project are covered under the control and assurance of the bank according to progress payments reported by experts" (Nef, 2015c).

### **Product Design**

Product design capability lies at the hearth of NEF's market success and it is the central focus of business since its establishment. NEF herein follows a few critical strategies: The creation of global design series strategy, adapted from the automotive industry, aims to standardize core design solutions. NEF prepares design guidelines for each of the series including houses (The Foldhome); flats; apartments; suits; residences; dorms; and offices, which are customized according to the characteristics of users in different locations (URL16; Emlakkulisi.com, 2016b). Another strategy aims to develop "difficult-to-imitate but easy-to-repeat" products (Timur; 2015:35). Finally, NEF collaborates with the leading architectural and industrial designers to develop its product series. Apart from the leading local names, Foster+Partners (UK); HOK, SOM (USA) and Lombardini22 (Italy) are among the companies, which anonymously work for the NEF brand.

## Research & Development

Differentiating NEF from many competitors in the R&D field, and supporting its strategic innovation focus, the company has a specific interest in developing alternative building production methods, for which it collaborates with researchers from Harvard University and Massachusetts Institute of Technology (MIT), in addition to companies from USA and China (Emlakkulisi.com, 2016b):

...Even if you pay in advance, it takes 36 months on average to deliver a project. We need to produce off-site and assemble on-site to speed up the process. We will reduce it to as less as 6 months. By this means, it is not impossible to reach 50,000 houses per year, while we produce 5,000 currently...We were to standardize the product in the first place. We did. We will realize the new production system in the next 5 years.

## Marketing

Screening changes in market demand and the detailed analyses of user feedback are the standard practices in NEF, similar to other real estate developers. NEF actively uses its Facebook group and other digital media to communicate with its target audience, deliver tailor-made messages through various forms of marketing campaigns. However, the real driver behind the success of Foldhome is the brand management capability of NEF. Erden Timur argues that not only being a brand, but also being a 'love brand' is critically important to create value in the market, for which little attention is paid in the construction industry.

According to Timur, Coca Cola, Apple, Volkswagen, Nikon, Harley Davidson are among the examples of 'love brands,' which could touch the feelings of people and offer a new lifestyle (Timur, 2016a). He believes that their central focus on being a love brand is the secret behind the NEF's ability to persuade globally-known designers to be part of Foldhome projects in the ordinary neighbourhoods of Istanbul. Having received national and international awards from numerous bodies and the patented products apart from the Foldhome leverage the company's brand. Brand management efforts include many other initiatives such a student design competition with the "Fold-it" theme, which aims to realize the awarded project with the support of NEF, and participation in the Design London fair, with the sculpture 'The Golden Horn' designed by Sebastian Leon Agneessens.

## DISCUSSION AND CONCLUSION

Using the ARCOM's 2017 jargon, the Foldhome can be properly described as a "brutally innovative" product, due to its commercial success and the visible potential to influence a relatively conservative market segment. Analysis of the entrepreneurial discourse surrounding the Foldhome experience shows that the language used to describe the innovation differs significantly from the typical language used in the AEC innovation literature, in terms of the strong emphasis placed on business dynamics, in particular on brand management and creating/offering a lifestyle for customers. The Foldhome calls for a wider lens to look at innovation in the building industry, since the technical aspects of innovation in the AEC industry cannot be isolated from the rapidly changing dynamics of the business world, where innovations are often the outcomes of the decisions of business leaders, who manage their resources strategically and create an entrepreneurial culture in their organizations.

After all, the Foldhome is the brainchild of a 28-year old entrepreneur. Practical and theoretical benefits from an in-depth analysis of the Foldhome experience, which is the PhD topic of the first author, can be multiple: From a practical perspective, it can be of

interest for companies which aim to link and align their strategies to position themselves as an innovative organization and understand which organizational capabilities lead to change. From a broader perspective, Foldhome offers a valuable opportunity to observe the relationships between the strategic management, innovation and strategic entrepreneurship fields, which are said to have little contact. An external evaluation, based on further empirical evidence will also help identify the shortcomings of the Foldhome concept.

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# **SOCIAL RESPONSIBILITY**

# MOTIVATIONS AND BARRIERS TO SOCIAL PROCUREMENT IN THE AUSTRALIAN CONSTRUCTION INDUSTRY

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Social procurement is an important requirement in many private and public sector construction contracts. To better understand the motivations and barriers to social procurement in the construction industry, semi-structured interviews were conducted with eight large developers, property managers and contractors in the Australian construction industry. The results indicate that social procurement in construction is currently compliance-driven, confined to low value and low risk activities and delivered mainly by existing industry incumbents who do not understand how to deliver social value, or by micro-organisations that do, but which suffer from a lack of scale and opportunity. Further research is needed into the development of new supply chain capacity to deliver social value and into strategies to resolve tensions from the conflicting objectives and institutional logistics which arise from the new cross-sector collaborations which social procurement brings to construction.

Keywords: community, social procurement, social value, third sector, social value chains

## INTRODUCTION

Social procurement involves “the acquisition of a range of assets and services, with the aim of intentionally creating social outcomes (both directly and indirectly)” (Furneaux and Barraket, 2014: 269). As Furneaux and Barraket (2014) point out, through social procurement initiatives, organisations effectively create a quasi-market for certain types of minority or social purpose business, diversifying their supply chains with the dual goal of maximising both economic and social value. This social value can take many forms such as providing new training and employment opportunities to the unemployed and can translate to numerous impacts for wider society such as improved income, health and well-being and reduced crime, substance abuse and incarceration.

The political, economic, legislative and social drivers of social procurement aligning in many countries such as the UK, EU, Ireland, Australia, South Africa and Canada mean that it is becoming a more widespread tool of governments to meet their welfare responsibilities in the communities in which they operate (Bowen *et al.*, 2008, Villeneuve-Smith and Temple, 2015, Loosemore and Higgon 2015, Barraket *et al.*, 2016). Existing and developing social procurement policies, legislation and regulations such as the South Africa’s Preferential Procurement Policy Framework Act (2000) Preferential Procurement Regulations 2017, UK’s Public Services (Social Value) Act (2012),

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Australia's Commonwealth Indigenous Procurement Policy (Commonwealth of Australia 2015a) and various EU Directives on the coordination of procedures for the award of public works contracts which play a key role in the Europe 2020 Strategy (European Union 2014), are promoting socially responsible public procurement, requiring those tendering for public construction contracts to demonstrate they are creating 'social value' in the communities in which they will build, usually by providing employment and training for minority groups and business opportunities in construction supply chains for social benefit organisations such as local, small and minority businesses and social enterprises which employ those groups or are majority owned by them.

Given the construction industry's potential economic and social impact, the public procurement of its products and services is at the very centre of this trend, although research into social procurement in the construction industry is in its infancy. While there has been a considerable body of related research in construction such as corporate social responsibility (for example Murray and Dainty 2009, Loosemore and Lim 2017) and responsible sourcing (Upstill-Goddard *et al.*, 2012), the specific challenge of creating 'social value' through procurement has received scant attention. However, from the little research that has been undertaken, we do know that social benefit organisations such as social enterprises are under-represented in the construction industry, that the uptake of social procurement in the public sector remains low and there is little understanding and how traditional power structures, role, relationships and responsibilities will be affected by the emergence of a new third construction sector (Loosemore and Higgon 2015, Loosemore 2016, Burke and King 2016, Petersen and Kadefors 2016).

It is against this backdrop that the aim of this paper is to explore for the first time, the motivations and barriers to social procurement for major contractors in the construction industry.

## **DRIVERS OF SOCIAL PROCUREMENT IN CONSTRUCTION**

At the highest level, social procurement in the construction industry is being driven by fundamental shifts in social policy landscapes around the world which are themselves driven by paradigm shifts in welfare provision and trends towards New Public Governance (Varghese 2015, Barraket *et al.*, 2016). These represent a movement away from traditional welfare services delivered directly by governments towards partnerships with business and third sector organisations using collaborative mechanisms such as outcomes-based contracting, public-private partnerships and social procurement. Social procurement is also being driven by the realisation that many social challenges are 'wicked problems' that governments cannot solve alone (Commonwealth of Australia 2007) and by broadening conceptions of 'value for money' in the public sector which incorporate social and environmental considerations as well as costs in the procurement of government products or services (Tilt 2016).

The attractiveness and viability of social procurement as a relatively new mechanism to meet these new imperatives is also being driven by a growing and increasingly viable social enterprise sector, although there are currently a relatively small number of social enterprises operating in the construction industry (Loosemore and Higgon 2015). In Australia at the last estimation there were over 20,000 social enterprises (Barraket, 2010) while in the UK there were approximately 70,000 social enterprises providing employment for almost a million people and contributing £24 billion to the economy (Villeneuve-Smith and Temple, 2015). It is estimated that about 2% of these operate in construction, despite construction representing approximately 8-10% of GDP in most countries (Loosemore and Higgon 2015).

It is also claimed that private firms can benefit significantly from engaging in social procurement in the form of improved competitive advantage (with socially responsible clients); demonstrable corporate citizenship; improved community engagement and public relations; and positive reputation with communities, clients, shareholders, employees and other stakeholders (Loosemore and Higgon 2015, Barraket *et al.*, 2016, Flammer, 2015, Andayani and Atmini 2012).

Finally, perhaps the most significant driver of social procurement is the potential benefit it can deliver for the government and the communities which they serve. For example, in one instance of a social enterprise being employed to perform cleaning services on a public housing estate in Australia, Burkett (2010: 9) reported “less fighting, vandalism, drugs, and improved perception of estate residents from other Council residents.” Similarly, a recent review of the UK’s 2012 Social Value Act, cites an example of one social procurement initiative which provided work and shelter for homeless people which saved “£1,478,506 to the Department of Health in NHS and emergency costs, criminal justice savings to the Ministry of Justice of £778,435, and welfare savings of £1,252,030 to the Department of Work and Pensions” (Cabinet Office, 2015: 16).

It must be pointed out however, that while advocates of social procurement promote it as a powerful mechanism for social change, critics argue it is simply a rhetorical smoke-screen for dismantling the welfare state and for justifying government austerity programs which have made deep cuts to social welfare (Doherty *et al.*, 2014, Whelan 2012). Social procurement is also criticised for being a further step towards the outsourcing and privatisation of welfare, motivated by cost-cutting rather than delivering better quality services to communities (Alcock *et al.*, 2013). Furthermore, as Rose and Bulloch (2013) note, there is no empirical evidence to indicate that private firms, third sector organisations and communities are equipped to take-on these additional responsibilities and that the outcomes of social procurement are better than publically delivered services. Indeed, Barraket and Weissman (2009: 4) found that social procurement policies, when poorly designed and implemented, can lead to an “inefficient mix of production across the economy” by excluding efficient firms from the existing supply chain. The European Commission (2010) also found that a risk of prioritising spending on enhancing social outcomes could be a reduction in competition in the economy.

## **METHOD**

Data was collected using semi-structured interviews with eight senior managers with responsibility for social procurement in eight leading construction, property management and property development companies in Australia. We adopted this approach because while our initial research had identified some barriers and motivations to social procurement outside construction, there was little research within construction to guide our questions, so a fully structured interview with standardised questions was not possible. Furthermore, in order to build and broaden our conceptual understanding of this area into a construction context, it was important that the interviewer was able to discuss and raise issues as the interview progressed that may not have been considered in the mainstream social procurement literature outside construction, which is in itself in a formative state of early theory development (Grob and Benn 2014, Barraket *et al.*, 2016).

To qualify for inclusion in the sample, the contractors had to be completing large scale construction projects and government work, since governments are currently the primary driving force behind social procurement in Australia. It was therefore reasonable to assume that most of the social procurement activity would be occurring on public sector projects. Our approach to sampling our interviewees was purposeful and involved a

discussion with relevant people (usually starting with the Head of Procurement who was sent the interview questions in advance) until the best person could be identified to answer the interview questions. The resultant sample is shown in Table 1.

*Table 1: Sample Details*

| Respondent | Role of Interviewee           | Company Description  | Approximate Turnover (AUD)                    |
|------------|-------------------------------|--|---|
| R1         | General Manager               | Multi-national Real Estate Services, Facilities Management and Project Management business | \$4.6 billion (client spend under management) |
| R2         | Employee Relations Manager    | Multi-national, Australia founded Construction Contractor                                  | \$5 billion                                   |
| R3         | Assistant Development Manager | Multi-national, Australian founded Construction Contractor and Property Developer          | \$600 million                                 |
| R4         | Central Procurement           | Multi-national, United Kingdom founded Construction Contractor                             | \$5.4 billion                                 |
| R5         | Former General Manager        | Multi-national, Australia founded Construction Contractor                                  | \$12 billion                                  |
| R6         | Commercial Manager            | Australian Construction Contractor   | \$2.1 billion                                 |
| R7         | National Supply Chain Manager | Australian Property Development and Building Management                                    | \$2.8 billion                                 |
| R8         | New Business Manager          | Australian Construction Contractor   | \$513 million                                 |

The interviews lasted approximately one hour and were conducted in the respondent's workplace. Open-ended questions were designed to collect narrative responses around: motivations for using social procurement (commercial, reputational, client, economic/competitive advantage, social, environmental); and barriers to social procurement (industry attitudes, cultures, large work packages, existing subcontractor relationships, resistance to change, competitiveness, social benefit organisational constraints etc.). The interviews were recorded and transcribed and the qualitative data analysed following Reissman's (2008) approach to narrative analysis which involved us analysing the thematic, structural and dialogic aspects of our interview data. The thematic analysis involved keeping the respondent stories intact and emphasising the words, phrases and themes used in the narrative over its structure, content and form. The structural analysis looked into the ways in which these narratives were structured, categorizing aspects of the respondent accounts guided by the research cited above which identified a range of motivations, cost and benefits associated with volunteering for each stakeholder group. In effect, these costs and benefits became our initial coding strategy. Dialogic analysis focused on 'performed' accounts and asking questions around power structures, role, relationships and responsibilities between actors in the social procurement process, an issue identified by Petersen and Kadefors (2016) and Barraket *et*

*al.*, (2016) as needing further investigation. True to the tradition of narrative analysis our results are also presented as a narrative because we wanted the results to retain the full richness of insight contained in the qualitative data we collected. Since, it is not possible to recount everything participants said in this paper. Instead we present the main themes emerging from the data using typical quotes and numerical analysis of themes in the data to illustrate these themes.

## **RESULTS AND DISCUSSION**

### **Drivers of social procurement**

Our results indicate that market factors are the main driver of social procurement in construction - perhaps not surprising given the legislative imperatives, such as the Federal Indigenous Procurement Policy (2015), which are creating significant social procurement markets in Australia at the moment (particularly for Indigenous cohorts).

The things that motivate us are business related. If we want to win a job, and a social objective is a requirement of that then we'll do it. For us and probably a lot of other builders, it's less about being a good social citizen and more about how we support our growth, business and our bottom line. It sounds selfish, but it's the reality of our business. The indigenous example is in part us wanting to be good social citizens but also about preparing our business for government work as part of our business plan.

Private clients barely featured in the interviews with contractors, although the two major property developers had other internal drivers revolving around general corporate social responsibility strategies which were more reflective of the 'investment mind-set' identified by Barraket and Weissman (2009). The results suggest that vertically integrated businesses which involve designing, constructing and operating facilities provide different motivations to engage with social procurement compared to contractors since such organisations remain in communities after the project is constructed which provides shared-value incentives to give back to the communities in which they were building. These do not exist in the temporary project-based nature of construction contracting businesses.

This is my personal belief and understanding, but [we] are motivated to doing good for the community first and foremost. We do acknowledge that we are proud of the good work that we do. That might set us apart from our competitors and this may produce commercial benefits down the track for us as a brand.

While there are clearly different drivers for contractors and developers, the majority of responses were fairly shallow, pragmatic and ultimately regulation and market-driven - certainly far more pragmatic than those revealed by Peterson and Kadefors (2016) in the Swedish construction industry.

Apart from one respondent, there was no consideration of the broader political and public governance trends which are driving social procurement which were discussed earlier in this paper and of the broader role of construction in building a stronger society and addressing disadvantage.

### **Barriers to social procurement in construction**

There are a number of different ways in which our respondents engaged with social procurement and the barriers were different in each case. For example, in directly purchasing social services from a non-profit organisation, the results support previous research by Loosemore and Higgon (2015) which found that there are clear costs and risks for construction firms of working with the social sector.

We did engage kids in an apprenticeship scheme through [charity name]. But to be honest I would say that was more of a hindrance to us than a benefit. They required a lot of supervision. They weren't able to work autonomously; you really had to watch them to make sure they did the right thing. I don't think they wanted to be there, probably more because someone had told them to be there. So yeah whilst that was us getting a perceived benefit through a social means it was really us providing work experience for those kids, more so than us receiving a benefit from their work.

These results also resonate with Barraket *et al.*'s (2016) observations around the challenges involved with the merging of different institutional logics in social procurement. This is also a challenge which Petersen and Kadefors (2016) also highlight in their preliminary research into construction social procurement in Sweden - arguing that this will result in new institutional configurations which are not yet understood. Other challenges highlighted in adopting this social procurement strategy included scepticism of working with social benefit organisations because they had "difficulty reporting and measuring" their social impact. This is important and supports Burkett's (2010: 48) assertion that "it is the management of the contract once it is awarded, and in particular how it is monitored and evaluated that defines whether or not social procurement is worth all the effort".

The use of social clauses in construction contracts to require existing supply chain incumbents to provide social value (such as training and employment opportunities to disadvantaged cohorts) was another common social procurement strategy employed by our respondents.

The fundamental thing to do, at the end of the day, is to insert it (social procurement) into the contracts. So we inserted social clauses into our subcontracts, which hadn't been done before....The single most important thing to do is embed it in contracts [...] then have people within the organisation who understand [the requirements] and support that discussion.

These results are consistent with the findings of Bonwick and Daniels (2014) who identified that most social procurement in Australia is being achieved through the use of contract clauses. However, it should also be noted that previous research has raised concerns about the capacity of existing construction supply chain partners to deliver on the social clause requirements - particularly as many only work on projects for short periods of time which prevent them providing sustainable training and employment opportunities for the social groups targeted by social clauses (Loosemore and Higgon 2015). Furthermore, research shows that as well as having well designed social clauses, it is critical to have people who understand and can communicate what social outcomes are required, why it is needed and how it will be monitored and enforced (Blee and Pidgeon 2014, Halloran 2016). This combination of contractual and interpersonal strategies is likely to be important in avoiding the compliance-based mentality which our research suggests is driving social procurement in construction at the moment.

In a third approach to social procurement, all respondents had directly procured construction products and services from social benefit organisations (mostly Indigenous businesses; charities and social enterprises). However, this did not always translate into meaningful collaboration and as a number of respondents note, there is often a challenge in integrating these organisations into the supply chain, rather than relying on them for tokenistic purchases only:

You can partner with social enterprises but it's hard to do during construction. It is much easier in a retail space, so for example towards the back end of the project we had retail pop-ups. Social enterprises and charities are at the back end and not during construction.

While Loosemore (2016a) identified a wide range of internal and external barriers which prevent integration into the construction supply chain, the most cited in our responses was the regulatory nature of the industry and the difficulties which these organisations have in securing the necessary licences and certifications to even prequalify to tender on construction projects. A number of respondents also talked about a lack of supply of credible organisations which were capable of undertaking meaningful construction work.

I would have very limited input on that to be honest. It's really not a big thing in our industry and I think it speaks to the high barriers for entry that we require such as insurances, resourcing, skills and experience, balance sheets. There are a lot of things that, when we are engaging a subcontractor we take into consideration.

As R5 noted, working effectively with social benefit organisations requires “a different way of thinking” and capacity-building initiatives which can help such organisations overcome the barriers identified above.

[When engaging with a social enterprise] the organisation has got to be prepared to mentor that social enterprise and bring them along the journey. You need to partner, it's not a set and forget thing.

The final type of social procurement strategy employed by our respondents was responsible sourcing from accredited social businesses (that is commercial for-profit businesses driven by social goals which make distribute profits to shareholders rather than the community). However, our results indicate that one of the main problems for companies employing this strategy was the lack of standards and certifications which can be used to reliably vet an organisation as socially responsible or not. A number of respondents discussed ISO Standards and various international indices such as Global Reporting Initiative (GRI) and Dow Jones Sustainability Index. However, they felt they were more about building quality and environment rather than achieving social requirements and that they were too onerous for the small businesses in their supply chain. In all, the results reflect the findings of Upstill-Goddard *et al.*, (2012) who show that the construction industry is yet to develop rigorous governance and certification frameworks to enable firms to fully engage with the idea of responsible sourcing.

## CONCLUSIONS

The aim of this paper was to explore the motivations driving social procurement in construction and the barriers preventing its implementation. Through semi-structured interviews with relevant people with responsibility for social procurement in eight major Australian contracting, property management and development organisations it has been found that social procurement is primarily market-driven and that these companies employ a range of strategies which are accompanied by unique barriers to implementation. This suggests that the quasi markets created for social value through legislation like the UK's Social Value (public Services) Act 2012 and the Indigenous Procurement Policy (2015) in Australia are crucial to the establishment of social procurement as a permanent practice in the construction industry. There appears to be little understanding of broader political trends driving this new variant of traditional procurement or of the important role that construction plays in addressing social disadvantage and inequity in the broader community. This suggests that firms are operating in an intellectual and contextual vacuum, doing what they are told but not really understanding why they are doing it. Every organisation in our sample had engaged a social benefit organisation at some time, and here the main challenges revolved around identifying appropriate and reliable organisations of sufficient scale to work on large construction projects. Social benefit organisations are widely seen as a risk and best

confined to low risk, low skilled, non-critical and off-site activities. The barriers facing these organisations in penetrating the industry are clearly significant and for contractors challenges remain in working across the differing institutional logics of the construction and social benefit sectors. In using social clauses to require existing supply chain incumbents to deliver social value the barriers largely revolve around the capacity of industry incumbents to do so and the absence of people who understand these requirements and the resources and expertise to monitor their implementation in practice. Finally, the barriers to responsible sourcing as a final common social procurement strategy mainly relate to the lack of certification and responsible sourcing frameworks which allow socially responsible businesses to be reliably identified. This makes any soft instruments such as codes of supply chain practice largely toothless and ineffective at the moment.

Further research is needed into the development of new supply chain capacity to deliver social value and into strategies to resolve tensions from the conflicting objectives and institutional logics which arise from the new cross-sector collaborations which social procurement brings to construction.

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# ASSESSING THE IMPACT OF AUSTRALIA'S INDIGENOUS PROCUREMENT POLICY USING STRAIN THEORY

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This paper argues that current methods of social impact assessment fail to adequately articulate the social impact of Indigenous procurement policies, presenting an overly optimistic and westernised view of success which does not align with Indigenous perspectives of social value. Using strain theory as a theoretical base, we show how social procurement policies aimed at helping Indigenous people can inadvertently create negative social outcomes and even disempower the very groups they are designed to help. It is concluded that this new conceptual perspective holds significant potential value to advance both research and policy in the important area of Indigenous social procurement, enabling the refinement of Indigenous procurement policies and social impact measurement methods which are more able to represent Indigenous cultures and interests.

Keywords: Australia, Indigenous, social procurement, social value, strain theory

## INTRODUCTION

Australia's Indigenous peoples have been marginalised in all aspects of modern Australian society since British colonisation in the 18th century (Kapuscinski 2013). The Australian government's most recent 'Closing the Gap' report into Indigenous disadvantage highlighted significant and persistent gaps in life expectancy, child mortality and incarceration rates (Department of the Prime Minister and Cabinet 2017). The negative effects of colonisation have meant that Indigenous people have been subjected to discrimination, a loss of culture, paternal protectionism and occasional violence in an uneasy relationship with the Australian state (Cooke *et al.*, 2007). Short (2016) argues that the effects of colonisation, namely the dispossession of Indigenous people from their traditional land, is increasingly being acknowledged as the root cause of today's systemic and considerable Indigenous disadvantage.

With previous strategies to address Indigenous disadvantage widely regarded as failures (Kapuscinski 2013) the government is turning to new social procurement policies such as the Commonwealth Indigenous Procurement Policy (CIPP) (Australian Government 2015) to require companies tendering on its projects to provide new commercial opportunities for Indigenous business and new employment opportunities for Indigenous people. The success of the CIPP is measured using two key performance indicators (Australian Government 2015: 8): an increase in the number of Indigenous enterprises contracted to the Commonwealth Government; and an increase in the number and value

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of contracts awarded to Indigenous enterprises. Social procurement is an increasingly popular policy lever for government to strategically use procurement activities to create social value (Barraket *et al.*, 2016), although Loosemore and Denny-Smith (2016) found that Indigenous construction businesses in Australia experience numerous barriers to entry into the construction industry, many as a direct result of traditional government procurement processes which have been designed for non-Indigenous firms.

Social Enterprise UK (2012: 11) define social value as “the additional benefit to the community from a commissioning/procurement process over and above the direct purchasing of goods, services and outcomes”. This social value can take many forms such as improved income, health and well-being and reduced crime, substance abuse and incarceration, which social impact practitioners controversially attempt to measure, quantify and monetise using a variety of techniques such as social return on investment (SROI) (Arvidson *et al.*, 2013, Maier *et al.*, 2015). However, these definitions and techniques for measuring social value reflect a western value paradigm which ironically, often does not align with the values of Indigenous and minority groups which social procurement seeks to help (Wagland and Taylor 2015). This irony has been largely ignored in the social procurement literature, ensuring that, to many Indigenous and disadvantaged groups, social procurement policies are seen as just another reflection of inequality, a lack of voice for disadvantage groups, suppression, and, in the case of Indigenous peoples, the perpetual imposition of colonial values. To avoid this problem, the aim of this paper is to present a theoretical critique of social value measurements in order to create a new conceptual model for analysing the success of this important social procurement policy from the perspective of the Indigenous people it is meant to help. This is important in the advancement of research and policy in the area of Indigenous disadvantage, not only in Australia but in other countries with significant disadvantaged Indigenous populations such as New Zealand, South Africa, Canada and South America.

### **INDIGENOUS SOCIAL PROCUREMENT**

Social procurement involves the purchasing of goods and services from social benefit suppliers, which are organisations and businesses whose main mission is the achievement of a social purpose, or are owned by groups or people who are considered disadvantaged (Victorian Government 2010). In doing so, client's use their purchasing power to buy goods and services as well as social impact or social value (Barraket and Weissman 2009, Bonwick and Daniels 2014). Within the social procurement literature Indigenous businesses are identified as social benefit suppliers (Burkett 2014, Victorian Government 2010) and the targeted process of purchasing from Indigenous businesses is commonly referred to as Indigenous social procurement.

Australia's CIPP includes a commitment to award three per cent of all domestic Commonwealth Government contracts (including for building, infrastructure and maintenance works) to Indigenous enterprises each year by 2019-20 (Australian Government 2015: 13). The intended outcomes of the CIPP as stated by the Australian Government (2015) mirror Porter and Kramer's (2011) concept of shared value, where businesses and governments create mutually beneficial value for the stakeholders affected. For government, the intended benefit of this policy is increased Indigenous employment and the economic development of Indigenous business which encourages broader social, cultural and economic benefits to Australian society (Australian Government 2015). In particular, it is argued that a strengthened Indigenous business sector will drive financial independence and create wealth and opportunities for Indigenous Australians (Australian Government 2015). According to Gray *et al.*, (2014)

the value gained to the government is broadly economic in the form of increased tax receipts from more Indigenous people engaging in the workforce, more Indigenous businesses gaining work and reduced spending on welfare, labour market, criminal justice and health programs. The value gained for increased employment of Indigenous Australians is achieved through training, financial independence, improved mental and physical health, higher rates of home ownership and lower rates of arrest and incarceration (Gray *et al.*, 2014). However, despite claiming to benefit Indigenous businesses and people, government-business partnerships like the CIPP have also been criticised for pursuing a purely economic logic that ignores other forms of social value-creation and for ignoring tensions they may inadvertently create between social and economic goals (Beschoner 2014, Crane *et al.*, 2014). For example, Mah (2014) asserts that Indigenous social procurement may cause more harm than good, as Indigenous firms become complacent and overly-dependant on government contracts to the detriment of building resilience by scaling their business activities into other areas. However, as yet there has been no empirical examination of the CIPP and there is no theoretical framework to enable researchers to explore claims that policies like the CIPP are misaligned with the interests of intended beneficiaries and whether these misalignments are hidden from view by existing approaches to measuring social impact. As Parkins and Mitchell (2016) point out, social impact measurement is currently plagued by a lack of theoretical and conceptual guidance.

## **CURRENT APPROACHES TO MEASURING SOCIAL IMPACT**

Haski-Leventhal and Mehra (2016) found that there is no widely accepted methodology for measuring social value. Vik's (2016) literature review found that the most dominant approach to measuring social value by both governments and organisations is SROI. SROI is an approach which seeks to attach a monetary value to social, economic and environmental impacts, ultimately producing a single ratio which reflects the relative costs and benefits of a social program, policy or intervention (Nicholls *et al.*, 2012). Bridgeman *et al.*, (2016) used SROI to demonstrate the commercial, social and economic impacts of the Construction Youth Trust's Budding Brunels program in construction and argue that the flexibility of this approach allows it to be applied to different situations. However, critics of SROI such as Tuan (2008), Arvidson *et al.*, (2013) and Maier *et al.*, (2015) raise a number of concerns with this approach to measuring social value which are relevant to an Indigenous context.

The concerns expressed by Arvidson *et al.*, (2013) centre on the short-term nature of a SROI assessment, challenges in valuing items that are intrinsic or intangible, failure to capture the social value of personal utility, and the monetisation of outcomes. Maier *et al* (2015) and Gibbon and Dey (2011) raise numerous concerns about SROI which include: the over-simplicity of producing a single figure SROI ratio which cannot be compared across different programs; the subjective nature of valuing different impacts; the high costs and resource needs of analysis which significantly determine the outcome; the lack of reliable impact data and standardised methods for collecting it; the utilitarian notion of SROI that the correct action is the one that maximises utility but does not consider motives or compassion behind any action; and the application of coefficients to compare different organisations with different starting points, which raises ethical questions over who sets the coefficient and by what means.

The last two criticisms of Maier *et al.*, (2015) are especially relevant in an Indigenous context since they recognise the inherent power imbalances attributed by society to different groups and how these can be translated into measures of social value. As

Mulgan (2010) notes, social value is a subjective term which means different things to different stakeholders. This means that the results of an SROI assessment may not mean the same thing, in terms of social value, to Indigenous people. Dey and Gibbon (2017) have called for impact reporting that uses less ambitious and more meaningful and reliable data and metrics. As Clifford *et al.*, (2014) argue, financial proxies and indicators, like those used in the CIPP, should only be used if they add value to the key stakeholders' viewpoint. Altman (2004) argues that economic development for remote Indigenous communities cannot be understood unless we recognise the relative importance of traditional cultural activities. Wagland and Taylor (2015) contend that the approach of Indigenous culture to money challenges mainstream Australian societal norms. For example, where mainstream Australian figures may see a value of more money spent on Indigenous enterprise as worthwhile if it creates employment (the primary intended outcome and success criteria of the CIPP), Indigenous groups may view this as a negative outcome if they are required to leave traditional lands and communities to get a job. Furthermore, Price *et al.*, (2012) found that, although in recent times there has been much insight generated with regard to carrying out research among Aboriginal groups, there is still a lack of evaluation methodologies that are relevant to Indigenous Australians.

While many criticisms have been levelled at SROI, other common approaches to measuring social impact can also be criticised from an Indigenous perspective. Muir and Bennett (2014: 33) provide an overview of some contemporary approaches to impact measurement from the perspective of organisations undertaking initiatives to create social change. For example, Muir and Bennett's work describes: Results Based Accounting (RBA) which tracks an organisation's performance at macro and micro levels by developing and integrating outcomes throughout a program rather than as-hoc surveys for evaluations; Integrated Reporting (IR) which demonstrates the linkages between an organisation's strategy, governance and financial performance and the social, environmental and economic context in which it operates with an emphasis on program outcomes; Social Accounting and Audit (SAA) which emphasises accountability by establishing a framework for ongoing monitoring, evaluation and accountability to internal and external stakeholders. However these approaches are designed to help organisations integrate performance and accountability into their business strategy, and while stakeholders are mentioned in these methods it is not clear if they involve a combined assessment of beneficiaries and program proponents. Loosemore and Higgon (2015) contribute to this discussion, providing a summary of various tools and techniques that can be used to measure social value, the most common of which include: Cost-benefit Analysis (CBA); Cost-effective Analysis (CEA); Social Impact Assessment (SIA); Social Accounting and Auditing (SAA); Social Return on Investment (SROI); shared value; Value Chain Analysis (VCA); and Benefits Realisation Management (BRM).

While the above common approaches are appraised to a degree, they are also not without their own criticisms. As a traditional economic tool CBA provides a ratio of benefits accrued against costs incurred. However, the difficulties associated with placing a monetary value on intangible items and calculating impacts that occur over a long period of time are the main criticisms of this method (Mulgan 2010). While SAA encompasses a whole-of-organisation approach improve monitoring and reporting systems to account for social impact, this method is also critiqued for quantifying intangible items and being internally focused due to its auditing aspect (Loosemore and Higgon 2015). BER evaluates impact compared to available resources and reports on performance by judging

units to other peer units. Unfortunately, such an approach would not account for the diversity of Indigenous Australia discussed by Altman (2004), making cross-comparisons difficult or impossible. While Loosemore and Higgon (2015) promote CEA as an alternative analysis to compare relative costs of two or more initiatives, the nature of its title implies the evaluation of how costs are being used. Further, Kahn *et al.*, (2002) note that CEA shows if a program is cost-saving or cost-effective, and question why a program should show cost-effectiveness just to show it is worthwhile or needed. VCA identifies weak points in an organisation's supply chain and allows managers to eliminate or reform them (Loosemore and Higgon 2015) but is not clear on how this is able to demonstrate social impact of a program like the CIPP as it is conducted by managers of an organisation seeking to report on the social value they are creating without input from the beneficiaries of their organisation's activities. BRM is potentially useful as it measures the benefits of an activity to stakeholders using measures defined as important by them but would require a modified approach as the current benefits proposed by the CIPP are different to values demonstrated by Indigenous Australians. SIA guidelines have been criticised for being too generalised and lacking in meaningful development since first being developed in the 1990's (Wong 2014), indicating SIA may not capture data on a beneficiary population if not designed correctly.

In summary, the majority of current approaches to impact measurement favour the value of input costs and outputs because of the considerable complexity of measuring social value based on impacts and outcomes (Barraket and Weissman 2009). Within an Indigenous Australian context, existing program frameworks used to evaluate various Indigenous programs are mainly criticised for: being too generalised across various and different communities and contexts; being conducted by outsiders who attempt to engage on a short, one-off basis and arrive with a pre-determined agenda to extract specific data without prior consultation; and occurring without seeing any change or improvement causing evaluations to be perceived as coming from outside the community's interest and control and based instead on an external agenda such as seeking to know that project funds have been well spent (Price *et al.*, 2012). Further, focusing on output data, such as those used by the CIPP in its KPIs, avoids the engagement of local communities and subsequent identification of new issues considered critical by the community (Price *et al.*, 2012). There is thus a need for a new method that considers an Indigenous Australian viewpoint to measure impact data that is both relevant and appropriate.

## **APPLYING STRAIN THEORY TO MEASURING INDIGENOUS SOCIAL VALUE**

The above review shows that current approaches to social impact fail to consider Indigenous perspectives on what constitutes social value. It also identifies a need to adapt existing measurement frameworks to take account of Indigenous people's perceptions of social value and the potential unintended, and as yet un-researched negative impacts which Indigenous social procurement policies might cause. To this end, theories of value are useful since they may explain why people make trade-offs that are required to engage in employment, which is the primary goal of the CIPP.

Theories of value can be traced back to the early work of Schumpeter (1908), who proposed that society, as a collective community, determines value and not individuals. Thus, Indigenous social values may be represented by the values and goals of the wider Indigenous community. Roos' (1973) work took a similar approach to explore societal goals, arguing that societies are similar to organisations and that, just as an organisation's

goals are driven by the designs of its owners, so too are the goals of a society driven by those in power within that society (Roos 1973).

A number of works within the Indigenous literature provide variables which may be included in a refined, more culturally relevant impact measurement framework. For example, Short (2016) notes Indigenous Australians' spiritual attachment to the land. Furthermore, the Secretariat of National Aboriginal and Islander Child Care (SNAICC 2017) notes: the importance of family; the land and spirituality; social structure; social relationships; and Aboriginal autonomy. Hampton and Toombs (2013) link Indigenous identity to cultural and social identity, where Indigenous identity is closely linked with the geographic area (Indigenous 'country') on which it emerged. Williams (2007) categorises three core Indigenous values of autonomy, collectivism and spirituality supplemented by subsidiary values that work in unison to reinforce their meaning and importance.

While conceptually useful for identifying criteria that can be incorporated into social impact measurement frameworks to better reflect how Indigenous societies collectively perceive social value, good practice social value measurement also requires the consideration of negative impacts and counterfactuals such as displacement (opportunity costs for those involved) and 'substitution' (losses for others who might have missed out) (Nicholls *et al.*, 2012). To this end, Merton's (1957) strain theory is potentially useful as a complementary framework to social value theory. Based in sociology and criminology, and used to conceptualise and explain deviant behaviour, strain theory argues that when society puts pressure on individuals to achieve socially acceptable goals who do not have the means to achieve them, a social 'strain' is created which leads individuals to pursue illegitimate means to achieving these goals. While this theory has mainly been applied in criminology to explain illegal behaviour, it is also a potentially useful and innovative paradigm to explain the potentially unintended negative impacts associated with the CIPP. For example, in imposing western social pressures on Indigenous people to conform with mainstream Australian society's expectations to get a job and integrate into 'normal' society, strain theory suggests that the CIPP could inadvertently create a strain in Indigenous people which could negatively impact on their society at both an individual and community level. For example, to get a job an Indigenous person may have to move away from the land and communities which the Indigenous literature indicates they value highly.

Merton's (1957) strain theory argues that society and culture have culturally acceptable goals (such as getting a job and economic wealth) to achieve through institutionalised means (such as a university degree or formal employment, or formal policies like the CIPP). Institutions are formal and informal rules and procedures which govern social behaviour, and formal institutions like the CIPP are disseminated and enforced through official channels like regulations and law (Helmke and Levitsky 2004). According to strain theory (Figure 1), individuals conform when they accept society's goals and the socially approved means of achieving them. For example, a person who accepts that their culture expects them to work and accepts the institutional opportunities available through the CIPP would display conforming tendencies according to strain theory. Innovation is the result of accepting societal goals and a lack of opportunities to reach them, leading individuals to use unconventional means to attain approved goals. An individual who accepts society's expectations to get a job but rejects that the CIPP provides the required institutional opportunities to do so may then innovate and create their own way towards achieving society's goals. Where societal goals are rejected but institutional means are accepted ritualism occurs and individuals work towards less lofty goals through

acceptable means. In this instance someone would reject society's goals but accept that the CIPP is the only viable institutional opportunity available and be an unwilling participant (they may show up for the sake of showing up). If both social goals and institutional means are rejected individuals retreat and may choose to cut themselves off from the world. For example, someone who rejects social expectations to work and rejects the CIPP as an opportunity to do so would remove themselves from their situation and avoid any avenues completely.

While strain theory has been criticised for assumptions that goals are universal to a society or culture (Farnworth and Leiber 1989), its value is in showing that positive social value is created when both cultural values and goals are attained through acceptable institutional means, and that the rejection of these two avenues results in negative social value. It also indicates that cultural values of Indigenous Australians must be refined through consultation and collaboration to be relevant and avoid generalisation of findings. Institutional factors to consider may include difficulties in accessing employment due to geographical location and capacity to take up employment (Altman 2004), and barriers to employment (Loosemore and Denny-Smith 2016).

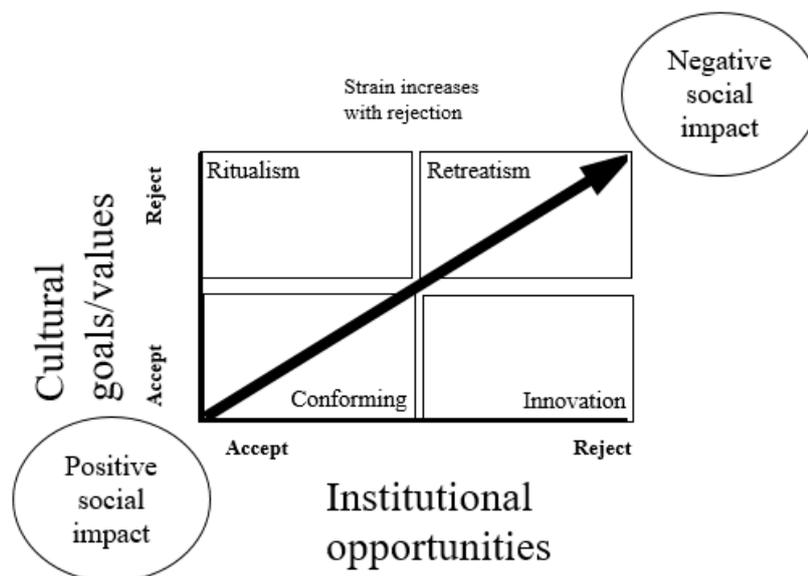


Figure 1: Adaptation of strain theory (Merton 1957) to explain the social impact of Indigenous social procurement

When combined with values theory, strain theory is able to inform a new conceptual approach to measuring social value from an Indigenous perspective, taking into account both the cultural relativity and the potential negative impacts of the CIPP in practice. When compared with existing social impact measurement tools such as SROI, such an approach will reveal the limitations of existing 'economic' approaches, and through a grounded theory approach (Glaser and Strauss 2009), enable us to refine the framework further to include variables which are perhaps not included in current values and strain theory literature.

## CONCLUSIONS

The aim of this paper was to present a theoretical critique of social impact measurements in order to create a new conceptual model for analysing the success of the CIPP from the perspective of the Indigenous people it is meant to help. It has been shown that the CIPP's current approach to determining the success of the policy is reliant on financial

information which may not be compatible with Indigenous worldviews and values. A critical review of the literature has shown that current approaches to social value are financial in nature, and are likely to be largely meaningless to the Indigenous community it seeks to empower.

This paper has shown that a combination of values and strain theory represents a promising conceptual foundation to address this problem. A new approach to social value measurement from an Indigenous perspective informed by these theories has the potential to holistically capture Indigenous views of what is perceived to be of social value and produce information on the success of the CIPP in a way that is relevant and relatable to the Indigenous community it is meant to help.

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# FRINGE BENEFITS? PLANNING, BUILDING AND THE DEVELOPMENT OF COMMUNITY IN A NEO-LIBERAL LANDSCAPE

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Melbourne has the largest population growth of all Australian capital cities, with significant growth in its outer suburbs. A key goal of Victorian planning policy is to establish economically strong communities that are socially cohesive. A deregulated planning system and a loosening of planning controls that allow private actors to play key roles in development decision-making complicates this task. A further layer of complexity is added when urban growth encroaches on existing hazardous buried infrastructure, such as high-pressure natural gas transmission pipelines that are a risk to public safety if they are damaged. This paper considers the efficacy of Precinct Structure Plans to support Melbourne's strategic planning goals and also manage public safety risks from gas transmission pipelines. To address these issues, 21 interviews were conducted with pipeline company representatives, housing estate developers, and state and local government planners. The paper also examines key planning policy and argues that planning policy and associated tools fail to sufficiently address the impact of a deregulated neo-liberal approach to planning in relation to development in Melbourne's Growth Areas. This has the potential not only to lead to policy and governance failure, and thus inadvertently increase risk to public safety, but also to contradict the fundamental goal of planning.

Keywords: neoliberalism, high-pressure gas pipelines, land use, planning policy, risk

## INTRODUCTION

Melbourne has seen the largest population growth of all Australian capital cities, with significant occurring in its outer suburbs (Lowe *et al.*, 2013). To support this growth, Urban Growth Zones (UGZ), land previously designated as Green Wedge Zones (GWZ) with limited urban development, has been identified. In some cases, these include areas where buried high-pressure gas transmission pipelines were already present. For the pipeline sector, increased urban development in these areas also means increased risk of a strike leading to a pipeline rupture with implications for public safety. The consequences of a pipeline rupture were illustrated in 2010 when a pipeline in San Bruno, California failed due to a technical fault, killing eight members of the public and devastating the suburb (Davidson *et al.*, 2012). Although a technical fault was responsible for that rupture, pipeline sector research has shown that excavation work from non-pipeline sector groups is the most substantial cause of external pipeline damage (Ramirez-Camacho *et al.*, 2017). Although also concerned with public welfare, planners' perception of risk to

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urban growth is focused on providing access to services and housing to support socially cohesive, environmentally efficient, and economically viable communities over the long term.

To support increasing population growth Melbourne's strategic planning framework, Plan Melbourne<sup>2</sup>, includes policies governing urban planning and infrastructure development in UGZ, including for gas transmission pipelines (DPTLI 2014). The gas pipeline sector is also governed by policy and technical documents that include measures to address risks from population growth near potentially hazardous pipelines. However, the operationalization and interactions of these policies across the planning and pipelines sectors is complex, as their stated objectives do not always align. Added to that, neo-liberal paradigms have permeated urban development and governance discourses, including in Victoria's planning scheme (Freestone 2007).

The paper starts with a brief outline of neo-liberal reform and Victorian planning and the implications of that for managing public safety risk in development near transmission pipelines. It then describes the methodology used in the research and how the assessment was conducted. It continues with a comparison of the risk governance mechanisms for urban development and pipelines as articulated in current planning and pipeline legislation. The paper then discusses Victorian planning policy with a specific focus on the role of Precinct Structure Plans (PSPs) to manage the risk to public safety from increasing urban development in areas with high-pressure gas transmission pipelines. The paper concludes that, in this case, a market-driven planning framework in which planning roles are increasingly decentralized has the potential to create a public safety risk.

### **Metropolitan Planning Strategy**

Over the course of the twentieth century, planning in Victoria evolved out of a need for government to provide amenity and services to communities because of haphazard development led by private enterprise. Over subsequent decades, planning came to be dominated by ideas of social democracy (Steele 2009). However, in the mid-1970s an economic rationalist agenda began to permeate government and planning discourse. This saw a greater reliance on market-based decisions (Gleeson and Low 2007, Huxley 2000, Sandercock 1998). In the 1980s, planning decisions became dominated by neo-liberal principles of economic efficiency, deregulation, and outsourcing. As a result, urban planning has become oriented towards short or medium-term planning decisions focused on market-oriented outcomes (Healy and Williams 1993).

One outcome of a market-driven focus for contemporary planning is the emergence of a third space or 'hybrid' governance context in which public, private, and community interests compete for attention (Steele 2009). This has created a context where private sector actors, such as developers assume functions of the 'state', rather than government, and make significant decisions about the type of development that occurs. Rather than the sole responsibility of government, a new process of governing (Rhodes 1996: 652) has emerged that is influenced and directed by the interests and objectives of multiple private and public stakeholders. Another consequence of neo-liberal, deregulated planning has been the decentralization of the planning role as planners work more in the private sector and less in the public sector (Steele 2009). This decentralization means that

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<sup>2</sup> Plan Melbourne has been updated to Plan Melbourne 2017-2050. However, at the time the research reported here was conducted, Plan Melbourne was the current strategic planning document.

planners are pulled in often contradictory directions and concerned largely with directly facilitating development through rapprochement with the private sector (Freestone 2007: 86).

The risk to communities and the challenges for planners in a neo-liberal planning system characterized by economic efficiency, deregulation, and outsourcing have been well canvassed in the planning literature (e.g. Firman and Fahmi 2017, Sager 2011, Savini 2017, Waterhout *et al.*, 2013). Australian planning research has identified a range of risks to the community that emerge from a planning system influenced by neo-liberal discourses. For example, Randolph and Tice (2017) argue that metropolitan planning strategies must understand the risk of rising inequality from neo-liberal policies and reliance on the market to deliver housing (see also Kadi and Musterd 2015). As well as this social risk, the literature also considers planning policy and public safety risks from bushfires or other natural disasters. For example, Llausàs *et al.*, (2016) considered Australian planning policy on Victoria's peri-urban areas and found that a market-led planning system and short-term development considerations failed to provide any long-term strategic vision or to address social, ecological or landscape impacts. The planning literature also considers risk in relation to urban infrastructure in Australia (e.g. see Bolleter 2017). Buxton and Chandu (2016) considered urban growth near Melbourne's Tullamarine airport and argued that a planning system 'co-opted' by influential social actors and a lack of integrated planning policy across all levels of government resulted in poor outcomes.

There is currently little research regarding planning policy and risk to public safety from urban development near potentially hazardous buried infrastructure. This paper considers the impact of neo-liberal planning frameworks and public safety risks from development on Melbourne's fringe that encroaches on existing hazardous buried infrastructure, namely high-pressure gas transmission pipelines.

## **METHOD**

The data presented here is drawn from a project exploring risk management in planning policy and the risk awareness of urban planners in relation to gas transmission pipelines in Melbourne's GWZs (see also Hayes *et al.*, 2015). This paper reports data from 21 interviews with pipeline sector representatives, planners (strategic and statutory, private sector, local and state government), housing estate developers, development consultants, and the pipeline technical regulator. Semi-structured interview questions were framed around the interactions between planners, developers and pipeline companies and probed participants' awareness of the risks associated with development near transmission pipelines and the strategies they used to identify and manage potential risks.

The research used a case study design with purposively selected urban growth areas where pipelines are present to illustrate the complexity of the planning process in relation to land use, pipelines, and risk. Importantly, although case study findings may not be generalizable across contexts, they nevertheless provide opportunities to draw from 'the power of example' (Flyvbjerg 2001, Timmermans and Tavory 2012), in this case to examine risk management in planning policy in relation to gas transmission pipelines. Specifically, using urban growth on Melbourne's fringe as a case study revealed how top-down governance frameworks affect the way that planners not only perceive, but also manage, risks in relation to urban development and transmission pipelines. The work received university ethics approval and all interviews were recorded, and later transcribed and coded for analysis. Open coding was completed independently by each researcher under the broad umbrella of the ways that the different groups perceived and experienced

risk in relation to planning and transmission pipelines, which were comparatively examined across the groups. This fine-grained analysis enabled the researchers to systematically tease out what emerged as a broader pattern of risk governance and specifically the way that Precinct Structure Plans, situated within a deregulated planning process, addressed risk in the context of urban planning near transmission pipelines.

## RESULTS AND DISCUSSION

### The Planning Sector: Governance and Risk

In Victoria, and in conjunction with Plan Melbourne, the primary planning legislation is the *Planning and Environment Act* (PEA). The strategic goals of these documents include providing housing and services to support socially cohesive, environmentally sustainable, and economically viable communities (Buxton *et al.*, 2016). A key part of Plan Melbourne is the densification of development in UGZ, located in four Growth Corridors (GCs), and guided by Growth Corridor Plans (GCP) that provide macro-level development details. Precinct Structure Plans (PSPs) determine the density of development and must consider amenity and infrastructure identified in the GCPs, as informed by urban design principles (GAA 2012, 2013; Hirsch *et al.*, 2016). The responsibility for PSP development rests with the Metropolitan Planning Authority (MPA)<sup>3</sup>, an independent statutory body with a broad, facilitative role to work with councils, other government agencies, and the planning and development sectors (MPA 2015-16). A PSP must be undertaken prior to any development and, like the GCPs, must reflect the objectives of the PEA and Plan Melbourne including a focus on the economic and social welfare of communities. The design of the PSP determines the use of the UGZ, namely defining land uses and imposing conditions, thresholds, and restrictions depending on the nature of the use. Zones are used to mitigate any risks to ‘sensitive use,’ understood in planning to include residential use, childcare centres, pre-schools and schools, from incompatible use (e.g. keeping industrial use and away from schools).

The PEA and the Victorian Planning Scheme recognizes pipeline risks, including in terms of public safety. For example, the Victorian Planning Scheme mandates that planners must ... recognize existing transmission pressure gas pipelines in planning and protect from further encroachment by residential development or other sensitive land uses ... (SPPF Clause 19.03-6). One way that planning legislation mitigates risk of pipeline encroachment is by recognizing easements over the pipe. Easements are registered on the property Title deed and provide pipeline companies with referral rights over the intended use of the land. The size and scale of the easement depends on the type of pipeline, although a typical example would be a 20 metre wide easement. This allows planners to design communities and also to minimize the threat to buried infrastructure; however, the referral right does not apply to an area of risk, defined by the pipeline sector as the measurement length of a pipeline (see below). As a result, for the pipeline sector, these planning tools are limited in their ability to adequately address the high-consequence, low-probability risk to the public of a pipeline rupture.

### The Pipeline Sector: Governance and Risk

The concerns of the pipeline sector are underpinned by an understanding that high-pressure gas transmission pipelines present significant risks to public safety if they are

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<sup>3</sup> In August 2016 the Minister for Planning renamed the MPA the Victorian Planning Authority (VPA) responsible for managing Melbourne’s urban growth including facilitating innovative, integrated land and infrastructure planning (MPA 2015-16, 4).

damaged. In Australia, specific legislation and technical Standards mandate the obligations and responsibilities of pipeline companies for safe pipeline operation, including controlling risk from external pipeline interference. In Victoria it is *The Pipelines Act 2005* (PA) and Pipeline Regulations 2007. However, across the pipeline sector the technical Standard that informs pipeline design, construction and operation is the Australian Standard Pipelines - Gas and liquid petroleum (AS2885) and especially Part 3: Operation and maintenance (AS2885.3) (Standards Australia 2012b). Part of the requirements mandated in AS2885.1-2012 s2 is to identify threats to the pipeline, including from external interference, and to reduce risk to an acceptable level using a safety management study (SMS) (Standards Australia 2012a AS2885.1, s2, p 21). In effect, AS2885 functions as a risk management protocol that, through the SMS process, assesses risk and stipulates the controls that pipeline companies must incorporate into their Pipeline Integrity Management Plan (PIMP).

AS2885 includes a range of physical and procedural measures to prevent pipeline damage but those of relevance in the context of this paper are the concepts of ‘measurement length,’ ‘sensitive use,’ and classification zones. These measures are intended to reduce the risk associated with pipelines in or near populated areas and can trigger additional engineering design and construction requirements if necessary. The measurement length of a pipeline is defined as the radiation contour that would result from a full-bore pipeline rupture (Standards Australia 2012a AS2885.1 s4.3.1, 42). The associated risk profile is a consequence of the land use occurring within the measurement length and classified according to ‘location classes’ with some types of land use defined as ‘sensitive use.’ In contrast to the planning sector, for the pipeline industry, sensitive use relates to situations where certain types of development (e.g. childcare centres, hospitals, schools) create vulnerable groups that are unable to protect themselves from the consequences of a pipeline failure. The industry preference is for sensitive land uses and concentrations of population to be located away from the pipeline, which has implications for housing density around pipelines.

### **The PEA, Governance, and Pipelines: The Realities of Planning on the Fringe**

Over the past two decades neo-liberal paradigms have seen core public planning functions and responsibilities shift from the state to the private sector (Rhodes 1996, Steele 2009). This has seen a decentralization of planning roles, with planners also employed directly by developers and engaged as ‘development consultants’ to guide developers through the complex PSP process (e.g. see Firman and Fahmi 2017, Freestone 2007). Steele (2009) argues that local government planning schemes and the assessment of development proposals are now written and assessed by private sector planning consultants that may also represent and advocate for the interests of private clients. There is evidence of this in the data. For example, one development consultant described their role as working for private clients such as developers as well as government clients such as local and state government.

Further, the new process of governing (Rhodes 1996: 652) that emerges as a result of a neo-liberal agenda and deregulation of planning means that policy objectives can sit uncomfortably against the interests and objectives of multiple private stakeholders (Firman and Fahmi 2017, Freestone 2007, Gleeson and Low 2007, Llausàs *et al.*, 2016). The data reveals that these types of tensions are evident in Victorian planning. For example, although the MPA and local councils are bound by legislation and strategic plans, a diversity of private actors and market mechanisms inform all aspects of community development within Melbourne’s UGZ. The data showed that even though

the MPA is charged with the development of PSPs there is no centrally mandated approach or guideline about who it partners with to accomplish this task. A PSP may be driven by a partnership between the MPA and a local council, between council and a consortium of developers, or a development consultant representing a developer and/or private landholders. One council planner described the process as a bit fluid and the following indicative comments from a developer illustrates these points:

...with the larger developments we actually fund the PSP. So it would cost us about a million dollars to put a PSP together ... Pay for a lot of reports to be done, manage the process and guide, oh, not guide, encourage the MPA to keep things moving, on a reasonable timeframe. There's usually a consortium of developers who contribute to make sure it's pushed through. [Developer]

As the comment cited above shows, developers play a key role in '*encouraging*' government actors, such as the MPA, to keep the process '*moving*.' One potential outcome of the apparent ad hoc nature of the PSP process, and irrespective of the objectives of the PEA and Plan Melbourne, is that design outcomes become aligned with those of the developer, rather than the long-term well-being of that community. Although this approach may represent some short-term efficiency for government, a dominant planning focus on short or medium-term outcomes also raises questions around long-term amenity for communities on the urban fringe (Bolleter 2017, Buxton and Chandu 2016, Llausàs *et al.*, 2016).). This issue becomes more complex when development is planned in areas where high-pressure gas pipelines exist and the safety requirements of the PA and AS2885, such as relocation of community facilities and the types and levels of permissible housing density clash with the objectives of private sector actors within the constraints of urban planning policy.

Plan Melbourne does not include any reference to high-pressure transmission pipelines as either providing an essential community service or as potentially hazardous infrastructure requiring particular risk management strategies in a draft PSP. A statutory council planner comments on the complexity of balancing community needs against pipeline risks in the following way:

...our first preference in terms of the residents there will have the best access to employment, to public transport, to services, which is planning 101. Then how do you manage the risk of being near the pipeline? Well, ideally, if you go completely risk averse, then you just say no one can be in there. But people live there already. Units are developed. There's hospitals and medical centres all in the vicinity. [Stat. Planner]

The PSP is used to design communities to meet the community welfare goals of the PEA and Plan Melbourne, described above as planning *101*. The PSP is also the forum where the objectives of various stakeholders, including design decisions, priorities, and outcomes for the proposed development are voiced. The PSP is a complex process that can take many years, with a draft PSP formally pre-exhibited to government agencies that includes councils and publicly owned utility companies. Problematically, non-government owned utilities, such as transmission pipelines, do not have '*determining referral status*' under clause 66 of the PEA (DPTLI 2014) and tend not be included in this stage. The only trigger for notification of pipeline companies is if a planned development is within a pipeline easement that is registered on the land Title. As one pipeline industry representative noted:

Under that Act [PEA]... [PIPELINE ORG] or all non-government utilities are not referral authorities ... they only really become aware of us at sub-division if we've got an easement. Not all our pipelines have easements. They're in road reserves sometimes and other places. So in a Planning and Environment Act perspective, they don't have to refer to us.

Any pipeline company concerns about land use and development within the pipeline measurement length, but outside the easement, are recommendations only. As one development consultant stated:

... outside of that easement, I think that that's up to the pipeline asset owner to put in place measures to protect it ... the issue is that there is no formal referral requirement in the planning scheme to the asset owners ... There's no trigger for the people involved to think to do it.

The opportunity for pipeline companies to provide input does not occur until late in the PSP process, when the Minister for Planning reviews comments from the public exhibition but prior to inclusion of a PSP in the Victorian Planning Scheme. The PEA requires that a number of prescribed Ministers, including the Minister for Energy and Resources responsible for administering the PA, be notified of planning scheme amendments. The Minister for Energy and Resources passes the notification on to the relevant pipeline companies who have 28-days to comment on the draft PSP. If the pipeline companies have not been made aware of this proposal it is at this point that a safety management study (SMS) may be undertaken, with any recommendations provided as feedback to the proposed amendment.

The management, or undertaking, of an SMS for a PSP further demonstrates the difficulties of a hybridized governance space. Although government actors, such as MPA, recognize the role of an SMS as it relates to minimizing risk from transmission pipelines, responsibility for coordinating an SMS often rests with those managing the PSP. This can be problematic because developers often fund a PSP with significant financial investments at risk. The requirements imposed by pipeline companies, as identified through a SMS, can raise issues for developers regarding costs and project delays. The following comments by a developer and a council planner illustrate the role of an SMS in relation to strategic planning, risk management, and pipelines:

... we had spent probably two or three years working with the MPA and council to come up with the background information that was going to feed into the design of the PSP. [PIPELINE ORG] came into the process midway ... and basically said, Sorry, we've got some feedback from the Panel Hearing that suggests that you're going to have to redesign your whole PSP ... The design and all the background work that ... had to be reconfigured to accommodate the requirements of an authority which, oh, sorry, an organization, which had the weight of some legislation behind it, and had a significant impact into that outcome. I'm just trying to think of the name of the Act that was sitting behind it ... They've talked about having to go through a SMS ... It was definitely The Pipelines Act that I can remember. [Developer]

... unless a planner knows to look at the PSP or knows there's a measurement length ... under the existing planning scheme, they will look at their referrals and it won't be there to do one. So you can put in the PSP that a safety management study's been done for these pipelines within this measurement length. But sometimes there might not be a safety management study, the planner might not know that that's within the measurement length ... [Council planner]

These comments indicate the complexity of a hybridized governance space that involves multiple private actors with competing objectives. Despite claims by some developers interviewed to be focused on positive community outcomes, the hybridized space in which planners work raises questions around the way that the risks associated with transmission pipelines are balanced against financial returns as well as long-term community outcomes. More significantly, not only do these comments emphasize the need to include pipeline companies early in the PSP process but also that the current planning framework fails to support planners to engage with these groups when making planning decisions.

## CONCLUSIONS

Both the planning sector and the pipeline industry are governed by legislation that seeks to manage risk in order to deliver positive, and safe, community outcomes. However, the data revealed several issues, stemming from requirements in the respective pieces of governing legislation and technical Standards that created tension between the pipeline sector and planners. Fundamentally, in terms of planning and development on Melbourne's fringe, these groups conceptualize the risk to communities in very different ways.

Although aware of the risk from an encroachment on a potentially hazardous pipeline and while also concerned with public safety, this is just one of many competing risks that planners seek to balance. Planners' perception of risk is primarily related to minimizing any negative impact on good long-term community outcomes. For planners, one key objective of Plan Melbourne is to increase the densification of housing within Melbourne's UGZ. This objective is clearly counter to the type of land use desired by pipeline companies. For the pipeline sector, increased urban development increases the risk to public safety from an accidental strike from excavation work by non-pipeline sector workers. Pipeline companies' preference is to prohibit, or at least relocate, sensitive land uses out of a pipeline measurement length in order to minimize the high-consequence but low probability risk to community from a pipeline rupture.

Effectively managing risk and public safety in relation to pipelines is complicated by a deregulated planning system where the boundaries and responsibilities for the governance of development have shifted away from the state in ways that give greater influence to powerful private actors. A deregulated planning system has also seen the emergence of a hybrid governance environment that includes the decentralization of the planning role. Planners increasingly work not only in public roles but also in the private sector representing the interests and objectives of multiple private and public stakeholders. However, the current planning frameworks in Victoria fail to bridge the gaps between the objectives of public and private actors associated with development in Melbourne's Growth Areas. Not only does this have the potential to lead to policy and governance failure, and thus inadvertently increase risk to public safety, but also to contradict the fundamental goal of planning, namely to establish communities with strong economies that are socially cohesive, now and into the future.

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# **SUPPLY CHAIN MANAGEMENT**

# THE CO-CREATION OF SOCIAL VALUE BETWEEN SOCIAL ENTERPRISES AND PRIVATE FIRMS IN THE CONSTRUCTION INDUSTRY

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This paper addresses the question of how and why social enterprises and private for profit firms collaborate to co-create social value in the construction industry and what institutional and organisational factors shape these practices. It does this using a documentary analysis and semi structured interviews with senior leaders of three construction organisations in the UK and Australia. Considering how collaborative practice is manifest in these arrangements, and the organisational and institutional factors that drive them, our findings suggest that the co-creation of social value through supply chain relationships in the construction industry is driven by commercial concerns which are in turn influenced by both industry and political institutional imperatives. Our findings point to differences in experience and opportunity for collaboration based on supply chain position and organisational scale. These have notable effects on the creation of social value and the legitimacy of different social benefit providers in an era of new public governance.

Keywords: cross-sector collaboration, social enterprise, social procurement, social value

## INTRODUCTION

In response to growing social procurement policies and legislation in countries like the US, UK, Australia, South Africa and Europe, there is a growing body of research addressing the subject of social value creation in the construction industry (Burke and King 2015, Loosemore and Higgon 2015, Farag *et al.*, 2016 and Petersen and Kadefors 2016). The aim of such policy and legislation is not only to require procurers of public and private construction, infrastructure and maintenance services and products to consider social value in their tender decisions, but to create a quasi-market to support the growth and development of third sector organisations such as social enterprises working in the construction industry (Barraket *et al.*, 2016). With their Scottish community organisation roots (Pearce 2003), and recent growth in response to trends in New Public Governance that stress the potential of collaborative multi-sectoral responses to wicked social problems that involve new forms of partnership between government, business, third sector and community organisations (Kolko 2012, Osborne 2007).

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As the fast growing part of the third sector, social enterprises represent a small but increasingly important part of the economy and the construction industry is seen as major potential market through the social procurement of public sector construction and maintenance contracts (Loosemore 2016). While a universally agreed definition of social enterprise remains elusive, it is generally accepted to be a values-driven hybrid organisation that trades for a social purpose, using economic activities as a means to create social value in the community and which redirects the bulk of its profits to the community in which it works to support its social purpose (Kay *et al.*, 2016). As Loosemore and Higgon (2015) and Petersen and Kadefors (2016) point out, the introduction of such organisations into the construction industry and the intermingling of institutional logics which this involves (Battilana and Lee, 2014), presents new challenges for the construction industry which are not yet understood, relating to management systems and changing professional roles and power structures in firms and supply chains.

Responding to the need for more conceptual depth in social enterprise research (Grassl 2012), our approach is informed by neo-institutional theory, particularly sociological conceptions of institutionalism (Suchman, 1995) that are concerned with the (re)production of norms and practice through processes of isomorphism (DiMaggio and Powell, 1983). In doing so we address the relative absence of this theoretical approach from construction management literature (Bresnen 2017). As Huybrechts and Nicholls (2013) note, cross-organisational collaboration occurs at the interface between macro institutional trends and micro organisational practices. This paper thus seeks to contribute to the micro-foundations of institutional theory, responding to Powell and Colyvas' (2008) call for a 'micro-motor' to complement macro-lines of institutional analysis. As they observe, "Institutions are sustained, altered and extinguished as they are enacted by individuals in concrete situations" (Powell and Colyvas, 2008: 276).

Our case study analysis particularly considers the institutional influences on what we refer to as 'social value chain' creation amongst social enterprises and private for profit firms. Institutional theory is useful for its emphasis on both *formal* and *informal* rules on policy outcomes (Lowndes, 2005). As stated above, existing analyses are overly focussed on macro level *formal* policies and new insights may emerge through an examination of how hidden *informal* organisational rules, norms and practices at a meso level operate in conjunction with formal rules in achieving greater social value chain creation (Helmke and Levitsky 2004). The aim of this paper is to explore the intersection between formal and informal rules and their enactment in relation to cross-sector collaborations involving social enterprise in the construction industry.

How cross-sector collaborations between purely commercial and independent social enterprises operate in this type of industry environment is unclear since social enterprises are historically under-represented and little research has been conducted into how they integrate into the industry's strongly path-dependent supply chain relationships and practices (Loosemore and Higgon 2015, Peterson and Kadefors 2016). Based on elite interviews with senior leaders of three construction organisations in the UK and Australia involved in collaborative activity that includes social enterprises, we consider how collaborative practice is manifest in these arrangements, and the organisational and institutional factors that drive them. In so doing, we seek to respond to the limitations of functionally-driven cross-sector collaboration research identified by Huybrechts and Nicholls (2013), by addressing why and how organisations collaborate to create social value in the construction industry.

### Cross Sector Collaboration and Social Enterprise

While cross-sector collaborations have disadvantages such as high transaction costs, dissatisfaction with other strategies has led to a search for innovative solutions in a number of fields which give primacy to this approach (Selsky *et al.*, 2014). Management and entrepreneurship studies concerned with the mutuality of interests between business and society have reflected this emphasis on collaborative thinking and stimulated conceptions of ‘blended’ (Emerson, 2003) and ‘shared’ (Porter and Kramer, 2011) value. These concepts link firms’ competitive advantage to meeting social needs, through both intra and inter-organisational practices. However, with the corporation as their primary focus, these concepts have been less prevalent in explaining third sector agency in the co-production of social value.

The idea of cross-sector collaboration has been more central to the emerging concept of ‘collective impact’ (Kania and Kramer 2011) in management studies. Collective impact is based on the premise that most of today’s persistent social problems are too complex for a single organisation to resolve alone but require collaborative multidimensional, multi-sectoral and multi-organizational solutions. In policy studies, conceptions of network governance (Sørensen and Torfing, 2005) and new public governance (Osborne, 2006) also reflect this collaborative approach to wicked problems and have placed increasing emphasis on the role of private actors in generating public value (Bozeman and Johnson, 2015).

Cross-sector collaboration is presented in each of these literatures as a mechanism through which new forms of social or public value are created. While the nature and characteristics of collaboration are both underspecified and contested in the available literature (Keast and Mandell, 2013), we adopt Kaljunen *et al.*’s (2013) definition of cross-sector collaboration as a process where autonomous actors from fragmented sectoral systems negotiate to share power and resources, leverage core capabilities and create rules and structures governing their relationships with the purpose of addressing multifaceted social concerns to create and capture social value. In this paper, we draw on insights from both management and policy studies, to better understand the drivers and consequences of cross-sector collaborations involving social enterprises within a single industry context.

The small but growing literature on cross sector collaboration and partnerships involving social enterprises has examined partnership as resourcefulness behaviour (Shaw and Bruin, 2013), as opportunity recognition (Henry, 2015), and as the dialectic of social exchange (Di Domenico *et al.*, 2009). Relatively few studies have examined the social impacts of such collaboration (Sakarya *et al.*, 2012). To date, studies have focused on higher order collaborative efforts, including social alliances (Sakarya *et al.*, 2012), joint ventures (Di Domenico *et al.*, 2009; Henry, 2015), and new venture co-creation (Henry, 2015). While our focus here is on collaborations between social enterprises and private for profit firms, other studies tracing the emergence of partnerships in the context of new public governance (Carmel and Harlock, 2008) have examined the emergence of social enterprise-government alliances (Simmons, 2008).

The theoretical and empirical literature is almost universal in finding that the local responsiveness and community legitimacy of social enterprise is its central source of value in cross-sector collaborations (Henry, 2015). These studies variously find that the exchange value of corporations in such arrangements are their access to resources and market reach, and the market legitimacy they signify (Huybrechts and Nicholls, 2013). However, for the most part, there has been little intersection between the literature on

cross-sector collaboration and social enterprise and the wider literature on social entrepreneurship practice informed by institutional theory. An exception to this is Huybrechts and Nicholls' (2013) single case study of the role of legitimacy in cross-sector collaboration between a fair trade social enterprise and a corporation in the UK. They found that organisational legitimacy - particularly practical and moral legitimacy - was a key driver of cross-sector partnership formation, and that industry and national context had a significant effect on shaping practice.

Building on this work, and responding to gaps in the literature to date, the study presented here takes social value chains as its conceptual starting point. Barraket *et al.*, (2016) have described social value chains as the processes by which organisations seek to generate progressive social outcomes through the value chain. They have observed that this involves embedding collaborative activity related to social value creation in the routines of business operation, including supply chain decisions, customer interactions and operational practices. The social value chain concept closely reflects how commercial organisations in construction industry studies are looking for competitive advantage by collaborating with not for profit organisations, and their supply chains, to create social impact and how social enterprises are also seeking to scale-up by working with bigger businesses. Recognising the institutionalising effects of new public governance on social enterprise practice (Mason, 2012), we are particularly interested in whether and how institutional factors inform these collaborative activities. Heeding Huybrechts and Nicholls' (2013) call for attention to context and recognising that social enterprises are diverse (Thompson and Doherty, 2006), we present a comparative analysis of activities in the UK and Australia located within a single industry, construction.

## **METHOD**

Our study takes an international comparative approach, drawing on case experience in two national jurisdictions, the UK and Australia and in one industry, construction. As Loosemore and Higgon (2015) showed, both construction industries face rapidly growing social procurement imperatives and at the level of informal institutions very similar challenges in incorporating social enterprises into their supply chains due to the same procurement traditions and very similar established roles, relationships and cultures. However, we do acknowledge that at the level of formal rules, the UK has a demonstrably stronger history of central governmental public policy support for social enterprise development than does Australia (Lyons and Passey, 2006).

To investigate how and why social enterprises and private for profit firms collaborate in creating social value and what impact these formal and informal institutions have on collaborative cross-sector practices, a multiple case study approach was employed to ensure that we obtained perspectives from the across the entire construction social value chain. As Yin (2009) points out, case study research cultivate a close connection between theory and data and our three cases were chosen on the basis that they represent different governance structures and examples of organisations in different parts of the construction social value chain (See Table 1).

Data were collected by via semi-structured interviews with a senior representative of each case who were purposefully sampled on the basis of their ability to provide information-rich answers to questions about the nature of collaborative activities undertaken to generate social value. Interview data were complemented by documentary sources such as social impact reports, marketing information and annual reports. The interviews were undertaken face-to-face and informed by neo-institutional theory were guided by questions relating to: the kind of social value/social impact the organisation aimed to

generate; drivers of social value creation - commercial or otherwise; how the organisation generated this social value (forms of collaboration, with who, type of relationship); and barriers to collaboration - formal and informal/ internal and industry-related).

The interview and documentary data were analysed using Reissman's (2008) approach to narrative analysis which involved inductively coding the data into separate statements, reflecting common themes articulated by the respondents. Given the exploratory nature of this research our results are presented as a narrative. Our intention is not to test the relationship between any independent and dependent variables but to present the results in a way which retains the full richness of insight contained in the stories of collaboration which the respondents told.

*Table 1: Case study descriptions*

| Governance   | Description  |
|--|--|
| Case One: Independent commercial building contractor                               | Case One is one of Australia's largest international contractors, operating at the top of the construction social value chain. It works directly for major public sector and private sector clients, managing projects on their behalf and subcontracting the majority of up-front design and onsite work to its extensive supply chain of consultants, subcontractors and suppliers.                                  |
| Case Two: Social enterprise owned by an independent commercial building contractor | Case Two is a medium sized UK social enterprise which is a commercial JV between a city council through the trading arm of a charity and a large urban regeneration firm. It tenders for general contracting construction work on the open market and acts as a subcontractor to larger developers including its parent company, a relationship which has proven important in the highly cyclical construction market. |
| Case Three: Independent social enterprise  | Case Three is a small UK social enterprise which specialises in alleviating poverty through providing employment and training in the construction sector. It is an independent company established as part of the larger skills and training Group, which includes a charity and training organisation.  |

## RESULTS AND DISCUSSION

### *Social value creation purposes and practices*

Creating employment and employment pathways for those highly disadvantaged in the labour market was the primary focus of social value creation within all three cases examined. While all identified clear substantive objectives related to their social purpose, the respondents also noted the shifting nature of their social value creation strategies. These shifts were typically described as a function of the shifting socio-economic needs of the communities in which they built. The construction sector is unique in that its production environment changes from project to project, which means that the socio-economic environment in which work takes places is constantly changing. Construction organisations' clients and their corporate social responsibility priorities thus change from one building to the next and respondents reported a need to strategically respond to these changes in tenders in order to win projects.

All participants mentioned social procurement as a practice through which social value creation was enacted, although the nature and types of social procurement with which they were involved depended on their position in the construction supply chain and their organisational size. While Case One reported collaborating significantly with social

benefit organisations through joint ventures and alliances with large charities, it noted that it had not yet significantly engaged in social procurement in its subcontracting activities because suitable social benefit suppliers are simply not there to compete (in quality, reliability, cost and timeliness) with existing supply chain incumbents. In the absence of these social procurement opportunities, the organisation reflected that it was currently constrained from innovating in creating mechanisms and opportunities where it could use social procurement. In creating its own opportunities to use social procurement, in a market that doesn't currently allow it, Case One has adopted the collective impact model as a philosophy with collaboration at its core. The challenge Case One described was in bringing together a highly fragmented and competitive construction supply chain with a highly fragmented and competitive employment services sector. This has involved creating solutions which broker relevant connections across the multiple interfaces that arise from such a structure. In all cases, opportunities for collaboration in social value creation was dependent on organisations' ability to leverage its unique social capital. Case Three reported having relatively fewer inter-organisational relationships upon which to draw, while Case One leveraged its long standing, broad and unique connections in establishing collaborative activities. Case Two identified mutual benefits flowing between it and its parent organisation in mobilising collaborative opportunities.

#### *Drivers of social value chain creation and participation*

Organisational factors driving social value chain practices identified by our participants included senior staff who were champions of social value creation, the breadth and accessibility of organisational networks, and the organisation's core purposes. In Case Two, the social enterprise's Managing Director was a former Regional Director in its commercial parent company and had chosen to resign from that position to grow the social enterprise, driven by his passion for providing employment opportunities for disadvantaged people. The social enterprise also provided certain commercial benefits to the parent, although the primary motive was to contribute back to local communities. In Case One, senior interest in social value creation was driven by both commercial imperatives and altruistic values associated with a history of connection with Indigenous employment and literacy and other social issues, formalised through its charitable foundation. These factors drove the corporation's practices, both in terms of initiating cross-sector collaborations and selecting the social issues or demographic groups to which the corporation sought to respond. In Case Three, the smallest organisation, social value creation was driven directly by the passion of its founder who had established the social enterprise as a mechanism for extending the charity's work and impact into the community.

Practices in social value chain creation and participation were also influenced by organisational scale and structural positions within the construction supply chain, according to our respondents. Our results suggest that the lower down the supply chain an organisation is, the less social procurement was used and the more direct employment solutions were used to generate social value. This is simply because the lower in the supply chain a firm resides, the fewer firms it has to procure from. Beyond procurement practices, structural positions affected organisations' capacity and opportunities for co-production of social value. In Case Three, which was at the end of the construction supply chain, opportunities to initiate collaboration were reported as being largely unavailable. In both Cases Two and Three, profit margins were also relatively small at their positions in the supply chain, limiting what was possible in terms of sharing opportunities or managing transaction costs associated with genuine collaboration. Competitive advantage did appear to be a driver of emerging practice within Case One,

while Cases Two and Three were less able to identify commercial benefits that accrued to them from collaborative activities due to their positions in the construction supply chain.

*Influence of social and commercial purpose on social value chain practices*

As illustrated above, commercial purpose drove collaborative activities within all three of our cases. For the social enterprise respondents, the commercial value derived from collaboration was one means by which social value - in the form of local and cohort specific employment and local regeneration - was able to be realised. In Case One, there was evidence that senior leaders recognised the intrinsic value of collaborating with third sector providers for social purpose. However, not surprisingly, commercial considerations drove most practices in this organisation's context. Corporate identity also seemed to influence organisational choices about collaboration partners, with this case organisation reporting working primarily with larger and well-established third sector agencies with arguably more commercially-consistent brands and cultures than smaller third sector organisations, social enterprises or minority suppliers.

Our findings suggest that the co-production of social value through supply chain relationships in the construction industry is largely driven by commercial concerns. These are, in turn, influenced by institutional factors, including both industry and political institutional issues. It is notable that the more active experience of social value co-creation amongst our social enterprise participants occurred within a nested business structure with direct structural and interpersonal relationships between companies' staff and board members. With regard to public policy levers and their effects on customer demands for social value creation, we note some variation in experience. In our Australian case, federal policy targets to stimulate supplier diversity (Rogerson, 2012) appear to be having a direct effect on the commercial environment in which it operates. These are stimulating new requirements to demonstrate a social bottom line which are, in turn, driving corporate approaches to social value chain development through collaboration with third sector organisations, along with small to medium enterprises. Conversely, in the UK - where social procurement by governments is legislated but not mandated - our respondents saw limited effects of social procurement in their operating environments and limited competitive advantages in marketing their social bottom lines.

Our findings also suggest differences in experience and opportunity for collaboration based on supply chain position and organisational scale. While social value co-creation in the construction industry remains marginal and was viewed by all participants as, at most, emergent activity, it is notable that the case where such activity was most widely practiced was a large corporate firm operating at the top of the construction supply chain. This firm also sought stability in its social value co-creation, by maintaining a small number of scalable relationships with larger third sector organisations, particularly welfare agencies that had some social enterprise capabilities embedded in their wider operations. As significant institutional actors in market relationships driven by new public governance (Osborne, 2006), such firms are clearly now playing a role in delimiting the governable terrain (Carmel and Harlock, 2008) of third sector activity.

Further, respondents from all three cases suggested that smaller social enterprises are least likely and least able to initiate social value co-creation through supply chain collaboration, because of their resource constraints and their supply chain positions. These findings somewhat counter the characterisation in the literature of social enterprises as having a high degree of collaborative agency and being network-oriented in their opportunity creation behaviours (Di Domenico *et al.*, 2010).

We find that organisational scale and supply chain position are significant determinants of social value chain creation amongst our sample. This is counter to Domenico *et al.*'s (2009) proposition that organisational aims and priorities are key modifying factors in social value co-creation opportunities and practices. Our findings are consistent with Maltz and Schein's (2012) conclusions that shared value is best generated where there is capacity to do so, and that organisational capabilities such as supply chain expertise and social capital can be used in cultivating shared value. In a new public governance context, where market drivers of partnership and collaboration are influenced by social procurement agendas, we also find counter to the existing literature on social enterprise partnerships (Di Domenico *et al.*, 2009; Haugh, 2007; Henry, 2015) that the exchange value of social benefit providers for corporate firms is less related to their local knowledge and legitimacy arising from community embeddedness and much more strongly related to their legitimacy as social service providers with governments and corporations. This exchange value thus favours larger welfare providers over smaller and more locally embedded social enterprises as active agents in social value chain creation.

## CONCLUSIONS

This research suggests that social value chains in the construction industry are driven by commercial and institutional imperatives, as well as by organisational commitments to meet social missions. In private for profit contexts, customer demands to demonstrate a social bottom line and new business opportunities are the key drivers of practice. In social enterprise contexts, organisational subsistence and a desire to increase social value through supply chain interactions play a stronger role. While not generalizable to a wider population, our cases' experiences suggest that the further down the supply chain organisations are positioned, the less they are able to collaborate with others through value chain creation. Our participants' stories also suggest that it is those least able to collaborate that may benefit most from such collaboration in terms of maintaining organisational sustainability.

Our findings suggest that institutional factors do have direct influence on firm behaviour in social value creation. In the UK where social procurement is legislated but not mandated, participants experienced limited implementation or competitive advantage arising from social procurement policy. In Australia where narrow but firm targets have been established in public policy, there was greater emphasis on the role of public policy in driving firm choices with regard to social value chain decisions.

We recognise the limitations of this research, in our small sample and further comparative research is needed across countries and to understand further the important differences in opportunity for collaboration to co-create social value afforded by different supply chain positions.

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# GLOBAL SUPPLY CHAINS: A PRELIMINARY ANALYSIS OF THE AUSTRALIAN CONSTRUCTION INDUSTRY

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Globalisation of the construction supply chain in Australia has led to an increasing amount of products and services being procured by construction companies or their sub-contractors from manufacturers or suppliers overseas. Led by the rapidly falling communication and coordination costs, the various stages of building construction need not be performed near to each other anymore; leading to increasing offshoring of manufacturing production to lower production cost countries in Asia. This study aims to characterise the extent to which the Australian construction sector has embraced global supply chains, and to determine the drivers for the increase in imports. Direct and indirect imports into the Australian construction industry are estimated at 7% and 14%, respectively. The main driver for this increase in imports is the manufacturing industry's loss of competitiveness in the domestic sector to lower production cost countries in Asia. In addition to the lower cost of imported products, other drivers for increased imports are increased competition, globalisation of Australian manufacturers, excess production capacity in Asia, and the shift to services. In response to these structural changes and increased global competition, labour needs to be retrained and reallocated from less competitive sectors to higher value added or higher skilled jobs.

Keywords: globalisation, outsourcing, supply chains, Australia

## INTRODUCTION

An increasing amount of products and services are procured by construction companies and sub-contractors from manufacturers or suppliers overseas. The aim of this exploratory research is therefore to characterise the extent of the globalisation of the supply chain in the Australian construction industry. The construction industry supplies all new buildings and structures, provides for the maintenance of existing structures, and accounts for approximately half of all total investment in Australia. In order to construct these buildings and structures, the industry relies heavily on other sectors of the domestic economy to supply the necessary materials, skilled labour, technology, transportation and finance. Goods and services that cannot be procured domestically are imported.

In Australia, and undoubtedly, in many other developed economies, there are increasing concerns about the offshoring of manufacturing production and the procurement of extensive amounts of goods and services from Asia, in general, and China, in particular. Led by the rapidly falling communication and coordination costs, the various stages of building construction (or any other manufacturing activity) need not be performed near to each other anymore. Increased possibilities for fragmentation mean in essence that more parts of the building process become open to international competition. Globalisation has

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entered a phase in which international competition is now played out at the level of activities within industries, rather than at the level of whole industries (see the 'second unbundling' by Baldwin 2006).

The lower cost of building products available from overseas cannot be disregarded when Australian construction firms now bid for projects in an increasingly competitive market. Utilising a growing volume of imported products leads to reduced final costs for buildings, creating greater value for construction clients. Extending the supply chain globally can bring great benefits but also new risks. The supply of an unacceptable degree of non-compliant, unsuitable and occasionally faulty building products and components is being seen increasingly in major development projects, pointing to a weakness of Australian compliance regimes. Despite a long history of imports of construction products into the building industry, recent cases of non-compliant products have focused the attention of construction companies, industry stakeholders and the government to the sudden surge in the use of imports from abroad. Recent cases of sub-standard imported building products such as combustible aluminium composite panels, non-compliant electrical cables and structural ply, and asbestos tainted building products have been reported to a Senate Committee inquiry (Senate Economics References Committee 2016).

The primary objective of this research is to characterise changes in the direct and indirect import of intermediate goods into the Australian construction industry over the last decade. The second objective is to identify the drivers of this increase in imports and to discuss its implications on the future of the industry. The focus of this study is therefore on the increasing international fragmentation of the value chain reflecting the higher import shares in the value of final construction products. This research is the initial part of a wider research project to quantify the scope of value chain fragmentation at all stages of the construction process, and to measure its implications on construction output, domestic employment, income and value added.

## **LITERATURE REVIEW**

Early trade models were based on the premise that national wealth and economic prosperity can only be attained by encouraging exports and the accumulation of gold or bullion. This mercantilist approach is based on the idea that exports should be encouraged, imports discouraged through the use of tariffs. A common viewpoint during the 18th century was that international trade is viewed as a zero-sum game where a gain by one trading nation results in a loss in another. In *The Wealth of Nations*, Adam Smith (1776, republished by Everyman's Library in 1991) defined the concept of absolute advantage, and suggested that two nations could gain from trade when each had an absolute advantage in one product. When Ricardo (1821) described the advantage of trade in his wine for cloth example, the difference in comparative costs reflecting a difference in techniques of production and division of labour resulted in a comparative advantage in each of these products in Portugal and Britain, respectively. Despite its extreme simplicity, the Ricardian model continues to perform surprisingly well empirically (Golub and Hsieh 2000). Later models to determine patterns and interactions of trade are founded on the Heckscher-Ohlin theory (Helpman 1981) that essentially states that countries will export products that use their abundant and cheap factors of production and import products that use the countries' scarce factors. In simple terms, it basically states that 'a capital-abundant country will export the capital-intensive good, while the labour-abundant country will export the labour-intensive good'.

Enabled by falling trade costs and new communications technologies, many products are now produced by networks of firms spread all over the world. These networks of production are located across multiple countries to gain access to capital, technology, natural resources, labour and other inputs to achieve cost and other competitive advantages. The emergence of such a network or global supply chain presents firms with opportunities to capture specific stages or niches within globalised production processes, and to expand their operations to higher value added activities in the value chain. Baldwin and Evenett (2012) asserts that developed economies should be chasing high-skills high-value added jobs such as design, marketing, and research and development to remain competitive. Asia's comparative advantage lies in the low-skill and capital value-added manufacturing segments of the value chain. Gasiorek and Lopez-Gonzalez (2013) reported that it is this complementarity which allows countries to engage in mutually beneficial specialisation.

Previous empirical studies of the international fragmentation of production were focused on estimating either the domestic value added content of a unit bundle of exports, or the shares of imports in all intermediate inputs. Using world input-output tables, Los *et al.*, (2015) proposed to measure for each product all value adding activities and to trace the location of these activities; in effect fully decomposing the value of the product into domestic value added and value added abroad. They concluded that the opening up of China and other countries with extremely low labour costs, combined with rapidly declining coordination costs have enable value chains to become global. Recognising the advantages of production in lower cost countries, manufacturing companies have developed global sourcing strategies to win competitive advantage (Murray 2001). Motivations for global sourcing include lowering production costs (Trent and Monczka 2003, Schiele *et al.*, 2011) or gaining access to superior technology, quality products, raw materials and specialised knowledge (Brockwell 2008).

## RESEARCH METHODS

This study drew upon the National Account Input-Output tables (ABS Cat.No.5209) for 2001-02 and 2012-13 produced by the Australian Bureau of Statistics ([www.abs.gov.au](http://www.abs.gov.au)) to characterise the changes of direct competing imports into the construction industry. These tables provide highly disaggregated supply and use data of goods and services throughout the economy. Changes to the primary and intermediate inputs for the construction industry over the period were analysed by comparing the actual import values and direct requirements coefficients. Additional data on the sources of these imports were obtained from the World Input-Output database - a project funded by the European Commission as part of the Seventh Framework Programme ([www.wiod.org](http://www.wiod.org)).

Indirect imports into the construction industry (e.g. via the manufacturing industry) can be obtained by mathematical manipulation of input-output tables with direct allocation of imports (ABS Cat.No.5246). However, the homogeneity assumption inherent in input-output analysis obscures the traceability of, say, steel plates imported by a steel fabricator for incorporation into the construction of a framed building compared to steel plates utilised in the manufacture of trucks. In order to overcome this limitation, data on imports for the manufacturing sectors that supply the construction industry were obtained from the IBIS World database ([www.ibisworld.com.au](http://www.ibisworld.com.au)) together with their respective shares of output supplied to the construction industry. The drivers for the greater utilisation of imports or company strategies to address competition from low cost producers were obtained from a search on secondary data sources: company annual reports, administrators' reports, government reports and industry publications.

## FINDINGS

A comparison of the top ten imports into the construction industry in 2001-02 and 2012-13 is shown in Table 1. Intermediate products such as fabricated metal products, electrical equipment, iron and steel, have consistently remained at the top of this list. Direct competing imports into the construction industry increased from about 4% of total output in 2012-02 to 7% in 2012-13.

*Table 1: Top ten imports into the construction industry*

| Rank | Imports 2001-02                 | Value \$(m) | Imports 2012-13                 | Value \$(m) |
|------|---------------------------------|-------------|---------------------------------|-------------|
| 1    | Fabricated metal products       | 654         | Petroleum Product Manuf.        | 3866        |
| 2    | Other electrical equipment      | 436         | Electrical Equipment Manuf.     | 3056        |
| 3    | Electronic equipment            | 404         | Iron and Steel Manuf.           | 2560        |
| 4    | Ceramic products                | 369         | Polymer Product Manuf.          | 2189        |
| 5    | Iron and steel                  | 361         | Basic Chemical Manuf.           | 2119        |
| 6    | Plastic products                | 356         | Structural Metal Product Manuf. | 1788        |
| 7    | Motor vehicles and parts equip. | 318         | Electronic Equipment Manuf.     | 1343        |
| 8    | Basic chemicals                 | 297         | Professional Services           | 1313        |
| 9    | Other machinery and equip.      | 246         | Other Fab. Metal Product manuf. | 1287        |
| 10   | Insurance                       | 239         | Other Wood Product Manuf.       | 892         |

Data from the world input-output tables produced by Dietzenbacher *et al.*, (2013) indicate that direct imports that were initially from USA, Germany and Great Britain were gradually being replaced by imports from China, Indonesia and Korea (see Table 2). Since 2011, China has become the main source of imports to the construction industry supplying electrical equipment, basic metals, fabricated metal, rubber, chemical and plastic products, and computers.

*Table 2: Top five source countries for imports into the construction industry*

| Rank | Country (1995)    | %  | Country (2011)    | %  | Country (2014)    | %  |
|------|-------------------|----|-------------------|----|-------------------|----|
| 1    | USA               | 13 | China             | 25 | China             | 20 |
| 2    | Japan             | 12 | USA               | 11 | USA               | 7  |
| 3    | Germany           | 10 | Japan             | 6  | Japan             | 5  |
| 4    | Great Britain     | 7  | Germany           | 5  | Korea             | 5  |
| 5    | China             | 6  | Indonesia         | 5  | Germany           | 4  |
|      | Rest of the World | 52 | Rest of the World | 49 | Rest of the World | 59 |

In parallel with this increase in direct imports, additional imports may also flow into the construction industry through the supply of intermediate products from the domestic manufacturing industry. A list of manufacturing sectors that commonly supply the construction industry is listed in Table 3 together with the proportion of output that was supplied to the construction industry in the right-most column. The total value of import

penetration into these manufacturing sectors increased from 19% in 2006-07 to 25% in 2015-16 leading to estimates of total imported content of approximately 20%.

Four manufacturing sectors that exhibited the highest import contents (> 50%) in 2015-16 were C2029 Ceramic Products, C2142 Aluminium, C2432 Electrical Equipment, and C2462 Construction Machinery. The high import proportion reflects the decision of local manufacturers to import from lower production cost developing countries. In 2015, GWA Group Limited (a ceramic products manufacturer) announced a strategy for a phased exit of manufacturing of bathroom and kitchen products and transition to sourcing from established overseas suppliers (GWA 2015). This strategic repositioning was to enhance competitiveness by shifting manufacturing of their products to lower cost countries while maintaining domestic product development, research and design, and marketing activities. In the same vein, Alcoa Australia's Point Henry facilities closed at the end of 2014 as part of its global strategy to lower its aluminium production cost by divesting or closing high production cost plants and investing in the lowest-cost aluminium production facilities (Alcoa 2015). Nearly two thirds of Australian domestic demand is now being met by cheaper foreign imports, the majority of which come from China. Growing import penetration of cheaper foreign products has led to the decline of the local manufacturing industry. In C2462 Construction Machinery Manufacturing, many of the earthmoving equipment are imported from multinational manufacturers that build equipment overseas. Latimer (2016) reported that foreign-owned construction equipment manufacturer, Sandvik, will gradually relocate majority of manufacturing operations offshore while maintaining client servicing and equipment support operations locally.

The sectors with medium import contents (between 25% and 50%) were C1413 Timber, C2090 Glass wool and Stone, C2221 Structural Steel, C2431 Electric Cable, C2452 HVAC, and finally, C2511 Furniture. Products from C1413 Timber are widely used in housing construction such as timber for the house framing, and in the manufacture of components such as door and window frames. Imported timber from New Zealand, Indonesia and Chile now account for 26% of domestic demand, up from 13% in 2006-07. Tasmanian timber company, Gunns, once a major player in this sector, entered into voluntary administration in September 2012 as a result of increasing competition from other countries, an oversupply of plantation woodchip and a high Australian dollar (Gunns Limited 2012). Imports for glass wool insulation and stone (C2090) increased to 26.4% of domestic demand mainly due to imports from high quality dimension stone from the United States and Italy, and low cost products from China. CSR, one of the largest insulation manufacturers in Australia, supplying close to 35% of the fibreglass insulation market, closed its rock-wool insulation factory in Victoria and mothballed a kiln in New South Wales in 2011 because of deteriorating international competitiveness and market oversupply due to the withdrawal of the government home insulation subsidies (CSR 2012).

The most significant change was observed for C2221 Structural Steel Fabrication that increased its imported content from only 5.4% in 2006-07 to 27.8% in 2015-16. This sector is one of the most important sectors supplying materials for the construction industry, which constitutes 95% of this manufacturing sector's market. Structural steel products include reinforcing steel rods and welded mesh, rolled structural sections, steel plates and fabricated steel girders, roof trusses and scaffolding. The bulk of fabricated steel product imports to Australia are sourced from low-cost producers located in China, Thailand and Indonesia. Excess production of steel in China has led to numerous allegation of dumping of surplus product into Australia, many of which have received

affirmative determination of dumping by the Anti-Dumping Commission (Anti-Dumping Commission 2015). Despite the imposition of duties of up to 53% for some steel products, domestic steel maker Arrium Limited remains uncompetitive and was eventually put under voluntary administration in April 2016 (KMR 2016).

Table 3: Changes in Manufacturing imports from 2006-07 to 2015-16

| Code  | Description                            | 2006-07<br>Imports<br>(%) | 2015-16<br>Imports<br>(%) | Change | Construction<br>Share |
|-------|--|---------------------------|---------------------------|--------|-----------------------|
| C1411 | Log Sawmilling                         | 16.9%                     | 17.5%                     | 0.6%   | 49.9%                 |
| C1413 | Timber Re-sawing and Dressing          | 12.9%                     | 26.0%                     | 13.0%  | 76.2%                 |
| C1490 | Fabricated Wood Manufacturing          | 16.6%                     | 25.0%                     | 8.4%   | 84.9%                 |
| C1492 | Wooden Structural Component<br>Manuf.  | 1.2%                      | 1.4%                      | 0.3%   | 76.7%                 |
| C1916 | Paint and Coatings Manuf.              | 12.5%                     | 16.4%                     | 3.9%   | 27.5%                 |
| C2010 | Glass and Glass Product Manuf.         | 12.9%                     | 18.8%                     | 5.8%   | 60.0%                 |
| C2021 | Clay Brick Manuf.                      | 0.3%                      | 0.0%                      | -0.3%  | 87.0%                 |
| C2029 | Ceramic Product Manuf.                 | 57.3%                     | 69.3%                     | 12.0%  | 57.0%                 |
| C2031 | Lime and Cement                        | 3.5%                      | 7.3%                      | 3.8%   | 78.0%                 |
| C2034 | Concrete Products                      | 5.5%                      | 12.1%                     | 6.5%   | 100.0%                |
| C2090 | Glass wool, stone and other mineral    | 18.4%                     | 26.4%                     | 8.1%   | 72.5%                 |
| C2110 | Iron Smelting and Steel Manuf.         | 17.1%                     | 16.2%                     | -0.9%  | 34.8%                 |
| C2132 | Aluminium Smelting                     | 0.4%                      | 4.4%                      | 4.0%   | 21.5%                 |
| C2142 | Aluminium Extruding                    | 43.5%                     | 68.5%                     | 25.0%  | 20.3%                 |
| C2221 | Structural Steel Fabrication           | 5.4%                      | 27.8%                     | 22.4%  | 95.0%                 |
| C2222 | Prefabricated Metal Buildings          | 3.4%                      | 7.1%                      | 3.7%   | 84.1%                 |
| C2223 | Aluminium Door and Window<br>Manuf.    | 2.0%                      | 8.5%                      | 6.5%   | 86.8%                 |
| C2229 | Structural Metal Product Manuf.        | 0.6%                      | 1.1%                      | 0.4%   | 91.0%                 |
| C2240 | Sheet Metal Product Manuf.             | 14.6%                     | 15.6%                     | 1.0%   | 36.3%                 |
| C2431 | Electric Cable and Wire Manuf.         | 36.1%                     | 48.8%                     | 12.7%  | 31.1%                 |
| C2432 | Electric Lighting Equipment Manuf.     | 39.6%                     | 67.2%                     | 27.5%  | 76.2%                 |
| C2452 | Heating, Cool. & Vent. Eqmt.<br>Manuf. | 39.8%                     | 45.4%                     | 5.6%   | 100.0%                |
| C2462 | Mining & Construction Mach<br>Manuf.   | 67.5%                     | 61.0%                     | -6.5%  | 49.1%                 |

Companies in the C2431 Electric Cable and Wire Manufacturing sector have similarly faced stiff competition from imported low-priced products manufactured in lower labour cost locations. Imports in this sector were nearly 50% in 2015-16 as purchasing decisions in the construction industry are made solely on price. The two largest wire and cable manufacturers in Australia are foreign-owned, and were reported to gradually shift production of more generic products overseas to lower operating costs. In reality, Australian manufacturer are also importers of significant quantities of electric cable. The

Australian Cablemakers Association has alleged that importers are dumping electrical cables from China, and asserted that some of these products do not comply with Australian standards (Moulis Legal 2015).

Increasing competition from imports over the past five years has resulted in 45% of domestic demand being met with imports in 2015-16 for C2452 HVAC Equipment Manufacturing. Local manufacturers have outsourced production to Asian countries to cut costs and improve margins.

Two other manufacturing industries that were examined were; C2010 Glass and Glass Product Manufacturing mainly because there is only one remaining local manufacturer of float glass; and C2031 Cement and Lime Manufacturing because the production of clinker is facing heightened competition from lower cost producers in Asia. Viridian, a division of CSR Limited, is the only local manufacturer of float glass. Low-cost imports from China have steadily captured a greater share of the domestic demand for flat-glass products leading to a number of applications by Viridian to the Anti-Dumping Commission to investigate cases of dumping by Chinese float glass producers. As a result, float glass from a majority of producers in China now attracts an Interim Dumping Duty. This led a turnaround for Viridian with earnings of \$3.1 m in 2015 and \$8.1m in 2016 after 3 consecutive years of losses in 2012, 2013 and 2014 (CSR 2016). Despite these duties, the importation of architectural and automotive glass products from China has consistently remained about 48% of total imports over the last three years.

C2031 Cement and Lime Manufacturing consist of firms that manufacture clinker, hydraulic cement and lime. For maximum environmental and economic efficiency, cement kilns must run at capacity. If a portion of the kiln's capacity is displaced by imports, a kiln is no longer economically or environmentally efficient to run. In 2015-16, imports constitute 7.3% of domestic demand, double the 3.5% in 2006-07. Australian producers of clinker have opted to scale back production, and decided to import clinker from lower cost manufacturers overseas and grind the cement in Australia. The cost of complying with the strict environmental regulations regarding plant emissions and effluent in Australia together with the introduction of the carbon tax in 2012 heightened competitive pressure on the domestic cement sector. In 2012-13, clinker was imported from Japan, China and Indonesia while imports of cement came predominantly from China, Taiwan and Thailand. None of these countries have put a price on carbon emissions. The carbon tax was eventually repealed in July 2014.

## **DISCUSSION**

There is now clear evidence of an increased utilisation of imported products and services in the Australian construction industry both directly through imports from construction companies, and indirectly through imported products utilised by the manufacturing sectors to produce intermediate inputs for the construction sector. This reaffirms Baldwin's (2006) paradigm of global trade where labour intensive activities are offshored to lower production cost countries. With increasing pressure from clients and heightened competition in the building market leading to tight margins (Deloitte 2016), construction companies are constantly under pressure to obtain the cheapest input prices. The Australian construction industry has clearly shifted from a reliance on 'Factory North America' in 1995 to 'Factory Asia' by 2011 where China is now the single largest source country for construction-related imports.

It may be argued that globalisation has affected the manufacturing industry, on which the construction industry depends for a large proportion of its intermediate inputs, to a greater

extent. In recent years, domestic manufacturing companies were affected by both the high Australian dollar and high unit labour costs, constraining its overall competitiveness (DOI 2014). The wage price index for manufacturing increased from 74.5 in 2001 to 110.1 in 2012 (ABS 2016) reflecting a wage increase of more than 3% annually. In the light of higher inputs costs, manufacturers have chosen to import intermediate inputs because these are cheaper than locally sourced inputs. Australian and foreign-owned manufacturing companies that operate across numerous manufacturing sites regularly monitor and compare performance on a cost basis; and would often take a strategic decision to shift production to a lower manufacturing cost location. As the scale of production increases, manufacturers may find it optimal to divide the production line into different fragments where a stage that makes relatively high use of unskilled labour can be shifted to another location where labour unit costs are relatively low. Obviously, the savings from this shift to locations with relatively low unit labour costs must outweigh the higher transportation and communication costs associated with the outsourced production. This is similar to manufacturers in the Australian automotive sector where the demise of the sector was attributed to the failure of tariff protection, the ineffectiveness of the economic assistance packages, the high Australian dollar during the period of the mining boom and immediately after the global financial crisis, and the strategies adopted by multinational automotive companies to shift production to lower cost economies (Clibborn *et al.*, 2016).

In response to these competitive forces, manufacturers have shifted their focus from production to the provision of services such as maintenance of lifts over the entire life cycle, product design, marketing and other high value-added services that rely on expert knowledge of product features and capabilities. This is in line with the observation by Timmer *et al.*, (2013) that international fragmentation does not necessarily lead to destruction of manufacturing jobs in advanced economies, but counteracted by a steady increase in the number of high value added jobs in the services sector.

The impact of the proposed carbon tax in 2012 was to cause the shift of a number of cement manufacturing lines to countries in Asia where no price is put on carbon emissions. This is an example of the cement industry exploiting trade as a means of mitigating emissions (Peters and Hertwich 2007). On the other hand, the cement sector has maintained an import parity pricing on cement as a recent measure to fend off the penetration of imports from lower production cost countries that seems to have slowed the decline of the sector, limited cement imports and maintained the viability of existing cement kilns.

## CONCLUSIONS

Direct imports into the Australian construction industry have doubled from about 4% of total output in 2005-06 to 7% in 2015-16. The increase of indirect imports through intermediate demand is now approximately 14% of total output. This level of imported products and services in the Australian construction industry lends further weight to recent observations that the sector has tapped into and now dependent on a global supply chain. The more important conclusion is that a great quantity of imported products and services flow into the construction industry through intermediate inputs from the manufacturing industry.

In response to the second research objective, the drivers for increased imports via the manufacturing sectors are: (i) cheaper goods produced overseas, (ii) increased pressure from clients to reduce construction costs and increased competition within the industry, (iii) globalisation of Australian manufacturers with production capacity in various

locations and their strategic decision to shift production to the lower cost location, (iv) excess production capacity in Asia that often exceeds Australian demand by several multiples, and (v) servitisation of Australian manufacturers (e.g., focusing on product design, marketing and maintenance).

In addition to these drivers for extending the supply chain globally, local factors such as the introduction of a climate policy or stricter environmental standards, which impedes the competitiveness of Australian manufacturing, can also cause a shift of production overseas especially when direct competitors do not face similar carbon costs or onerous emission regulations.

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# THE DEVELOPMENT OF A MORE EFFICIENT INTERNAL TENDER PROCEDURE FRAMEWORK FOR AUSTRALIAN CONSTRUCTION CONTRACTORS

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With increasing corporate governance requirements the nature of Australian construction contractors' (CC) internal tender review procedures is changing. A research program is underway to determine the effectiveness and efficiency of such changes and whether they are producing improved CC business results. To facilitate this objective a better understanding of current CC tendering practices and procedures was sought through detailed semi-structured qualitative interviews with 18 CCs, including five of Australia's largest contractors. Drawing from these interviews and extracts of tender procedures provided by nine of the CCs, a new internal tender procedure qualitative flowchart is developed, running from prospect identification to contract award. Many CCs now spend more than 10% (some over 15%) of their tender period hours addressing their internal tender reviews due to increased involvement of legal, commercial, finance and risk departments. Many CCs advised their key tender focus is risk mitigation to avoid the company winning a potential loss making project rather than determining a tender winning 'mark-up' value. While providing greater insight into the inner workings of CCs' internal tender procedures, the new tender process flowchart also enables CCs to benchmark their tender procedures against empirically researched current practice.

Keywords: bidding, contractor, corporate governance, risk, tendering procedures

## INTRODUCTION

Following various high profile corporate failures and the fallout from the global financial crisis, corporate governance requirements placed on Australian companies have increased through legislation, market/industry expectations, and company practice (SAI 2003, ASX 2014). The extent of such governance requirements is dependent on company size and type - public/private ownership and annual turnover being two critical criteria. Corporate governance drivers relevant to construction contractors' (CCs') internal tendering procedures include: strategic planning; setting risk appetites; delegations of authority for target project tender selection, submission and ultimately contract execution; cost of tendering; and, business continuity.

However, other than by works by such as Laryea (2013) there has been limited recent empirical research on how CCs manage and control their internal tender processes while satisfying increasing corporate governance obligations. Available tendering texts are: largely experiential in nature; focus more on estimating processes; provide limited detail

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behind the structure of CCs' internal tendering and review procedures; and, tend to provide a United Kingdom centric perspective (Brook 2011, Greenhalgh 2013). By comparison, the Australian CC industry has produced little to guide CCs on what constitutes contractors' internal tendering procedure norms, or to provide guidance on efficiently managing tender processes to meet governance requirements. It is also questionable as to whether complying with good governance leads to better performance (Kay cited by Faherty, 2015). CCs have limited opportunity to benchmark their internal tendering procedures against their competitors due to the risk of perceived anti-competitive behaviour or possible breach of the Australian Competition and Consumer Act 2010.

CCs' internal tender procedures appear to be driven largely by individual company management experiences or experiential based texts rather than empirical research. To address this identified gap in Australian research, a research program is analysing CC internal tender procedures to determine whether increased corporate governance controls have led to improved CC business performance outcomes. A key step is to obtain current empirical qualitative research on the nature of CC internal tender procedures. This paper describes the research methodology adopted and the findings from semi-structured interviews with 18 CCs, including five of the largest contractors operating in Australia, aimed at obtaining information on such internal tender procedures and developing a representative model of those current processes.

In this paper 'tender' is considered to include all the stages a CC undertakes from prospect identification through to contact execution. A tender therefore has a wider context than a 'bid', which is commonly used in the literature. Depending on the client's selected project delivery model and procurement approach tenders may include an expression of interest (EOI) shortlisting process before involving price and/or non-price assessment methods. This research is not looking at the client/designer - contractor interactions that occur within the client led tender procurement process.

CCs' tender review process stages were found to be significantly more complicated and demanding, requiring more time and effort, than the current literature suggests applies in the industry. Drawing on the interview results a CC's internal tender review process flowchart has been developed from this research and is presented below. The flowchart represents the processes CCs are adopting to address their internal tender governance obligations. This improved understanding of current CC internal tender procedures will facilitate later stages in the wider research program, namely assessment of the efficiency and effectiveness of those procedures and whether they are producing improved CC business results.

## **LITERATURE REVIEW**

Tender research from Ahmad and Minkarah (1988) through to recent Australian work by Shokri-Ghasabeh and Chileshe (2016) has commonly focused on CCs' 'bid/no-bid' decisions and/or price 'mark-up' decision processes. Such research has led to the identification of over 100 factors (Ravanshadna, *et al.*, 2011) that influence such decisions and/or the development of numerical models to assist CCs make them. Various researchers have noted the vagaries of mathematical models that fail to reflect what CCs actually do and that model constraints vary with time, market and contractor (Cheng, *et al.*, 2011). However CC decisions regarding tenders can still involve complex reasoning processes (Egemen and Mohamed 2007). Mochtar and Arditi (2001) suggested that as CCs' highly unstructured tendering approaches made them difficult to model, there was

limited benefit in further quantitative studies, and more would be gained through a greater qualitative focus on CCs' tender methods.

Laryea (2013) found that of the over 1300 papers published in six construction management related journals between 1983 and 2012, only 29 papers dealt with the specific process of CCs' tendering procedures. Of those papers three were Australian based research, but all were pre-2000. As part of the literature review for this paper, the authors searched the same six journals for the period 2013-2016 found of the 82 papers mentioning 'tender' or 'bid' none related to Australian CC tender procedures and only Laryea's 2013 paper addressed CC tender review processes. This suggests a gap exists in up-to-date research on CC tendering methodology, particularly in Australia. While various client best practice tendering guides have been written (DTF 2013), research funded by the Australian Contractors Association has more a marketing intent to promote an industry position to clients, rather than focussing on effective tender procedures CCs should adopt (Blake Dawson 2011, Ashurst 2014).

With tenders commonly awarded to the lowest tenderer (Loosemore and Richard 2015) CCs must maximise time spent seeking innovative methodology and pricing objectives during a tender period, rather than being overly constrained with extended internal approvals processes that may not necessarily add to tender quality or success. CCs' tender review processes typically involve a tender launch meeting, mid-term review and a final review meeting with senior management (Brook 2011, Greenhalgh 2013, Laryea 2013). The final review meeting (often called an 'adjudication meeting' in UK based literature) may comprise two meetings. The first focusing on reviewing the estimate figures and the second on commercial matters leading to a 'mark-up' decision (Laryea 2013). Whyte and Cammarano (2012) found time limitation, often due to company policy or design procedures, was one of the biggest factors hindering value management. Time spent in reviews can be a significant component of the tender period and hence a CC's tender cost. Laryea (2103) found 6-9% of a CC's available tender time was consumed in such reviews.

## **RESEARCH METHODOLOGY**

With engineering construction making up 43% of the \$47B Australian construction industry (19% being non-residential building and the balance residential construction) (ABS 2016), this research is focused on engineering construction and more specifically CCs participating in civil engineering construction work. Civil infrastructure is a market sector that often experiences significant construction cost overruns (Flyvbjerg 2009, Love, *et al.*, 2013).

Primary research data collection involved semi-structured qualitative interviews with 'convenience sampling' from the CCs accredited under the Austroads' National Prequalification System (NPS) (Austroads 2017). The Austroads NPS, which uses road/bridge/finance accreditation levels, forms the closest to a classification system for Australian CCs operating in the civil construction industry. Interviews lasting 1.5 to 2 hours were held with 18 high profile CCs from November 2016 to June 2017. Interview transcripts were provided to the CCs to review and correct if required.

Interview questions, informed by a detailed literature review, included: describe the CC's tendering process stages from prospect identification to contract award; outline strengths and weaknesses of those procedures; identify factors that influence 'bid/no-bid' and/or 'mark-up' decisions and timing as to when such decisions are made; describe the nature and staging of tender review meetings including management levels involved; an assessment of time spent on such reviews; and opinions on the efficiency of their

processes. Other interview questions probed any legal, accounting, financial, and risk committee involvement in tenders and their ability to influence tender strategy decisions; and how CCs integrated lessons from past tenders and projects into tenders. Questions about specific delegation of authority limits, commercial limits and actual 'mark-ups' were avoided, as they were unlikely to be answered given their sensitive commercial nature. Similarly questions regarding ethics were not included following lessons from Oladinrin and Ho (2016). CCs were also invited to provide extracts of their tender procedures and/or forms as exemplars, a request granted by 50% of the CCs.

Interviewed CC demographics are summarised in Table 1. The terms 'Tier 1, 2 and 3' are a necessarily unofficial classification used for this paper, although they roughly reflect the approach Australian CCs use when describing their competitors. Interviewees ranged from Pre-Contracts Manager to Chief Executive Officer (General Manager being the most common), while their construction industry experience ranged from 10 to 44 years with an average of 24 years. Ten of the 18 CCs interviewed have the highest Austroads rating combination of R5/B4/F150+ (Austroads 2017). Thirteen CCs secured 80-100% of their annual turnover by competitive tender while the remaining five CCs secured 60-80%.

*Table 1: Interviewed construction contractor company demographics*

|  | Public company<br>(including subsidiaries) | Private<br>company |
|--|--|--------------------|
| Company size based on annual turnover (AUD): |  |                    |
| Tier 1 - (\$1B - \$10+B)                     | 4  | 1                  |
| Tier 2 - (\$100M - \$1B)                     | 2  | 4                  |
| Tier 3 - (<\$100M)                           | 2  | 5                  |

## RESEARCH RESULTS

Current literature suggests CCs' internal tender processes commonly involve: a decision to tender ('bid/no-bid' decision); development of a tender strategy; estimation of prices (in consultation with subcontractors); risk and opportunity assessment; a mid-term tender review; and a final tender review with senior management leading to a 'mark-up' decision. However the 18 CC interview responses and nine exemplar tender procedures provided reflect a CC's internally determined staged multiple review tender process more complicated than that identified by Laryea (2013).

### Summary of Interview Findings

#### *Use of 'bid/no-bid' 'approval gates' occurs throughout the tender period*

The 'bid/no-bid' assessment was found to be an iterative decision process CCs undertake throughout tender periods as more information about the target project becomes available, and as commercial risks are balanced against their strategic advantage to win. Type of project (scope of work); financial capacity and payment record of client; and, risks and complexity of the project were found to be the top three reasons impacting CCs' 'bid/no-bid' decision. Approval to bid requests were largely qualitative assessments detailing issues such as: tender strategies; client relationships; and advantages over competitors, rather than involving a deterministic decision model. Thirteen of the 18 CCs did not use a mathematical model to assist initial 'bid/no-bid' decision making. The other five CCs adopted simple parametric models as decision guides with senior management still able to override the results.

Eight CCs used the term 'approval gate' to describe the stages requiring levels of formal management sign off. It is understood the concept of a 'gate' is not as rigid as a 'hold point'. Terms such as 'Approval to Pursue', 'Approval to Prepare' and 'Approval to Submit' were common applying at prospect identification, expression of interest (EOI), tender submission and even re-submission of post-tender negotiation correspondence stages. Various CCs advised that personnel involved in such decisions may change depending on the stage in the tender process approval. Escalation through management levels is dependent upon delegations of authority that incorporate project value, contract terms and corporate risk parameters. Approval to submit a tender could still be withdrawn during a final tender review should a risk profile be considered unsatisfactory. Larger CCs placed higher levels of importance on 'bid/no-bid' decision processes, which is consistent with Shokri-Ghasabeh and Chileshe's (2016) survey of contractors.

### *Risk, strategy, commercial and other intermediate reviews*

CCs often adopted a series of tender review meetings, especially where multiple layers of management approvals are required. Mid-term 'bronze', 'silver' and 'gold' reviews often include how the tender submission (including numerous management plans and schedules) aligns with the agreed tender strategy. Within many of the larger CCs separate legal, commercial and finance, and risk committee reviews and approvals, often looking at overall business risk rather than just tendered project risk, are now commonly required under governance obligations. Several CCs stated they could not submit tenders without these independent departments' or committees' separate approvals. This poses a tender management challenge when such departments do not have an interest in securing a construction tender win, but rather see their role as protecting the company from potential loss or excessive liabilities.

CCs' business models, including risk appetite and delegated authority levels, were found to influence their tender prospect decisions which is consistent with findings by Pekuri, *et al.*, (2015). Six CCs stated their procedures were designed to mitigate the risk of winning a loss making project, ahead of improving the opportunity to win a project. Several CCs advised that if risks could not be adequately mitigated they would include non-conforming qualifications or withdraw from the tender altogether. However, many of those CCs acknowledged that despite strengthening their internal tender procedures to meet increasing corporate governance constraints they still occasionally won what is colloquially called "a dog of a project", that is, one that loses rather than makes money.

### *Time spent preparing for and in tender reviews*

Each CC was asked to assess the percentage of tender time spent on preparing for and attending reviews and 'approval gate' requests to meet their procedural requirements. Most CCs noted the high use of bespoke contracts, favoured by clients in some industry sectors (Whyte 2015), added to the complexity of their tender processes. It was also acknowledged that a client's decision to include an EOI or similar shortlisting process before releasing tender documents added an extra 'bid/no-bid' decision loop approval. Four CCs advised over 15% of their total tender workhours (a further five CCs said at least 10%) can be spent in tender review related activities, which is significantly more than the 6-9% identified by Laryea (2013). One CC advised its total time could exceed 25% on design and construct (D&C) tenders and even higher on early contractor involvement (ECI) delivery models requiring reviews with clients.

### *Determination of risk allowance, corporate overhead and profit margin*

The interviewed CCs typically made a distinction between risk mitigation measures (either pricing risk or qualifying out) and the addition of a corporate overhead and profit

margin to a tender price. The concept of a single 'mark-up' figure applied to estimated costs to cover all three items (risk, corporate overhead, and margin) does not appear to commonly apply, especially in 'Tier 1' and 'Tier 2' CCs. Risk allowance and margin were considered separate and reviewed accordingly. Several CCs selectively used Monte Carlo risk modelling software, though its use was dependent on project types, specific values or client requirements. Results of such analysis were often treated with a degree of scepticism by some levels of management and adjusted to get "the right answer". While many CCs agreed commercial viability of the combined risk and margin amount influences a final tender price decision, the importance of not winning a potential loss making project was a strong corporate driver for six CCs. As those six CCs are spread across the public/private and 'Tier 1/2/3' demographics it was concluded this was not just a 'Tier 1' company approach.

A contractor's financial return requirements; strategic importance of the project to the contractor; and the contractor's need for work were commonly among the highest rated factors as reasons affecting the CCs' margin decision. The importance of 'need for work' reflects findings by Ahmad and Minkarah (1988). Eight of the CCs advised their margin decisions were made within 2 to 30 minutes while a further six were less definitive declaring instead "not long" or "minimal". Only one CC used a mathematical model to determine margin decisions. When asked to describe the basis of their model the interviewees were only able to advise that the company accountant provided the margin figure. None of the interviewed CCs were aware of the international research into the development of margin decision models. This is consistent with Egemen and Mohamed's (2007) finding that 93% of contractors failed to use prescriptive models in the industry.

#### *Ongoing pursuit to improve tender procedures*

When asked whether their tender procedures were keeping pace with their business and corporate governance requirements, nine CCs advised they had updated their procedures in the last three years. A further four CCs were in the process of updating their tender procedures. While two CCs were increasing governance control, three other CCs were seeking to reduce or streamline their procedures to make them more workable. Interestingly most interviewed CCs did not have as strict a controls process over their post-tender negotiations leading to contract execution and recognised this failure as an area for procedural improvement.

#### **Development of a Representative Contractor's Internal Tender Process Flowchart**

Drawing on information gained from the 18 CC interviews and the tender procedure extracts provided by nine CCs, a representative internally determined tender process flowchart developed by this current research is presented in Figure 1. The flowchart includes internal and legislative factors driving corporate governance directives that influence: 'bid/no-bid' decisions; how tender kick-off meetings are structured; approaches on risk and margin expectations; and involvement of specialist departments at key tender review stages. Such 'bid/no-bid' decisions may occur many times during the tender process (from initial prospect identification through to contract execution). The flowchart reflects that a client's decision to undertake an EOI process to shortlist tenderers may add to the number of decision stages. Each of these 'bid/no-bid' decision points may involve multiple layers of line management review and approval depending on a CC's delegated authority levels. Additional legal, commercial, finance and risk committees may impact approaches taken to mitigate risk and even the eventual tender submission.

The qualitative flowchart (Figure 1) recognises that, while corporate governance may drive tender strategies, tendering decisions may still be influenced by market conditions,

i.e. 'need for work'. Whenever a tender is abandoned through a 'no-bid' decision there should be lessons learned feedback, though various CCs advised this process was not as well structured as desired in their businesses. This mirrors Shokri-Ghasabeh and Chileshe's (2014) findings.

Additional tender review requirements for D&C or ECI project delivery models can be considered to be addressed within the "Kick-off meeting" and "Tender Pricing Developed" boxes in Figure 1. Most of the interviewed CCs advised they do not significantly change their tender procedures to account for different project delivery models, though the amount of information prepared for a review can be increased. There also remains the additional design management processes and appropriately focused risk and opportunity reviews. Several CCs who pursue public-private partnership, or PPP, project opportunities indicated further requirements occur as a result of equity participation decisions and treated outside the D&C tender issues.

## **CONCLUSIONS AND FUTURE WORK**

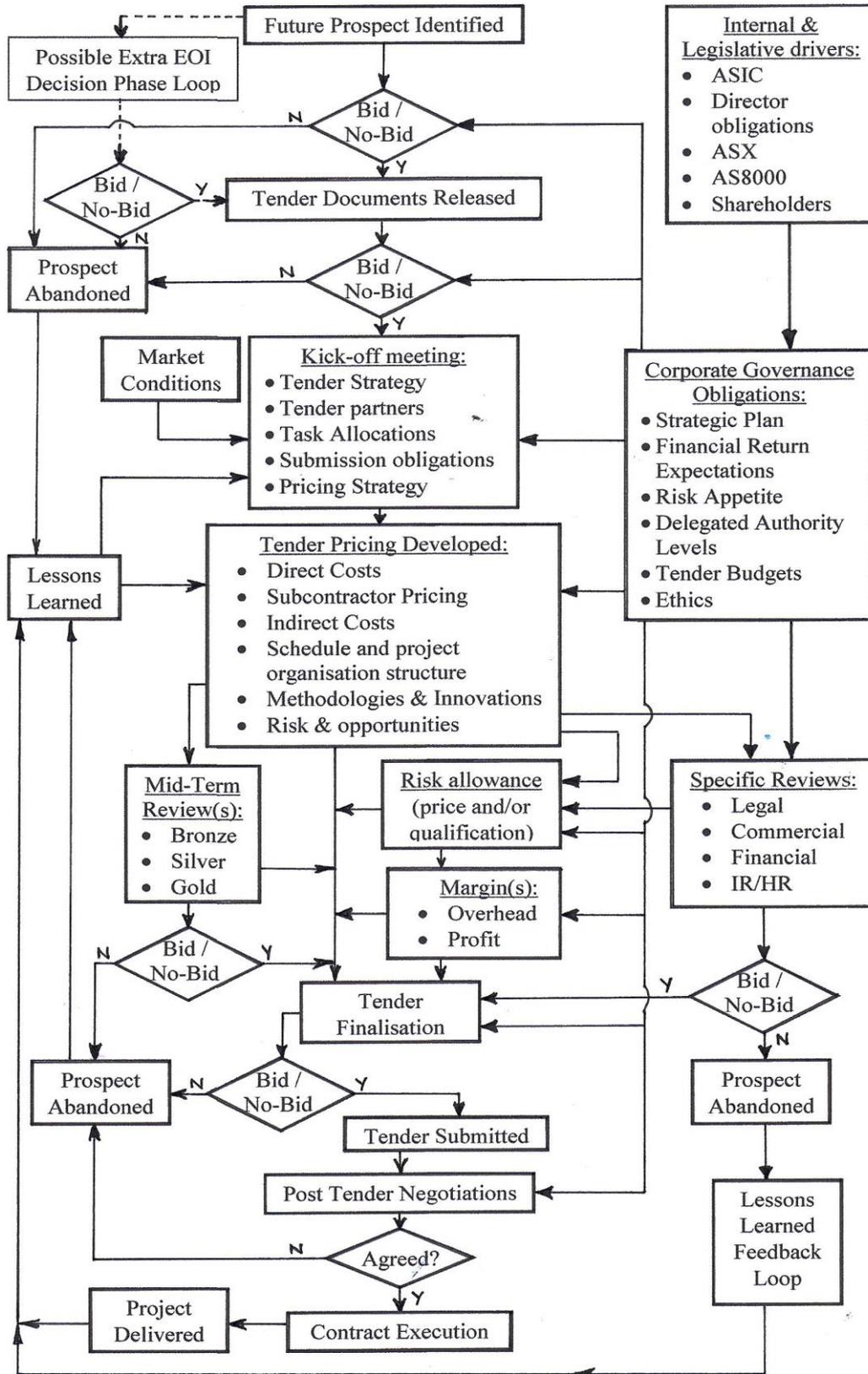
With increasing corporate governance requirements the nature of Australian CC internal tender procedures is changing. A research program is underway to assess the effectiveness and efficiency of such changes and to determine whether such increased governance is producing improved CCs' business results. To facilitate this objective a better understanding of current CC tendering practices and procedures was sought through detailed semi-structured qualitative interviews with 18 CCs, including five of Australia's largest contractors.

This interview based research finds that Australian CC internal tender review processes are increasingly being driven by risk identification, mitigation and internal reporting requirements rather than determining a winning 'mark-up' value. CCs' commercial, legal, financial and risk departments are increasingly influencing the approaches taken with tender strategies, reviews and any subsequent qualifications. In some CCs such internal independent review committees see their role as protecting the company from potential loss or excessive liabilities rather than facilitating the securing of a winning tender. Given these additional constraints 22% of the CCs said they were now spending as much as 15% (half the CCs said over 10%) of their total tender period hours on work associated with internal review processes.

Information obtained from these semi-structured interviews together with extracts from tender procedures provided by nine of the CCs have been used to develop a detailed qualitative contractor internal tender procedure flowchart (Figure 1). This new qualitative flowchart provides researchers with a greater insight into the inner workings of CCs' internal tender procedures and CCs with an opportunity to benchmark their tender procedures.

These semi-structured interviews also serve as a pilot study for a quantitative survey, on CCs' decisions to tender and how their tender procedures interrelate with corporate governance approval requirements, to be issued to the 408 individual CCs on the Austroads' NPS (Austroads 2017) in the next stage of the wider research program.

Figure 1: Developed contractor's internal tender process flowchart



In a later stage a Delphi technique involving a panel of CC experts will evaluate various tender procedure framework examples to identify and prepare what could be considered as an 'efficient' CC tender procedure. An assessment of the effectiveness of the tender procedures and whether they are producing improved CC business results will be undertaken by reviewing CCs' financial performance over the last five years. Overall business performance is considered to be a better guide than the vagaries of individual projects.

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# DEVELOPING RESILIENCE IN SUBCONTRACTING ORGANISATIONS DURING DISASTER RECOVERY

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The large-scale reconstruction in Christchurch following the 2010/11 earthquakes has generated a substantial demand for construction employment. Given the fact that subcontractors execute up to 90 per cent of the on-site jobs in most construction projects, subcontractors exert a strong influence on the outcome of reconstruction projects. Based on case studies of subcontracting businesses involved in the reconstruction of the Christchurch City, this study investigates the workforce resourcing strategies adopted in subcontracting construction businesses. Research findings revealed that the subcontractors' workforce resourcing is highly vulnerable to labour market changes and competition in securing projects. Business agility and resiliency have been seen as critical for the survival of the subcontracting businesses, especially during recovery operations. In producing resilient business, subcontractors enhance their business survival by strengthening their core businesses, diversifying their business operation, maintaining good relationships with main contractors and outsourcing work to provide flexibility. In this study, a simplified version of the workforce planning is provided to suit the needs of the construction companies. The interdependency between the subcontractors' business environment and their organisational strategic planning has been developed. The suggested workforce resourcing strategies could benefit small and medium-sized businesses in strategizing their workforce needs and sustaining their competitiveness in a complex and uncertain construction market.

Keywords: Christchurch earthquakes, post-disaster, reconstruction, workforce resourcing

## INTRODUCTION

The Canterbury earthquakes series-Darfield earthquake (September 4, 2010), Lyttleton earthquake (February 28, 2011) and Christchurch earthquakes (June and December 2011)-have taken a severe toll on the built environment of the Canterbury region (Potter *et al.*, 2015). The destruction equated to NZD40 billion dollars, approximately 20 percent of the New Zealand Gross Domestic Product (GDP) (Potter *et al.*, 2015; Stevenson *et al.*, 2015). The physical destructions reduced the operative capacity of the affected businesses and constrained the businesses' operation routine (Parker *et al.*, 2012). The Canterbury earthquake series affected the sustainability of small and medium enterprises in Christchurch. Some businesses survived and thrived in the post-earthquakes environment while many small and medium-sized found it more difficult to sustain their businesses (Inland Revenue Report, 2014). Stevenson *et al.*, (2015) showed that resource adequacy and strong inter-organisational networks reinforced organisations' business continuity in an altered post-disaster environment. The Christchurch construction sector

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grew in the post-earthquakes but the high demand for skills and costs to rebuild Christchurch led to significant skills shortages in the labour market. Consequently, the complexity of post-Christchurch earthquakes presents a challenge for accurate forecasting of the workforce (Chang *et al.*, 2015b). Skills shortages in the Christchurch subcontracting businesses are attributable to the lack of matching skills within the sector (Piri *et al.*, 2015, Chang *et al.*, 2015a; Chang *et al.*, 2016), workforce fluidity (Chang *et al.*, 2015a), ageing workforces (Chang *et al.*, 2015a) and fluctuations in the workflow outlook (Chang *et al.*, 2015a).

The mainstream literature reported the universal relevance of workforce resourcing strategy in large construction organisations (Loosemore *et al.*, 2003; Raiden *et al.*, 2003; Dainty *et al.*, 2005). However, small and medium-sized construction organisations face wider challenges and there is little empirical research on this sector. Collective workforce planning is affected by the limited subcontractor financial capacity (Chang *et al.*, 2016), constraints in the subcontractors' internal knowledge base (Chang *et al.*, 2016) and the subcontractors' vulnerability to the construction market fluctuations (Ng *et al.*, 2009). Despite the subcontractors' domination in the construction industry, there is a dearth of research exposing their resourcing capacity in the construction projects (Shash, 1998; Dainty *et al.*, 2001; Asgari *et al.*, 2014). Based on case studies of subcontracting businesses involved in the reconstruction of the Christchurch city, this study analyses the workforce resourcing strategies adopted in small and medium sized subcontracting construction businesses under an environment facing severe pressure. It addresses the following queries - (i) What are the resource shortages in the investigated subcontracting businesses; and (ii) What are the investigated subcontractors' workforce resourcing strategies?

## **SUBCONTRACTOR BUSINESSES AND DISASTERS**

Subcontractors play an important role in construction project outcomes. Previous studies indicate that subcontractors execute 60 to 90 percent of the overall physical execution in any construction project (Kumaraswamy and Matthews, 2000; Karim *et al.*; 2006). The predominance of subcontracting businesses makes construction project success rely heavily on the subcontractors' performance and capability (Ng *et al.*, 2009; Banki *et al.*, 2009; El-Mashaleh, 2009). Alzahrani *et al.*, (2013) show that accessibility of labour resources is critical to the construction project success. Their findings revealed that labour availability acts as a strong influencer over the builders' project scheduling, budget and impact models. Similarly, the degree of labour productivity has been shown to be decisive in ensuring a positive outcome on the construction projects (Sacks and Harel, 2006). A preliminary study conducted by Harel (2005) identified (i) capacity utilisation, (ii) workflow stability, (iii) level of financial exposure and (iv) cash flow as important factors for subcontractors' business continuity.

The subcontracting businesses stand in stark contrast to the low rate in implementing formal institutional of workforce management. Informal routinisation is most likely to be legitimised in their businesses' operation as a result of resource constraints within the organisations (Dundon and Wilkinson, 2009). Additionally, the subcontracting businesses are inevitably prone to the external business interferences; particularly to the construction market fluctuation and turbulences in the economic cycle (Ng *et al.*, 2009). Arditi *et al.*, (2000) indicate that most subcontracting businesses are not well equipped with business knowledge and thus, jeopardise the permanency of their businesses. Business failures, high bankruptcy rate, poor performance and/or non-performance are therefore, synonymous with small and medium-sized construction businesses (Russell *et*

*al.*, 1991; Shaikh, 1999; Schaufelberger, 2003). Subcontractors' business failure is associated with defective managerial skills and stunted business maturity (Abidali and Harris, 1995; Schaufelberger, 2003).

Following the Christchurch earthquakes, subcontracting businesses were at the forefront of rebuilding efforts. Chang *et al.*, (2016) found that subcontractors in Christchurch encountered fragile business stability because of the heightening unemployment growth and workload inconsistency within the sector. Investigating subcontracting businesses showed difficulties with workforce resourcing planning, susceptibility to the construction market changes and informal management approaches. When the Darfield earthquake struck Christchurch in 2010, the New Zealand construction industry was going through a period of low activity caused by the 2008 global financial crisis. Wilkinson *et al.*, (2015) reported that earthquakes provided a period of significant growth for construction contractors of all sizes. Their report showed that between 2010 and 2011, capacity building, innovation and upskilling for growing businesses become a focus for construction businesses. Most businesses went through a period of significant growth and there were new entrants to the market. For companies, this meant a period training, recruitment, resource shortages and developing ways of maintaining their staff in the face of external competition. Some businesses focused on developing better working environments, others had to develop new business systems to cope with growth.

Their report (Wilkinson *et al.*, 2015) also showed that between 2012 and 2013, with the continued demand for labour and associated cost inflation in the construction market (in the earthquake and the non-earthquake related construction markets), businesses focused on improving their efficiency, productivity and capability in undertaking earthquake-related work. Imported workers from outside Christchurch impacted businesses including businesses having to pay higher wages and facing increased pressure on housing their workforce. The 2014 and 2015 activity showed that, workload fluctuations meant contracting businesses moved to diversify into new business markets such as new subdivisions in Canterbury and housing and infrastructure markets elsewhere. There were concerns about the risks of overcapacity in Christchurch.

The surge in construction activity following the earthquakes offered the sector the chance to develop skills and capital base for improving business economic prospects. The results of the work on Christchurch subcontractors by Chang *et al.*, (2014) and Wilkinson *et al.*, (2015) showed that there was a range of initiatives that subcontractors used to develop their business. The first element was in establishing and maintaining a solid client base where future opportunities coming from the new subdivision areas in Christchurch and/or other building activities likely in Canterbury region meant a conscious decision to focus on existing clients and growing new business relationships. Diversification of business services and skillsets was also a key initiative seen in Christchurch where recruitment of skills in specialist areas combined with resource sharing through partnership, became a channel to diversity business types. Retaining flexibility in workforce composition, especially through recruiting younger workers (under 25 years old) in an attempt to ensure flexibility in the use of labour due to the lower skill sets these workers have and to enable them to respond to uncertainties in the economic environment. However, this form of flexibility increased turnover rate among younger workers and hence companies ran the risk of lower performance.

## **RESEARCH METHODOLOGY**

In 2016, a group of small and medium-sized subcontracting businesses in Christchurch were approached to take part in this study, with thirteen agreeing. This study adopted a

case study approach to understanding the business strategies and management of the labour markets. Interviews were conducted with the managers (e.g. operation, general, managing) of the subcontracting businesses; enabling insights into the micro-level of the subcontractors' resourcing priorities. All the interviews were verbatim transcribed and analysed using Leximancer, NVivo 10 and Vensim PLE software. Leximancer scrutinises the transcribed texts and graphically displays the extracted data into concept maps and the interrelationships between the themes (Smith and Humphreys, 2006; Sotiriadou *et al.*, 2014). In this study, transcriptions relating to resource shortages were fed into Leximancer and the results are presented in Figure 1 and Figure 2. Following this, the subcontractors' workforce resourcing strategy is thematically collated using NVivo 10. Details of the participating subcontracting businesses are provided in Table 1.

*Table 1: Subcontracting Business Profiles*

| Subcontractors | Characteristics                                       | Resourcing for Disaster Recovery Projects Experience (Year) |
|----------------|---|---|
| S1             | Roofing specialist                                    | 4   |
| S2             | Civil construction and drainage subcontractor         | 4   |
| S3             | Civil construction subcontractor                      | 4   |
| S4             | General civil subcontractor                           | 4   |
| S5             | Building services specialist                          | 4   |
| S6             | Civil construction subcontractor                      | 4   |
| S7             | Steel reinforcing specialist                          | 3.5   |
| S8             | Commercial, heritage and residential subcontractor    | 4   |
| S9             | Civil construction and drainage subcontractor         | 4   |
| S10            | Civil earthworks and civil construction subcontractor | 4   |
| S11            | Building façade specialist                            | 3.5   |
| S12            | Civil engineering earthmoving subcontractor           | 3.5   |
| S13            | Geotechnical and civil construction subcontractor     | 4   |

## FINDINGS

The paper focuses on two main findings as follow:

1. Analysis of labour shortages and the contributing factors to labour shortages in the case study subcontracting businesses
2. Analysis of subcontractors' workforce resourcing planning strategies

### Labour Shortages

Figure 1 shows the major themes relating to resource shortages based on the case study subcontracting businesses. A direct connection was evident between labour, demand, skill shortages, tradesperson, experience and local pool of talent. The subcontractors involved with the recovery projects have felt the tightening of the labour market, facing difficulties in accessing the right staff. From the interviews, a frequent referral to labour shortages was found, reflecting an exhausted talent pool in the Christchurch construction industry.

Labour is a problem with the increased workload. The workload is getting bigger even now from last year so yes, getting labour in place is a priority and it's not easy. S11

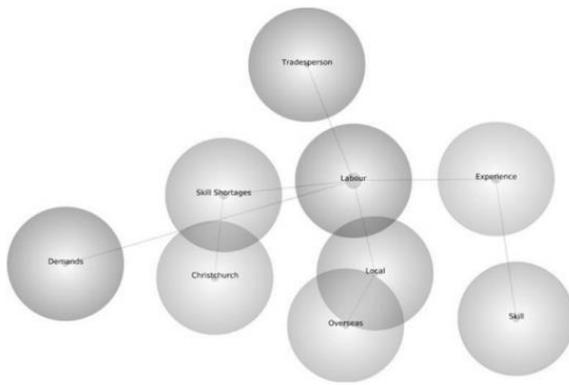


Figure 1: Leximancer Analysis on Resource Shortages in the Case Study Subcontracting Businesses

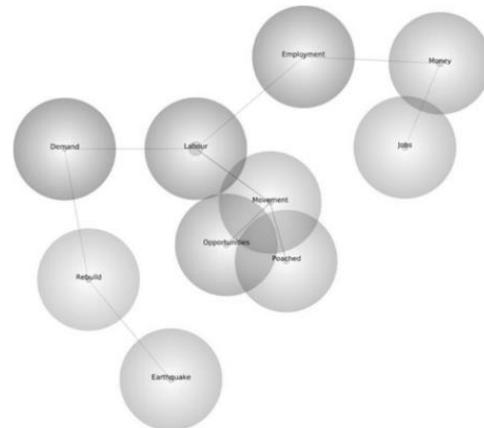


Figure 2: Leximancer Analysis on Contributing Factors to Labour Shortages in the Case Study Subcontracting Businesses

The Christchurch recovery projects demanded an escalation of workforce expectation within its construction industry. A 100 per cent upsurge of construction workforce employment has been quantified in the second quarter of 2015 as compared to the pre-quake environment. In September 2015, 31,000 construction workforce employments have been recorded with the anticipation of continuous growth until 2018 (MBIE, 2015). The derived demand for construction employment has a significant impact to the subcontracting businesses in Christchurch.

Demand for these people (skilled labour) is high and therefore they are free to come and go as they please, like within other businesses, etc. So you've got to work hard to retain them and you've got to be very flexible with how you tackle the problem. S7

The findings also revealed that the escalated demand for skilled workforce has plagued subcontractors with a significant workforce difficulties.

One of the difficulties is they're a bit transient; they don't stay. They try to move around for more money. Some of them are just here for a short time so they try to use the opportunity of getting a job and they agree on a rate for the work. Then, they immediately want more and then they go to another contractor and maybe they get more, maybe they don't, but they just move around. S13

There was general agreement on the consequences of the workforces' portability. The workforce departures restricted the businesses in taking up work. This scenario signifies the need for a smarter workforce management strategies to combat the 'early-departure workforce' trend.

The contributing factors to labour shortages within the case study subcontracting businesses are presented in Figure 2. From the analysis, labour shortages emerged in conjunction with the demand for rebuilding Christchurch, workforce fluidity across the industry and the monetary-driven employment trend in Christchurch. The scarcity of workforce was agreed by a majority of the subcontractors to affect their business performance. Essentially, the investigated subcontractors acknowledged the workforce as drivers for productivity improvement and achieving sustainable competitive advantage.

We don't want it to be a negative in our tendering processes. We still want to be able to price the jobs on the basis that we will have the people, but with the same token, we are actively looking to try and hold the people we think can fill those roles. S3

The notion indicates that organisational performance is correlated to the quality, suitability, and capability of the organisation’s workforce.

### Subcontractors’ Workforce Resourcing Planning Strategies

The results featured in this study showed the subcontractors’ initiatives in ensuring sustainable success to their businesses. In particular, a prioritisation of the organisations’ market adaptability and business agility has been evident; supplemented with a ‘short to medium-focused’ business planning. Two fundamental planning elements were found from the investigation, (i) workforce skill requirements, and (ii) business strategy. Workforce skill requirements place attention on strategizing the organisational ‘workforce supply and demand’ essentials, workforce composition, staffing, retaining and capacity building of the human resources. Business strategy focuses on the creation of adaptable business operations.

We still stick to the core business, but we are just trying to get our teams a bit tighter. So, better staff. We pay some of them a little bit more, the good guys a wee bit more, but they are achieving more. S10

As such, a great deal of effort is directed to strengthening and growing business.

Diversification is a necessary part of growing a business. The first part is your core strengths - your core strengths are what you’ve got to be good at - but as you grow your business you need to be agile enough to diversify into other markets. That’s not to make those the core instrument for your revenue, but it’s to meet modern demand. S5

The ability to acclimatise promptly to the construction market fluctuations is most desirable in the dynamic business environment. Accordingly, organisational agility has been cited by one of the investigated subcontractors to be pivotal in sustaining the business success.

Resilient and agile as well. Agility is important because there are opportunities all the time. S13

In order to deliver benefits of the workforce resourcing planning initiatives, the identified workforce requirements have to be embedded into the organisations’ business decisions. Figure 3 demonstrates the integration of these two elements to form the subcontractors’ workforce resourcing planning strategy. This integration is expected to enhance businesses with the capacity to shift, flex and adjust in a highly dynamic market.



Figure 3: Subcontractor Workforce Resourcing Planning Strategies

## DISCUSSIONS

Over the years of responding to earthquake rebuilding, subcontracting businesses became strategic in their business decision making and in their approach to sustaining their businesses. Findings from this study demonstrate a maturing of the studied businesses coupled with the application of multiple methods for solving workforce problems. It is clear from the results that businesses had to absorb the effects of the earthquakes, seeking to minimise any adverse impacts on their business, especially around resourcing the workforce and the changing workforce structures.

Given the susceptibility of the subcontracting businesses to the construction market fluctuations, it is, therefore, important for subcontractors to understand the interplay between the environmental scenarios and their organisation's strategic planning. Knowledge of the business environmental forces afforded the investigated subcontractors with their business environment pattern, identification of the industry's opportunities and threats and, most importantly the development of the organisations' strategic action plan in responding to the changing environment. Essentially, sensitivity to the labour market fluctuations facilitates subcontractors to establish workable measures in circumventing the impacts of skills shortages (Dainty *et al.*, 2005).

In order to build a resilient business performance, it is critical to establish organisational performance in accordance with the organisations' vision, goal and growth plans. Figure 4 shows a conceptual model of the interdependency of the subcontractors' business environment, workforce planning strategies, project resourcing and organisational outcomes applied in rationalising the basis of the workforce planning imperatives.

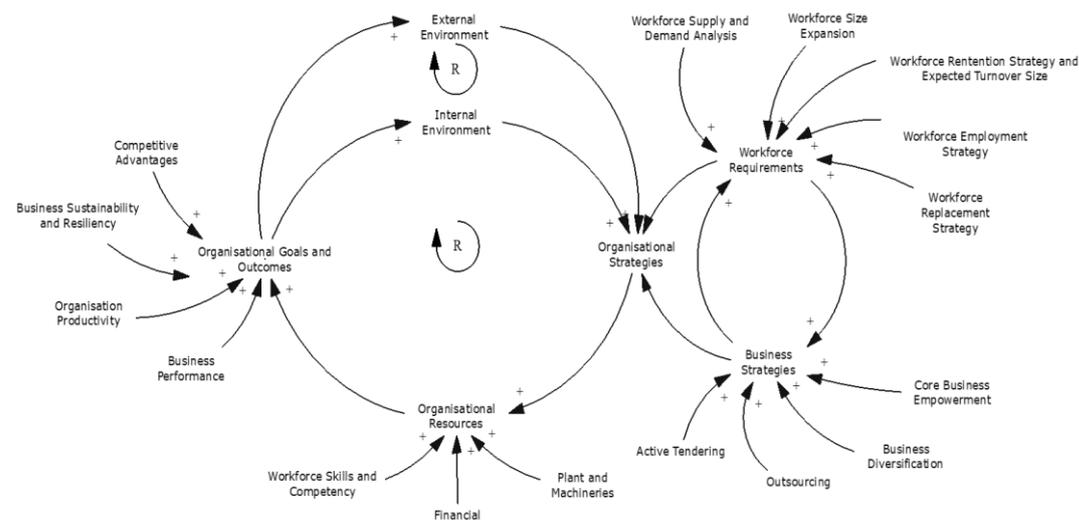


Figure 4: The Interdependency of Business Environment, Workforce Planning Strategies, Project Resourcing and Organisational Outcomes in the Subcontracting Businesses

The need to sustain competitive advantage makes it germane to embrace adaptive capacity to cope with the external turbulences. For this reason, the subcontracting businesses have to demonstrate business agility in seizing strategic opportunities. The sustenance of an organisation competitive advantage often gravitated around the ability of the organisation in sustaining its people and the execution of people processes (Brandenburg *et al.*, 2006).

Maintaining workforce flexibility results in improving the internal organisational strength to capitalise on business opportunities. The external environmental dynamics are readily recognised to interfere with the subcontracting businesses' internal attributes. Therefore, a diagnosis of the organisations' internal environment is important in averting the external

threats and overcoming the internal weaknesses. The internal capacity of the subcontracting businesses (e.g. workforce skills and competency, financial, plant and machinery) determines the execution of the subcontractors' competitive strategy.

Workforce utilisation has been actively practised and agreed by a majority of the investigated subcontractors as an ad-hoc solution to meet the organisations' staffing requirements. Although workforce utilisation is capable of ameliorating the adverse effects of the organisations' skill issues, its long-term focus could strain the organisations' ability in coping with business expansion (Loan-Clarke *et al.*, 1999). An integrated system of workforce resourcing programming and the organisations' strategic business planning with the ability to manage future events' consequences can strengthen business performance.

## CONCLUSIONS

The changing built environment in Christchurch, coupled with intensified competition in acquiring qualified skills meant that subcontracting businesses were forced to adapt their businesses and focus on business demands of lack of resources and workload fluctuations. Post-earthquake challenges demanded an organisational ability to respond and successfully change. Workforce planning initiatives were developed to ensure the organisations' skills base could be maintained. A planned approach to long-term workforce resource planning is needed in for greater predictability to the organisations' employment outlook and equipping subcontracting businesses with a specific functional procedure on workforce resourcing planning. The research also suggests that a focus on adaptability, internal skills and workforce capacity building are critical to resilience building in subcontracting businesses. Through the crisis, subcontractors have emerged with the ability to create sufficient workforce resourcing for projects, strategic utilisation of workforce, better workforce cost control and higher overall organisational efficiency. As the earthquake rebuild continues further analysis will provide an examination of how maturing subcontracting businesses face the market slowdown.

## ACKNOWLEDGEMENT

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# **TECHNOLOGY**

# EPISTEMOLOGICAL DIFFERENCES AND NEW TECHNOLOGY IN CONSTRUCTION

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New technology within the construction industry originates from appeals to replicate the efficiencies seen in other sectors such as automation and manufacturing and construction firms are increasingly engaging in collaborative research and development (R&D) projects with sector specialists. These R&D projects create new communities of practice with a shared collection of knowledge, experience, and problem-solving approaches representing the disparate expertise of each member contributing to the development of new and innovative technological solutions. However, fundamental epistemological differences between the collaborating firms can hinder this process. Shared knowledge and experience to develop ideas is not easily communicated across a project team within which each member possesses a differing approach to understanding the common problem. This paper presents early research engagement in an R&D project investigating the potential of utilising Flexible Robotic Assembly Modules in the Built Environment (FRAMBE). Challenges observed to date during the process of developing FRAMBE as a technological solution are described. This paper aims to exemplify communication issues within cross-sector R&D projects to argue that boundary objects offer a means to consider the epistemological differences within communities of practice, establish a common understanding of the problem, and therefore ways in which to resolve issues surrounding technology development.

Keywords: robotics, technology development, epistemological differences

## INTRODUCTION

Cross-sector collaboration is seen as an important contributor to the increase in rate and efficacy of technology development within the construction industry (Fairclough 2002). Organisations are increasingly engaging in R&D projects that explore and test new methods of construction using concepts widely used in the manufacturing and automation industries - for example, robotics and prefabrication. But more specifically to this study, Flexible Robotic Assembly Modules in the Built Environment (FRAMBE).

These R&D projects bring practitioners from disparate fields of expertise - defined by the project objectives - together within a group to develop a solution to a problem. Problem-solving in this context necessarily requires the communication of knowledge and experience but in contrast to R&D projects carried out within single-industries, R&D projects in developing fields involving cross-sector collaboration - in this instance robotics in construction - 'much of the knowledge is yet to be codified' (Cardinal *et al.*, 2001). Project members draw on knowledge, experience, and problem-solving approaches specific to their field in order to engage in an iterative 'learning-by-doing'

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process however, this is particularly difficult the greater the epistemological distance there is between collaborating participants.

Using the concept of boundary objects this paper begins to unpack the epistemological differences among disparate firms within a construction R&D project at the early stages of the problem-solving process. It is argued that epistemological differences can be better understood - particularly in an early stage R&D project - by placing more focus on the materiality of artefacts mobilised within group interactions. The production and transformation of boundary objects are suggested as a useful method to examine the epistemological differences within a cross-sector R&D.

This paper is structured as follows: firstly, the concepts of communities of practice and boundary objects are used to discuss the ways in which they can be used to frame knowledge development within cross-sector R&D projects; secondly, using these concepts the case study project is described, introducing the situated activities of each community and illustrating the localised contexts of their knowledge, experience and practice; finally, the utility of focussing future research activities on the examination of boundary objects in the development with R&D to support the process of technology development in the construction industry is discussed.

## **KNOWLEDGE PRODUCTION ACROSS COMMUNITIES**

A community of practice is a group of individuals 'who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis' (Wenger 1998). Within this context practice is defined as the work done by the group, and as a social learning theory communities of practice focusses on the way in which individuals 'establish themselves and function as a group by engaging in practices that are unique to or characteristic of that group.' (Cook and Brown 1999). Each member has knowledge derived from theories, rules and concepts that constitute the epistemology of the community of practice in which they are situated. The focus of learning is placed on how the group interacts and the way in which the tacit body of knowledge held by the group is exchanged to support, enrich and direct practice. Within a community of practice meaning and consensus of understanding is negotiated through participation and engagement with practice that is fundamentally social in nature.

However, this implies interconnectedness between individual knowledge and group knowledge to interpret meaning. Yet in some cases the epistemological differences within a group are too broad to be considered as a single community of practice - Wenger (1998) describes these configurations as 'constellations of practice' - and lack the connectedness between individual knowledge and group knowledge. Knowledge is 'localized, embedded and invested' in each community of practice and the greater the distance each community has from another makes the task of working 'across' practice boundaries and accommodating knowledge created in another more difficult (Carlile 2002).

In this instance, the concepts of reification and boundary objects are significant in bridging these epistemic boundaries. Wenger defines reification as "the process of giving form to our experiences by producing objects that congeal this experience into 'thingness'" - understanding is given form which then becomes the focus for the negotiation of meaning. These objects represent the tacit knowledge inherent within the group - the abstractions of epistemological perspectives - that the group interacts with.

Cook and Brown (1999) conceptualise the interaction between knowledge and ways of using knowledge ('knowing' as practice) as a 'generative dance' whereby knowledge is not simply transacted. Knowledge is acquired, reshaped by existing knowledge and practice to produce new knowledge and new practice, and it is through this 'generative dance' that epistemologies are 'bridged'. This interplay between knowledge and ways of using knowledge in the process of learning-by-doing brings to light the ways in which each community carries out their work. Reification within this context produces material artefacts that are a representation of the generative dance taking place and reflect the practices used to develop them. Both Cook and Brown (1999) and Wenger (1998) position these objects as products of human agency and secondary to the understanding of the social. However, a number of scholars provide an alternative to this perspective placing more emphasis on the role objects have to play in the bridging of epistemologies (Whyte and Harty 2012; Leonardi and Barley 2010).

In this way, the products of reification in the context of a cross-sector R&D project become boundary objects with attributed materiality. As the project moves through development these boundary objects - going through various 'generative dances', negotiations, and reifications as part of the learning-by-doing process - change in their content reflecting the new knowledge and practices used to produce them.

However, R&D projects have development programmes that define the types of activities that need to be completed and who are required to complete them. The types of knowledge boundaries faced will vary as will the type of objects that are useful to intersect them and transform knowledge (Carlile, 2002). Star and Griesemer (1989) define boundary objects as "both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites" maintaining that the methods used to generate boundary objects should "maximise the autonomy and communication between worlds". Based on their empirical analysis Star and Griesemer (1989) developed four types of boundary objects mobilised as analytical categories: **REPOSITORIES** - ordered piles of objects indexed in a standardised fashion provide a common reference point for shared definitions and values for problem solving. **IDEAL TYPE** - diagrams, atlases or other descriptions that are abstracted from all domains but are adaptable to a local site because of their vagueness serving as a 'good enough' roadmap for all parties. **CO-INCIDENT BOUNDARIES** - common objects which have the same boundaries but different internal contents that can be used across different sites demonstrating the current differences or possible resolution of different goals. **STANDARDISED FORMS** - boundary objects devised as methods of common communication across dispersed work groups in the form of structured standardised indexes that convey unchanging information.

Carlile (2002) discusses the effectiveness of each boundary object category at different types of knowledge boundaries (syntactic, semantic, pragmatic) to characterise the most effective type of boundary object in new product development. Recognising that knowledge is 'localised, embedded, and invested' in practice that needs to be transformed - to create new knowledge, old knowledge has to change (Teece *et al.*, 1997) - Carlile found that objects, models, and maps (co-incident boundaries and ideal type combined) were the most useful in dealing with pragmatic boundaries. But more significantly, boundary objects "have a portfolio effect; repositories and standardised forms support the use of objects, models, and maps as well as support processes to manage knowledge at a pragmatic knowledge boundary".

The context of new product development and R&D are similar - cross-cultural boundaries, different ways of presenting and interpreting meaning etc. - but more specifically in developing industries the production of repositories and 'codified knowledge' are somewhat necessary in establishing them as developed.

However, a key consideration in the development of knowledge and practice is the effect of power (Oswick and Robertson 2009) - communities of practice are defined as self-organising, however one member of the group make take precedence over another dominating the type of knowledge deemed useful and legitimating the ways in which that knowledge is used. As is illustrated in the vignette described in the case section this has had an influencing effect on the type and effectiveness of boundary objects in use.

## **METHOD**

The University of Reading are engaged within the consortium in a research capacity to examine the skills needs and cultural change required to facilitate the implementation of FRAMBE at an industrial scale. This is an ongoing project in the early research stages and this paper presents an emerging case study that focuses on a preliminary examination of the problems associated with trying to communicate tacit knowledge that resides in practice across epistemologically distinct boundaries.

### **Data collection techniques**

Empirical work has involved observations of early factory visits and consortium meetings, and formal and informal discussions with Skanska's project manager and industrialisation manager. Each of the data collection techniques are discussed in more detail below:

- Observations

Field notes were used as a record of key events that happened throughout researcher engagement in consortium activities; including factory visits and consortium meetings. The primary purpose of these visits was to form an initial understanding and conceptualisation of the problem bringing to light the difficulty of these types of collaboration. Field notes were not standardised and not used explicitly for data analysis but used as points of discussion within informal interviews with the consortium members to corroborate researcher understanding of the problems faced by the R&D team.

- Consortium technical meeting - process map meeting

The R&D team have technical meetings whereby they discuss specific work packages related to the delivery of FRAMBE. On this occasion, the focus of the meeting was to discuss the development of process maps to support the design and development of the pilot project. The researcher attended this meeting as a non-participant observer with the aim of capturing how the R&D team interact and exchange knowledge with one another to meet FRAMBE deliverables. The meeting was videotaped and preliminary observations were made - framed through the literature - to identify instances of differing conceptualisations of the problem discussed and the way in which they were overcome.

- Informal interviews/discussions

An informal interview was held with Skanska's project manager and industrialisation manager to discuss the current progress of FRAMBE. Workflow diagrams, created by the Lean Consultancy firm (Figures 1 and 2) but based on consortium activities, were

used as a visual point of reference to talk about project progression and future consortium activities. Within the context of this paper, these workflows are taken to represent emerging boundary objects that bridge the epistemological differences between consortium members and form early codified knowledge from which to collectively problem-solve. Talking around these workflows with Skanska's project manager and industrialisation manager focussed discussion on how the project had got to the point it was currently at and why decisions were made as they were. This interview was recorded but at the time of writing, was not fully transcribed.

## **THE CASE: FRAMBE**

The Flexible Robotic Assembly Modules in the Built Environment (FRAMBE) concept is a scalable, automated and modularised Flying Factory solution that will integrate advanced robotics to manufacture a wide range of building components that are appropriate to the needs of a specific project. Using robotics in a Flying Factory setting to automate a range of construction processes brings a broad set of benefits to both the project and the operatives involved, such as improvements to health and safety and productivity by using machines to carry out physically demanding and repetitive tasks in dangerous environments. This task-general approach to robot design also has a number of potential benefits including: reduced threshold and personnel training costs; provides a better economic justification by distributing initial capital costs across multiple projects; and also provides the opportunity to lease the robotic system.

The FRAMBE pilot project forms the early stages of a larger innovation project aiming to expand the concept of mobile 'flying' factories (Young *et al.*, 2015) to include robotic automation. Prior to industrialisation Skanska are testing the feasibility of introducing robots and investigating the process change and technological requirements through a pilot project.

The consortium, led by Skanska UK, consists of: a major robotics manufacturer designing and developing the robotics technology; a lean consultancy firm mapping existing workflow processes and the higher level feasibility processes that a company will need to go through to identify tasks for automation; and a CAD/BIM consultancy firm developing a means to extract programmable data from 3D models for robot task execution.

Each of these project team members represents a distinct and localised context of knowledge, experience and practice. The epistemological differences between Skanska, the robotics manufacturer, and Skanska fabrications begin to emerge in the following vignette that describes the development of boundary objects necessary for the practical aspects of developing the pilot project.

### **Selecting an appropriate pilot project**

In the early stages of the R&D project, the team conducted a number of workshops to identify a suitable project to focus design and development activities. A simulation of the Flying Factory concept was used to stimulate discussion of various options to focus the pilot project on.

However, one of the primary goals of the FRAMBE project is to be able to export the required data from 3D models to automate the process of creating a tool path that the robot understands. In order to design a tool path for the robot to pick up a component, angle it against another, and begin to carry out a defined function it needs to have physical dimensions, diameters, vertices, edges and surfaces to trace around.

In light of this prerequisite the consortium have chosen to focus the pilot project research activities on the introduction of welding robots at Skanska's factory in Slough UK to improve the efficiency of manufacturing pipe modules for plant/boiler rooms. The purpose of selecting this case is that the prefabrication division of Skanska UK already have relatively consistent and well-defined workflows in place. These provide an ideal scenario within which to test and prove the information management solutions developed by the consortium that are necessary for the introduction of robotics into one of the factory's welding bays.

### **Emerging epistemological differences - defining the problem**

Whilst the pilot project had been selected, further problems emerged that exposed competing epistemologies as to the scope of the problem and what kind of solutions should be investigated.

For example, in a technical meeting - that took place at the robotic company's head office - where the team first discussed the viability of focussing the pilot project on the manufacture of pipe modules, various automatable tasks were identified: painting, welding, manipulation, assembly etc. These were discussed by both Skanska and the Lean Consultancy representatives in terms of the wider process change requirements necessary to implement them, posing the question "*Can we automate all these things?*" - signifying their approach to the problem was coming from an industrialisation perspective. The Robotics representative responded to this question with a categorical "*the answer is yes to all of those things*" going on to imply that the wider considerations of how to implement robotics in construction was not the focus of inquiry at this juncture of the project, saying

...let's get the automation in there first and then the construction industry is going to have to look at how it optimises its materials to take advantage of that.

Recognising the difficulty the team were having in deciding what to automate and how this could potentially stall the progress of FRAMBE the robotics project manager went on to describe the process by which they normally design and develop robotic systems with manufacturing based clients:

...what our customers would normally do is to give our engineers or our applications guys these drawings and basically say 'go do' and the applications guys will look at it and say yeah do it that way. [Robotics Project Manager]

In effect presenting an abstraction of the process of robotic system design to which Skanska and the Lean Consultancy firm could focus the inquiry that followed. The problem was reframed toward the process of designing and developing a robotic system - that of requiring well-defined processes - and project activities turned towards capturing the factory's existing information and welding bay workflow processes. The development of these and the project decisions this resulted in are described in the following section.

### **Existing factory processes - an 'ideal type' boundary object**

Developed from discussions between the factory manager and members from each consortium partner, Figure 1 shows the current information management processes of the factory. This provided a 'good enough' scope of the context for Skanska to understand how to approach the industrialisation aspects of FRAMBE and the robotics and CAD consultants to understand how to begin the design of the robotics system.

Currently the factory receives client drawings and 3D models that are insufficient to use as-is for the way that the factory manufactures - components may be in the wrong place, incorrectly specified, or misaligned. The factory then redrafts these 3D models solely for

the purpose of rationalising the original into the design for manufacture standard the factory processes are attuned to - the models do not contain any useful data within them for the CAD consultants and robotic designers to easily proceed with the design of the robotic system. After the model has been rationalised the factory engineers draft cut-sheets independently from the 3D model handwriting orientation, vector, diameter and wall thickness information for the welder's to use on the shop floor. The reason for this two-stage information production process is primarily related to well-established practices on the shop floor that centre on the use of cut-sheets - as illustrated in the Welding Bay Process shown in Figure 1.

Through the production of this workflow diagram - as a boundary object to articulate the problem - decisions were made regarding the approach to both the development of the pilot project and the industrialisation of FRAMBE. Firstly, that the requisite data contained within the cut sheets would have to be manually translated into 3D objects by the CAD consultants to meet the primary objective of BIM integration.

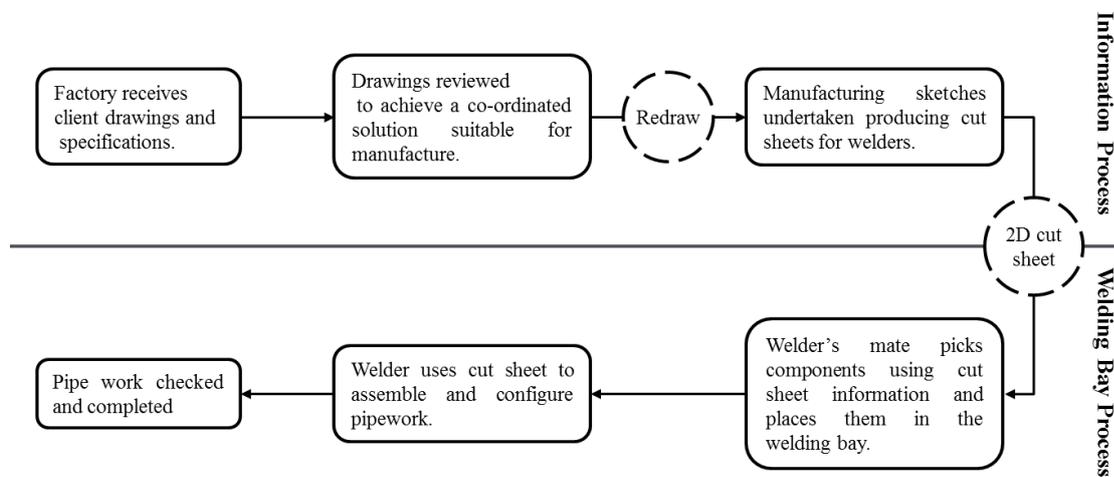


Figure 1: Skanska fabrications factory processes

Secondly, that in order to industrialise FRAMBE the consortium need to develop better defined processes that can be used to bridge the knowledge boundaries between the FRAMBE team and Skanska fabrications, as the Lean Consultant alludes to:

...once FRAMBE has proven the concept they can then go back to Skanska fabrications and say look this is how you should be producing drawings if we want to industrialise it as a method of construction

Furthermore, in understanding the existing process by which the factory operates, the team were able to circumnavigate issues relating to the practices of factory workers bringing coherency to the problem and focussing efforts on the technical activities that could be completed to move the project forward. In the following comment, this boundary is acknowledged by the FRAMBE project manager whilst also alluding to the ineffectiveness of the cut sheets as an object to bridge the boundaries between all the practices within the R&D group. Currently, the cut sheets are only useful as a boundary object between the CAD and robotics company to develop the technical aspects of FRAMBE:

...we need to change knowledge and learning I suppose and the way things are done in order to make an automated robotics solution work. We can create something for the pilot to get by in which we need and at that point we need somebody to say we are going to change our procedures.

Figure 2 represents the synthesis of these decisions and shows how the robotic system fits into the existing factory context, in some ways forming an early example of codified knowledge within the R&D team. The development and transformation of the workflow - that centred around the cut sheets - represents an example of a 'generative dance' that occurred within the R&D team to move the project from a vague concept of FRAMBE through to a pragmatic set of solutions as to how to actually go about delivering the pilot project within Skanska Fabrications.

## DISCUSSION AND CONCLUSIONS

Using the concepts of communities of practice and boundary objects this paper has begun to unpack the epistemological difference inherent in the process of knowledge development within a cross-sector R&D project. The project investigates the potential of incorporating robotics into a 'flying factory' situation as a method of construction to reduce waste, transport costs, improve productivity, and to bring improvements to the health and safety of operatives carrying out dangerous and repetitive work.

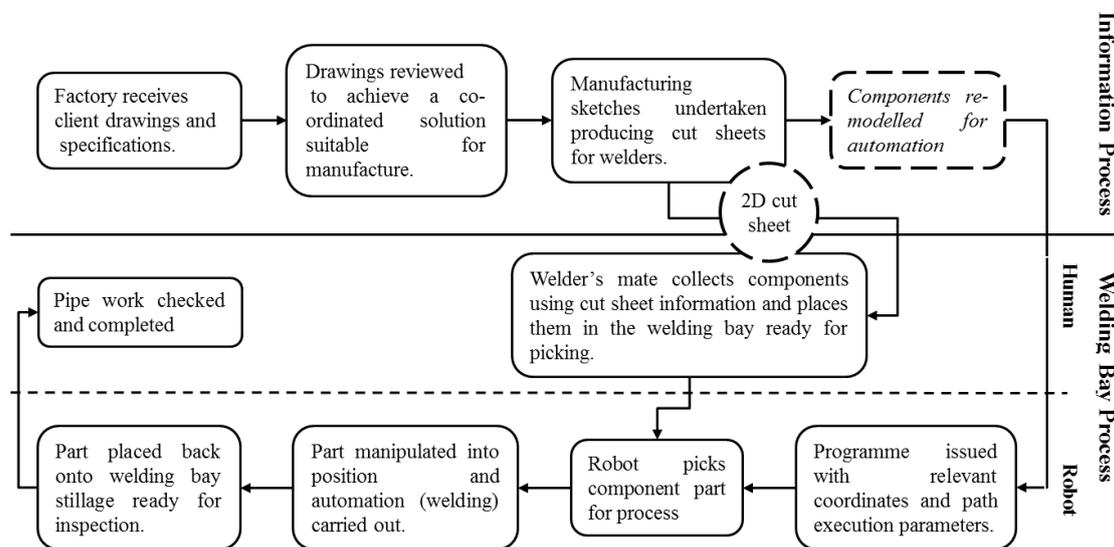


Figure 2: Pilot project factory processes

However, this requires cross-sector collaboration between communities of practice that necessarily bring challenges to the design, development and ultimately deployment of FRAMBE. Each community - Skanska, the robotics company, lean consultancy, CAD consultancy - possess specific knowledge and ways of using knowledge that when brought together in a collective problem-solving scenario meet barriers and difficulties to the exchange of knowledge within the community.

The concepts of communities of practice and boundary objects were used within this paper to frame this problem-solving scenario and begin to unpack the epistemological differences between each community. However, whilst useful in framing the work contexts of each community we argue that the use of communities of practice and the conception of boundary objects that it defines is insufficient in explaining these differences.

Groups of different communities often collaborate but it is our contention that the organic production of boundary objects implied by Wenger (1998) and Cook and Brown (1999) provides inadequate understanding of how groups interact. In the previous section we described how the issue of producing programmable data was addressed - the team identified a potential object to develop into a boundary object rather than going through

an iterative 'learning-by-doing' process - illustrating both the significance of material artefacts in shaping knowledge exchange but also the epistemological challenges of creating effective boundary objects.

Epistemological difference causes imperfect knowledge exchange especially if one community presides with epistemological dominance over another. In the case of FRAMBE, core competencies required to produce a robotic system in construction resided with the robotics company and dictated the type of knowledge required. In the acquisition of this new knowledge, the processes of Skanska, the lean consultants, and the CAD consultants were directed towards the identification of an object that could usefully serve as a boundary object. Whilst this dominance over legitimate and illegitimate knowledge may also have been a result of the time constraints associated with a R&D project it still serves to illustrate how epistemological differences can be identify using the boundary objects - whether effective or ineffective.

For robotics to become a mainstream construction method that continues to improve and develop - rather than a one-off proof of concept - the relevant parties involved in the process of design and development need to be able to understand the problem. By capturing the process of knowledge development - focussing on boundary objects and their production - the epistemological differences between the FRAMBE team may be further unpacked to focus efforts on activities that produce effective boundary objects that bridge these.

As such, future research activities will be directed toward expanding on the vignette described within this paper, examining in further detail project participants' accounts of boundary object creation within FRAMBE. In this paper we have focussed on the creation of 'ideal type' objects - in the form of workflows and how these were used to solve the problem of how to approach the primary objective of BIM integration - but as the FRAMBE project progresses the transformation of knowledge into the different categories of boundary objects will be expanded on and documented. In doing so we can begin to highlight those that were effective as epistemological bridges, those that exposed epistemological differences, and how to use this deeper understanding of the knowledge development process of a cross-sector R&D team in the wider construction industry.

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# A CHANGE OF SCENE: HOW THE CANTERBURY EARTHQUAKE SEQUENCE LED TO A DEPARTURE FROM CONCRETE TECHNOLOGIES

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Over time, nature can expose even the slightest weakness. This became very clear following a sequence of unexpected earthquakes that struck in Christchurch, New Zealand earlier this decade. At the time the quakes struck, research and development with concrete building technology Canterbury had gained an international reputation and contributed significantly to the region's development. Structural and architectural innovation helped make concrete the material of choice for new commercial buildings. The paper outlines some of the key architectural and structural innovations evident in the buildings of the city. The earthquake sequence exposed several shortcomings in the design, construction and maintenance of buildings, including to several buildings that represent key moments along the innovation pathway. Now that the rebuild is well under way it is becoming clear with every building that is completed that the city's visual character will be significantly different. The emerging character appears to be developing around the global materials of steel and glass, with concrete no longer featuring in the ways it had. The paper discusses the background to this departure and how it signals the end of a productive period of innovation with this local material.

Keywords: Christchurch earthquakes, performance, concrete, disaster, innovation

## INTRODUCTION

Throughout its brief history of post-colonial settlement, and prior to the widespread losses arising from the 2010-12 seismic sequence, Christchurch had gained a well-deserved reputation for the quality of its built environment. With the city situated on the flat and expansive Canterbury Plain, those who created the city were untroubled by the landscapes that challenged the builders of New Zealand's other major cities. The flip side to this is that designers have not been able to rely on natural features to frame their work and that the city's visual character is derived almost completely through its buildings, gardens and infrastructure. Buildings in Canterbury are seen against a largely man-made context rather than in relation to nature. There are no distant views to celebrate, no natural landscapes to relate to; instead the outlook from every building and public space has been constructed (Mitchell and Chaplin, 1984).

During the Victorian period of colonisation and growth, architectural sensibilities could be traced back to the English buildings that were familiar to the early settlers. These traditions were often modified by material availability and environmental conditions. The immigrant architect Benjamin Mountfort was one who helped transform Christchurch

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from a village of crude timber buildings into a magnificent city of Gothic Revival buildings by the end of the century (Lohead, 1999). The strong and angular basalt and volcanic stone materials found in the area around Christchurch lent themselves to a style of building that quickly became associated with the city and with its public buildings in particular. Public and expert opinions also agreed that this architectural character was attractive (Fowler, 1984; Terrence Hodgson, 1990).

A factor in the development of a distinctive Canterbury architectural character has been a willingness on the part of architects and engineers to challenge prevailing conventions. For example, Mountfort pursued a different vision for Gothic Revival than did his contemporaries working in Britain and America. The freedom that Mountfort and his colleagues enjoyed by working in a still emerging colony in an isolated part of the world led to opportunities that would have been unlikely had he remained in Europe (Lohead, 1999). Over time, and as architectural theories and practices change, new opportunities emerge for local designers to adapt these to local conditions. In response to such opportunities, concrete materials and technology came to be adapted for use in the Canterbury region by local architects and structural engineers. Over a particularly interesting 40-year period of development last century, this made significant contributions to local architectural and cultural character.

The paper traces the lineage of concrete usage, noting the contribution it made to Christchurch's architectural character, particularly in buildings built between 1950 and 1990. Many of these buildings represented points along a path of innovative architectural and technological development. A sequence of earthquakes in 2010-12 led to widespread demolition of damaged buildings and with it, the city's architectural character. As the city is rebuilt from the ground up, material preferences have shifted to glass and steel. The paper pursues the question of why designers have departed so markedly from the materials and technologies they were working with before the quakes. The analysis is based on published sources, supported by structured interviews with representatives of the design and property management professions. The interruption to the long and productive period of development is contextualised through literature.

## **A CONCRETE HERITAGE**

The conditions throughout the Canterbury region are ideally suited to the manufacture of concrete. The Southern Alps are the backbone of the South Island and continue to grow as a consequence of the ongoing collision between the Australian and Pacific tectonic plates. With each passing year the process spills crushed stone to either side, a continual source of aggregate. Until recently, Portland cement was also manufactured on the west coast of the island, providing a dependable source of concrete's active ingredient. With an abundant and accessible supply of the raw materials needed for concrete manufacture, concrete is without doubt one of the country's indigenous construction materials.

Early settlers were able to build with concrete as early as 1843, using casks of Portland cement imported from England by boat (Reed, Schoonees, and Salmond, 2008). Over the following century their skills and techniques developed and the material was used extensively for infrastructure projects as well as in agricultural and industrial buildings. Somewhat surprisingly at the time, concrete found its way into several residential and civic buildings under the sponsorship of architects such as William Clayton, Frederick de Jersey Clere and Thomas Douce. These early adopters all saw opportunities to enhance construction efficiencies and performance with the still relatively new material (Thornton, 1996).

It was not until the arrival of two European architects in the late 1930s that the architectural potential for concrete began to be realised more widely. In the wake of World War II, the government's ambitious housing programme identified concrete as the principal material in medium and high density housing developments. Immigrant architect Frederick Newman felt that local architects were wasting timber and recognised that concrete would provide better structural performance and durability in social housing projects (Newman and Leach 2003). Even so, in the context of the prevailing Modernist design philosophies, architects considered the material as a means to an end; when it could be plastered and painted white it was an effective medium with which to create geometrically clear architectural form and space. The task of reflecting New Zealand culture and conditions through architecture would fall to the next generation of architects, and concrete became a material of choice.

The period following the war is widely acknowledged as a rich period in New Zealand's cultural and architectural history. From the late 1940s there was widespread interest among architects to develop appropriate design responses, working with the country's unique cultural and social characteristics, responding to the environmental conditions and making use of local materials (Clark and Walker 2000). It was during this time that designers began to recognise the potential of concrete as an architectural medium beyond its previous manifestations.

At this time, New Zealand was riding a wave of international modernity. Participation in the war effort had brought them closer to their European and American allies. However, "international architectural culture began attending to the specificity of particular locations. The conjunction of the local and the modern is a fundamental issue in New Zealand architecture." (Clark and Walker 2000). In these ways, critical regionalism could be distinguished from simple, nostalgic vernacular design. This would drive the search for appropriate architectural forms, embedded in local culture and expressive of the national identity.

These efforts were particularly productive in the South Island, where development was taking place at a great rate to make up for a generation of minimal construction activity. The architects whose work would contribute to the quality of this period were well acquainted with New Zealand's architectural history and also able to draw on their experiences of other places. Accordingly, their work reflected a mix of inherited architectural traditions animated by their own personalities and thoughtful reflection about key architectural concerns of the day (van Raat 2005). The quality of work being produced in Christchurch at that time was particularly high. Walker (2005) suggested that this was in part due to the willingness of clients to commission young designers and in part to the wide variety of projects that were being commissioned. Beaven (1967) also attributed it to the amount of time architects were able to lavish on their work. In his mind architecture enjoyed higher social stature in the city than elsewhere and by the 1960s Christchurch architecture had attained a mythical status (Walker 2005).

A strong lineage of Canterbury designers experimented and worked innovatively with concrete as an architectural material in the latter half of the 20th century. None were as successful as two young architects who set up separate practices in the 1950s. Miles Warren had worked in London where he witnessed the emergence of the Brutalist movement in architecture. Mitchell and Chaplin (1984) noted that Warren was influenced by the aesthetic approach taken by the Brutalist architects, who sought to express the way a building was made. As much as Warren was a rationalist, the architect Peter Beaven was committed to romanticism. He drew his architectural inspiration from

Mountfort, Ruskin and everything Gothic. Having grown up around the family engineering business, he was also comfortable with the honest reality of the grain stores and freezing works built by his grandfather (Beaven 1967, 2002). Beaven (1962) also wrote to educate his colleagues on the exciting aesthetic possibilities that he could see emerging with concrete construction techniques. He was particularly taken with prestressed, precast concrete elements. Earlier construction methods and materials had proven inappropriate for use in the ruthless New Zealand climate and he expressed dissatisfaction with 30 years of depression and wartime standard building. Architecture, he wrote, has a role of excitement and fitness for purpose that must come with more flexible and expressive methods of building. Over the course of their parallel careers, the expressive use of precast concrete elements would be another area their architectural sensibilities would overlap.

The work of these two designers helped redefine the character of the city toward the end of the century. Perhaps the country's most famous 20th century building, the Christchurch Town Hall has been discussed widely since the winning entry to a national architectural competition was first announced. Concrete elements feature throughout the building and the structural proportions are elegant (Gatley 2008). Also around this time, Peter Beaven was given the opportunity to build a new administration building for the Lyttelton Tunnel Authority. The proportions of space and structure are grand, expressive of the widespread pride felt by Cantabrians with the completion of the vehicle tunnel linking the port to the city (Hodgson 1990). The confident use of materials and formal expression also signalled a new maturity in New Zealand's modern architecture (Gatley 2008).

Although it can be difficult to appreciate this now with the central area largely empty, Christchurch earned a well-deserved reputation for the quality of its office buildings. Many of those that were most highly respected were built for those who would be working in them (Warren 2008). Organisations such as Canterbury Frozen Meats and Colonial Mutual commissioned buildings that they planned to own, that needed to provide for their ways of working and that would often go on to represent the company in the eyes of the public. Three important projects from this era were those undertaken for SIMU, Manchester Unity and General Accident. Only the latter remains standing today.

These projects are all linked by their facades, where precast concrete was used with great effect. The buildings predated widespread use of air-conditioning and the architects each realised that overheating could be the main cause of discomfort in large office buildings. While three-dimensional modelling of the façade panels helped provide all-important shading it did much more than that in architectural terms. These buildings have a generosity of depth and high levels of visual interest generated by the repeating patterns that is unmatched in this country or elsewhere. The façade designs and construction materials were important elements in the development of an architectural language that became synonymous with the Canterbury region.

In 1964 Peter Beaven broke new ground on several fronts when designing the Manchester Unity building on the corner of Worcester and Manchester Streets (figure 1). He conceded that it was the first time he had consciously addressed the local context and in this case his design referenced Mountfort's Trinity Congregational Church on the opposite corner. The project was built using the lift-slab method, innovative at the time in Canterbury although its use was short-lived (Gatley 2008). The key design feature developed by Beaven to link this building with the Trinity Church were the articulated precast concrete mullions, which extend the full height of the street facades. The depth of

the mullions allowed the architect to manipulate the alignment of the glazing and the floor structure over the height of the façade. This articulated façade contrasted with thin curtainwall systems being used elsewhere at the time.

With a generous, largely glazed ground floor and copper clad roof the building adopted the classical tripartite composition. Along the shopfronts the design revealed 'Y' shaped columns, which were used by Beaven to 'collect' adjoining pairs of mullions from the upper levels, and running them to the ground. With this building Beaven provided punctuation to an important corner of this gridded city. He also brought a sense of European elegance to Christchurch (van Raat 2005) but tempered this through references to local buildings and by using his beloved precast concrete innovatively.

The structural solution for the SIMU building, designed for a site facing onto an important public square in the city, adopted Lyall Holmes's technique of concentrating lateral support into a stiff core - in this case two cores - allowing the outer columns to be relatively light as they were only required to support gravity loads (Warren 2008). Spanning between floors, the precast concrete cladding panels used at SIMU had an exposed aggregate finish and adopted tight rhythmic spacing. While Warren remained committed to the expressive potential of roofs in the Canterbury landscape, SIMU was given a light, almost ethereal conclusion. The vertical mullions of the panels below stretch upward causing the building to literally merge with the sky.



Figure 1: The Manchester Unity building by the architect Peter Beaven



Figure 2: The SIMU building by the architect Miles Warren

The buildings from this period stood as a testament to effective collaborations between architect and structural engineer in the concrete medium. Moving from structures designed to rigidly resist lateral forces, where shear walls could limit interior space planning freedom, engineers adopted more open solutions that were designed to flex. Virtually all new commercial buildings in Christchurch from the early 1980s utilised moment resistant frame structural designs (Hare 2013). In principle, these structures were designed to flex under load and this brought new challenges to designers as façade claddings and other architectural elements needed to be able to accommodate this movement. Construction solutions were developed in close consultation with the building industry and engineering schools. At the University of Canterbury, Professors Tom Paulay and Robert Park had a profound worldwide influence on the design of structures to resist earthquakes. A book they published in 1975, *Reinforced Concrete Structures*, became the seminal work on capacity design internationally. Engineering academics,

supported by a steady stream of PhD candidates, were able to undertake full scale testing of structural design innovations. In most cases the design development has followed an evolutionary track, such as taking on contemporary industry issues like the seating details of hollow-core flooring units. However, in a few cases the research has been revolutionary, such as the programme to develop Damage Avoidance Design solutions.

## **A CHANGE OF SCENE**

The circumstances surrounding the Christchurch earthquakes are now well rehearsed in several academic and media outlets. For example, see Brownlee (2011), Bennett, Dann *et al.*, (2014), Brand and Nicholson (2016). The knockout punch was delivered in the form of a 6.3 magnitude earthquake on the 22nd of February 2011, taking 185 lives and reducing many parts of the city to rubble (Brownlee 2011). This was the defining event, with ground accelerations recorded at one and a half times that of gravity leading to structural loadings of up to twice the levels specified in the New Zealand Building Code (NZBC). With some 1,350 buildings in the central business district alone having been demolished, the architectural character of the city has unquestionably changed forever.

While the older unreinforced masonry (URM) buildings were the most vulnerable to damage, due largely to their age and lack of comprehensive reinforcement, there was also considerable damage to concrete buildings (Ingham and Griffith 2011, Hare 2013). The two most catastrophic failures, which together led to the deaths of 133 people, occurred in concrete structures. The Canterbury Television (CTV) Building was built during the heady boom period of the mid 1980s, when a great number of older buildings were demolished to make way for new commercial buildings that were commissioned in response to unprecedented financial growth. Many of the structural innovations that took place during the 1980s, such as those employed in the CTV project, challenged the prevailing concrete performance limits of the day in the name of innovation (Hare 2013). Like the CTV building, the Pyne Gould Corporation (PGC) Building had an offset services/structural core but was older, having been originally built for local government in the early 1960s. The innovative plan configurations for these two buildings were driven by space planning objectives, which the structural design for each was required to support. The failures of the two buildings were a reminder that those with irregular plan configurations do not perform as well as those more rationally configured. The seismic forces exposed the tendencies toward torsional twisting, which the concrete load bearing columns around the perimeter of the plan were unable to cope with (Canterbury Earthquakes Royal Commission 2013). The two Achilles heels of concrete are its inability to resist tensile forces and its tendency toward inelastic (crumbling) failure. Both were exposed under the duress of the shaking and the consequences were fatal.

The CTV building represented the only failure of a building designed after building regulations changed in 1976. Hare (2013) confirmed that all others performed above the bottom line required by the NZBC, which is to provide for the safety of those within them. However, after people had a chance to reflect and speak to others, their opinions of building performance was diminished significantly. Although many had initially taken comfort that the city had come through the earthquakes surprisingly well, their attitudes changed to alarm once they came to understand how many buildings would have to be demolished (Matthews 2012). The fact that most of these had a concrete structure led building owners and the public to form negative associations with the material and structural design approaches that had been used. As some experts were looking backward, interested in learning more about how concrete buildings had behaved, others were looking forward to suggest how buildings could be designed to be more resilient to

seismic events such as this. Other competing structural systems such as timber and steel, which had not been part of the landscape before the earthquakes, were suddenly being considered. Neither material would have to overcome the negative associations that concrete had with building failure.

It is clear now that the lineage of concrete technology that could be traced through buildings dating to different eras has been abruptly stopped though the invisible hand of the market. As the rebuild has taken shape it is now obvious that building owners and designers have been almost universally attracted to glass and steel (Marshall, Sheppard *et al.*, 2016). While this attraction has undoubtedly been fuelled by global fashion, the manner and consistency with which braced steel frames are celebrated in the new building facades suggests that architects seek to send a not-too-subtle message to potential occupants: “This building’s structural design has been given top priority”. The emerging Christchurch style can be attributed to what urban designer Hugh Nicholson calls corporate urbanism, where the goal of attracting tenants in the current market leads to the expression of seismic engineering features. See figures 3 and 4. This opinion was confirmed by property developers and owners, who are aware that safety and resilience are now much higher on the list of tenant needs than they were prior to the earthquakes. These demands are fuelled by tenant organisations aims of attracting and keeping high quality staff and enabled by the current competitiveness in the market as property owners seek to attract tenants. In this context, it is about perceptions as much as it is about demonstrated performance. Residual concerns about the performance of concrete have led the market away. Property owners’ motivations toward steel structures complement those of the designers consulted in this research. They expressed strong preferences to explore lightness, crispness and transparency in new buildings, qualities that glass and steel make possible. The architects expressed low regard for the earlier character of the city, noting that with so much of it gone there is an opportunity to create a new visual environment.



Figure 3: Like many new buildings, the steel structure is clearly expressed in the facade design.



Figure 4: The glass facades of most new buildings lack the articulation and visual interest that was a hallmark of concrete facades in the city prior to the earthquake sequence.

## DISCUSSION

The reasons for this departure are several. The two most dramatic building failures were to concrete buildings. Of these, it is perhaps most relevant to consider the CTV building as it was the one modern design that failed. While the project was developed in the post-1976 era it was also undertaken during a period of wholesale economic liberalisation. That socio-economic circumstance invited innovative practices that could enable designs

to meet performance-based outcomes more efficiently. Hare (2013) noted that prescriptive, code-based approaches around the world are written in ways that provide for the required design performance AND higher performance to be achieved. Such “better than expected” performance derives from the factors-of-safety that have been allowed for in prescriptive engineering design solutions. However, where the engineer steps outside a code-based approach in order to pursue a more innovative solution “the onus must fall back on to the engineer to ensure they can meet this level of performance”.

Hare (2013) took a critical view of the performance of some of his structural engineering colleagues when he noted that ‘professional judgement’ is given as a justification for a solution far too often. The unfortunate truth in many cases has been that the engineer has neither the ability nor the energy to deliver an appropriately robust analysis. Although Hare’s opinions were expressed in connection with the on-going investigation of performance during the earthquake sequence, they extend past this circumstance and suggest that structural design practices would need to change. The evidence provided by the seismic sequence confirms that, during a period of economic liberalisation, concrete structural innovation processes was not appropriately reflexive.

While all but one modern concrete designs did meet the minimum life safety standard, many others failed to respond in a manner that would allow them to remain in service. The majority of the 1,350 buildings that were demolished could not be reinstated following the damage they had suffered. Two factors may help explain why so many concrete buildings were amongst those that were required to be demolished. The first, and most important, is that many failed to perform as expected. While many more buildings had been designed around empiric evidence than had been configured based on the professional judgement of the designer, the structural responses of these did not meet the performance of tests carried out in research laboratories. There was a lack of correlation between observed laboratory testing and actual structural behaviour (Canterbury Earthquakes Royal Commission 2013). Clearly such poor results against the predictions would cause property owners to think carefully when deciding on a replacement. A second factor affects the potential for concrete buildings to be rehabilitated following the event. While the concrete provides the compressive strength, in a seismic event it is likely that the tensile steel will be the most severely tested. With steel reinforcing buried deep inside the concrete and unable to be comprehensively inspected, it is also impractical to replace. Techniques for repairing and rehabilitating concrete structural elements is only in its infancy and the easy decision made by many building owners has been to avoid any attempts to repair buildings if there is a likelihood of real or perceived shortfall against seismic strength.

Through active exploration of the architectural and structural potentials of concrete, this locally sourced material became closely associated with Canterbury. The positive relationship was reflected in the testing laboratories at the University of Canterbury, in the concrete related businesses that had established and most visibly in the built environment. Those who developed new technologies and uses for concrete in the Canterbury region for over a century were driven to add value, a fundamental expectation for innovative practices (Orstavik and Dainty *et al.*, 2015). Whether that value was conceived in aesthetic terms, thermal performance, economic cost or sustainable sourcing of materials, development followed rigorous processes of design, evaluation and refinement. Smith (2001) advised that innovation for seismic performance must be supported by rigorous evaluation and testing of new materials and processes in laboratory conditions. However, he also cautioned that further development and refinement must be made in conjunction with performance in the field. Ours is an applied science that learns

from failures as well as from successes. It would seem that the reaction by designers and building owners to steer away from using concrete structural systems has interrupted processes of innovation at an important moment in time. Innovative practices depend of stock being taken following a failure such as this in order to base further development on what has been learned. No doubt, forensic assessment of failures will continue to inform improvements in the ways buildings and infrastructure can be designed to withstand seismic activity, but it is becoming more likely that those improvements will not be made in ways that will extend the lineage of concrete buildings and technology in the Christchurch built environment. On the evidence to date of the rebuilding effort and the views of those making decisions about the form and structural approaches of new buildings, concrete is no longer the structural and architectural material of choice.

## CONCLUSIONS

Concrete has enjoyed considerable favour with local architects and engineers for over a century, being used creatively to enhance structural performance and building appearance. Over time concrete became closely associated with the Canterbury region and was increasingly utilised in important building projects. The paper has discussed the wholesale departure from a concrete-based building approach in Christchurch in the wake of the Canterbury earthquake sequence. As the city sets about to reconstruct its central area, the most prominent materials are glass, aluminium and steel, none of which are produced locally and all of which come with environmental costs.

In a positive sense, the change in approach has been influenced by an attraction to new, shiny materials by architects and their clients, informed by global fashion. However, the bigger factor seems to have been a negative reaction to concrete structural systems which could be attributed to poor performance during the earthquakes. While concrete systems have been progressively developed to meet anticipated structural loads through innovative thinking, they've never been severely tested, at least to the extent of this event. The building stock response has exposed several shortcomings in process and systems that have no doubt led the industry to look for alternatives. In some instances, concrete systems did not perform as predicted by laboratory testing. In others, while they remained intact and protected the lives of those inside, the ongoing viability of buildings was compromised. Not only did this lead to widespread demolition but it also gave cause for building owners to look for alternatives. Finally, some of the most devastating failures were attributed to a failure in process. Economic liberalisation, which provided opportunity for some professionals to innovate beyond sound judgement, was exposed in the process.

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# IS THE SMART SAFETY VEST A BRUTAL INNOVATION? EVALUATION OF MICROCLIMATE PERFORMANCE USING A THERMAL MANIKIN

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Heat stress is a growing concern in the global construction industry due to its life-threatening consequences. The Smart Safety Vest is a proposed ‘internet of things’ solution to the heat stress problem in construction. This innovative e-textile monitors the physiological parameters of construction workers in real time, communicates the data to the cloud, then visualises the data on the wearer’s smart-phone, and in a web-based management system. Alerts warn of anomalies. The feasibility of this system has been validated through iterative design and by rigorous laboratory tests. This paper reports the experimental procedure used to investigate microclimate variations prior to field testing, which involved a sweating manikin placed in a thermal chamber. Various microclimate scenarios were tested on different layers of protective clothing, and during different activity levels with carefully chosen sweat rates and walking speeds to represent working conditions in construction. These tests showed variations in microclimates under different working and clothing conditions. This research provides initial evidence about microclimate variations, offering useful insights for regulators. The Smart Safety Vest has the potential to improve H&S in construction by addressing a key health risk. The research also significantly contributes to the application of innovations in a poor-performing sector.

Keywords: internet of things, thermal stress, thermal manikin, heat stress, microclimate

## INTRODUCTION

The empirical association between ambient temperature and work-related injuries has been investigated globally (Morabito *et al.*, 2006; Xiang *et al.*, 2014; Rowlinson and Jia, 2014; Chan *et al.*, 2015). Due to its potentially life-threatening consequences, heat stress is a growing health and safety concern in the inherently dangerous construction industry. Workers exposed to extreme temperature conditions are at risk of heat stress, manifested in a spectrum of disorders (Lugo-Amador *et al.*, 2004), including heat stroke, which can result in serious consequences such as permanent disability or even death. National and international regulatory bodies, such as SafeWork in Australia, the National Institute for Occupational Safety and Health (NIOSH) in the USA, and the Occupational Safety and Health Administration (OSHA) in the UK, are increasingly recognising heat stress

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hazards in the construction industry. Clothing is a key factor determining human thermal environment in the industry (Rowlinson *et al.*, 2014).

The Smart Safety Vest is a technological solution to the heat stress problem in construction, and it also represents a timely response to calls for innovation in the industry. The aim of the project reported in this paper is to present the results of experiments on the Smart Safety Vest system conducted in a controlled environment prior to field trials. The contribution of this research is two-fold. Firstly it presents the initial evidence about microclimate variations with different protective garment layers and under different activity loads. Secondly, it contributes to achieving the vision of the smart construction site of the future, addressing perceptions that the construction sector is a poor performer in innovation.

## **BACKGROUND**

### *Factors affecting heat stress*

Fanger (1970) describes the human thermal environment as an interaction of six fundamental factors, categorised as: (i) environmental factors (dry bulb, black globe, wet bulb temperatures, and wind velocity), and; (ii) behavioural factors (metabolic rate, and clothing). The clothing factor includes insulation and moisture permeability (Parson, 1995; Epstein and Moran, 2006).

Attempts to define an accurate heat stress index based on environmental and metabolic variables and zones of discomfort are on-going. Sophisticated indices, such as 'rational indices' (based on calculations involved in heat balance equations), and 'empirical indices' (based on subjective and objective strain) take physiological and environmental factors into account (Epstein and Moran, 2006). Indices, such as the widely used Wet Bulb Globe Temperature Index (WBGT) and Discomfort Index (DI) are based on measurement of basic environmental factors (Epstein and Moran, 2006).

Clothing is a key factor in heat transfer between humans and their surroundings (Qian and Fan, 2006). Unless clothing is skin tight, air gaps exist both between the skin and different layers of clothing; this is referred to as the microclimate. It is important to study microclimate variations in heat stress studies under varying operational set-ups to understand the thermal comfort of the wearer (Qian and Fan, 2006).

### *Solutions to the heat stress problem in Construction*

Parson (2014: 178) suggests three main categories of working practices to address hot environments: (i) engineering controls; (ii) work and hygiene practice and administrative controls, and; (iii) heat alert programmes. Chan *et al.*, (2012) developed a nanomaterial-based anti-heat stress uniform for construction workers by reference to measured site temperatures. Some of these indices were trialled in construction. For example, the predictable heat strain index of ISO 7933:2004 (ISO, 2004), has been criticised for its complexity of use (Miller and Bates, 2007) and for its lack of reliability when used with thick protective clothing (Wang *et al.*, 2010). In 2014, Rowlinson and Jia trialled this index in the construction context, but, further, accurately measured evidence on reliability is yet to be reported. A study by Miller and Bates (2007) has also validated the use of the Thermal Work Limit (TWL) (Brake and Bates, 2002) with mining workers. In 2016, Jia *et al.*, investigated the problem of heat stress in construction to develop a protection logic that made broad use of WBGT measurements. However, the limitations of the WBGT heat index have been widely recognised (see Brake and Bates, 2002; Taylor, 2006; Miller and Bates, 2007). The development of thoroughly validated, accurate environmental

indices, combined with data on metabolic and clothing factors, is critical to determining reliable trigger points.

The unrealistic heat stress policy (Jia *et al.*, 2016) by the Construction, Forestry, Mining and Energy Union (CFMEU) (CFMEU Queensland and Northern Territory, 2015) for the unionised construction sector suggests work-rest regimen based on daily maximum temperature. It is evident that self-regulation, which is the main practice in the un-unionised sector, is also ineffective. Construction fatalities (Australian Mining, 2013) and serious injuries (Workcover Queensland, 2016) from heat stroke have been reported in Australia. A recent study based on occupational hygienists' perceptions also suggests a need to refine occupational heat management and prevention strategies (Xiang *et al.*, 2015).

#### *Innovation in the construction industry*

Compared to other industries, the construction industry has not been pioneered in embracing technology, and has often been criticised as poor performer in innovation (Bowden, 2006; Ruddock, 2006; Navon and Sacks, 2007; Hosseini *et al.*, 2013). Aligning the construction industry with the global trends of exponentially growing smart technologies, a new vision for the 'construction site of the future' (Bowden, 2006) has emerged, characterised, according to Carbonari *et al.*, (2011), by real-time context awareness embedded in construction applications. More recently, the strategic need for research and innovation in smart technologies in the building and construction industry has become apparent. Some examples of attempts to meet this need include the formation of the Task Group on Wearable Sensor Technology (TG 92) in 2015 by the International Council for Building (CIB) to encourage research and innovation in wearable technologies in construction. An innovative E-textile based system by reference to workers' physiological conditions is an example of a technological solution to the heat stress-inducing conditions of construction workers (Edirisinghe and Blismas, 2015).

## **METHODOLOGY**

### *Smart Safety Vest System*

In the recent past, an increasing volume of research has aimed to contribute to the future smart construction site, but research gaps remain in the technology development process due to the lack of use of an appropriate framework to validate such technologies. The Smart Safety Vest project was carefully designed to systematically validate the development process by using the technology readiness levels (TRL) model (Mankins, 1995). The Smart Safety Vest project is ongoing, and followed Mankins' (1995) stages of technology readiness, including: (i) pre-concept refinement/knowledge production, (ii) applied investigation, and (iii) early stages of development and operations.

The pre-concept refinement and proof of concept stage has already been completed, and discussion of that stage is beyond the scope of this paper. The design and functionality of the system were iteratively refined, and then the basic principles of the concept were formulated (Edirisinghe and Blismas, 2015). For example, the sensor circuitry was iteratively redesigned for better response/time of sensors through laboratory tests for thermal conductance/capacitance. The current version of the Smart Safety Vest system is an Internet of Things (IoT) device, and is composed of: (i) textile-attachable, cloud-connected temperature sensors that transmit real-time data of either skin temperature of the wearer or the microclimate between the clothing; (ii) a smart phone mobile app to visualise individual data, and; (iii) a web-based management system to monitor company-, project-, and site-level data, both in abbreviated, dash-board and more comprehensive

formats. Both the mobile app and the management system have alert generation mechanisms as per the policy.

An applied investigation of the system was conducted, including functional validation in laboratory and simulated site environments. This paper reports the findings of the applied investigation, which was conducted in a simulated environment using a thermal manikin. This study was done in collaboration with fashion and textiles experts. The objective of these experiments was to validate the system in a controlled environment prior to taking it into the relevant operational environment for real world on-site testing.

### Thermal Manikin Test procedure

#### *Thermal sweating manikin*

Thermal manikins are useful for bio-physical testing and investigations of functional clothing and living systems under harsh conditions (Fan, 2006) that simulate environmental dynamicity. Such modelling, conducted in a thermal chamber, helps to understand system functionality/response within controlled parameters. Due to the dynamicity of construction activities (Bowden *et al.*, 2006), and the highly complex nature of the operational environment and its impact on the six agents of heat stress (Epstein and Moran, 2006), the Smart Safety Vest system was tested with a thermal manikin in a controlled environment to demonstrate TRL5. The Smart Safety Vest prototype was demonstrated using a Newton thermal manikin, model P357, from Measurement Technology Northwest (USA). The model placed in a thermal chamber has dry or sweating skin configurations and a removable wicking fabric skin. The skin of the manikin was saturated with distilled warm water before dressing. The manikin features 20 independently controlled thermal zones, as shown in Figure 2. The sweating systems feature computerised fluid delivery through distributed fluid ports.

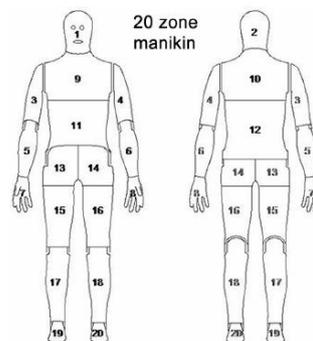


Figure 2: Thermal zones

#### *Test Procedure*

Murakami (2004) analysed the microclimate surrounding the human body using the characteristics of the upward airflow generated around the body. In placing Smart Safety Vest sensor patches on the manikin, the factors considered were: (i) the upward airflow and the fact that the upper body is closest to being at the core body temperature; (ii) practical implications (for example, imposing minimal impact on mobility and manoeuvrability during labour-intensive activities), and; (iii) user comfort and convenience. Sensor patches were placed in zones 9 and 10 (Figure 2). The standard manikin skin temperature was set at 35°C. In each test, readings were taken from 15 to 17 minutes after the system reached steady state (thermal balance) with a coefficient of variation (CV) of <5%, which is the manikin standard. A number of test procedures were conducted to investigate the microclimate conditions (thermal characteristics) under two different pieces of clothing and at different activity levels, both of which are significant

factors in the creation of heat stress conditions (Epstein and Moran, 2006). The sensor patches were attached to two different commercially available safety garments commonly used in the construction industry: (i) a 100% cotton safety shirt, and; (ii) a 100% polyester safety vest with 100% cotton undergarment. Figure 3 illustrates these tests. For wet tests (with sweating), the thermal chamber temperature was set to  $35^{\circ}\text{C} \pm 2^{\circ}\text{C}$ , relative humidity was set to  $40\% \pm 5\%$ , and the water vapour resistance of the garment was recorded. The cover factor was set to 1 for both the garments. Bates and Schneider (2008) report that sweat rates between 0.3 and 1.5 L per hour can be expected for construction workers in hot climates. The manikin simulates different activity levels by varying the rate of double steps per minute (DSPM) and the sweat rate. Three sweat scenarios were tested to simulate low, moderate and high intensity activities as follows: (i) a 20 DSPM and 500mL/hr.m<sup>2</sup> sweat rate; (ii) 30 DSPM and 1,000mL/hr.m<sup>2</sup> sweat rate; and (iii) 40 DSPM and 1,500mL/hr.m<sup>2</sup> sweat rate.



Figure 3: Manikin Tests: left: control room and cloud data; middle: 100% cotton innerwear and polyester safety vest test; right: 100% cotton shirt test

Table 1 shows the experimental configurations. Figure 4 illustrates the arrangement of the clothing layers and positioning of sensors in the microclimates. Sensor placement is depicted at SM1 (F) (sensor for micro-climate 1) in the front zone of the manikin (Figure 2), and SM2 (B) (sensor for micro-climate 2) in the back zone.



Figure 4: Clothing layers and sensor positioning: left: 100% cotton inner-wear and polyester safety vest; right: 100% cotton shirt

## EXPERIMENTAL RESULTS

The manikin's skin temperature, heat flux in the relevant zone, and sweat rate data were recorded during the experiments. The microclimate and/or skin temperature values were recorded to a cloud server during each test through the Smart Vest sensors. Data from the thermal manikin was recorded every minute in the ThermDAC manikin software, and the Smart Vest data was recorded every six seconds. To facilitate better representation and comparison of the two data sets, the average of the sensor data over a minute was calculated. Table 1 summarises the heat flux and water vapour resistance (WVR) values in each experiment. Figure 5(a)-Figure 5(d) graphs the results.

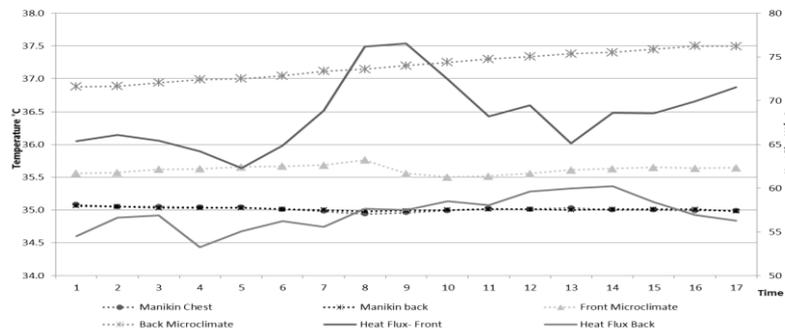
*Findings*

The water vapour resistance (Ret) of clothing indicates how well it can transport water vapour to the environment, which affects thermal comfort during activity. According to Table 1, the Ret values are higher for the cotton shirt than for the cotton innerwear with polyester vest. This could be due to the thickness of the cotton shirt and the open structure of the polyester vest. In other words, water vapour transmission through the cotton innerwear and polyester vest combination is better compared to the cotton shirt alone. It was observed (Table 1) that as the activity level is increased the Ret is decreased - this could be due to the garment becoming saturated with sweat. Figures 5(a) and (b) shows the variation in the temperatures of the front and back microclimates at low activity levels for the CIV clothing set-up. This could be due to the difference between the boundary air layer thicknesses at both zones.

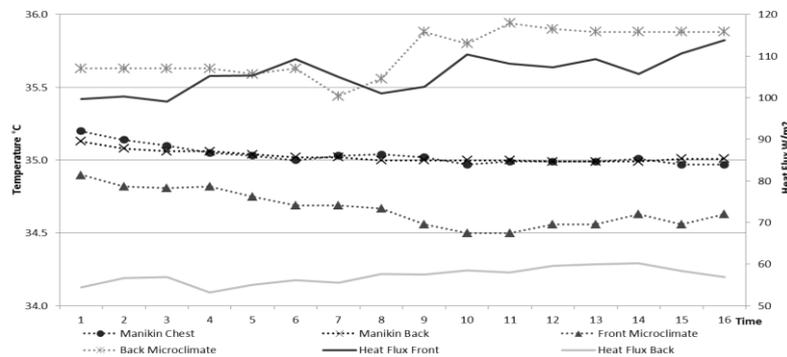
*Table 1: Test procedure and results*

| Clothing   | Experiment | DSPM | Sweat rate (SR) (mL/hr.m2) | Water vapour resistance (Ret) in m2/Pa/W | Heat Flux W/m2 |
|--|------------|------|----------------------------|--|----------------|
| Cotton innerwear and polyester safety vest (CIV) | Exp. 1     | 20   | 500                        | 29.60                                    | 106.51         |
|  | Exp. 2     | 30   | 1000                       | 26.78                                    | 122.56         |
| 100% cotton shirt (CS)                           | Exp. 3     | 40   | 1500                       | 22.25                                    | 143.20         |
|  | Exp. 4     | 20   | 500                        | 47.93                                    | 68.89          |
|  | Exp. 5     | 30   | 1000                       | 38.53                                    | 84.18          |
|  | Exp. 6     | 40   | 1500                       | 34.09                                    | 101.55         |

*Note: the water vapour resistance value is the sum of the boundary air layer resistance and the WVR of the clothing. Front Heat flux was considered after stabilisation.*



*Figure 5(a): Thermal characteristics of CIV, 500 SR*



*Figure 5(b): Thermal characteristics of CS, 500 SR*

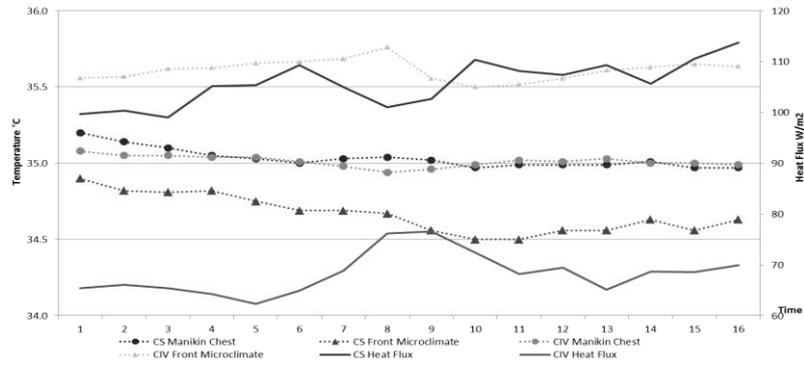


Figure 5(c): Microclimates of CIV & CS, 500 SR

If the boundary air layer is thinner, this means there will be less thermal resistance. Figure 5 (c) shows the variation in the temperature at the front microclimate zone between each garment set-up. A 100% cotton shirt shows a 1°C higher temperature compared to the cotton innerwear + polyester vest garment set-up. Further, variation can also be seen in the heat flux values.

This could be due to the layer assembly of the cotton innerwear + polyester vest garment set-up. The microclimate between the cotton innerwear and the polyester vest is influenced by the light weight and open structure of the polyester vest. Interesting results can be observed in Figure 5 (d); at higher activity rates, the temperature of the microclimate is lower than the manikin's skin temperature.

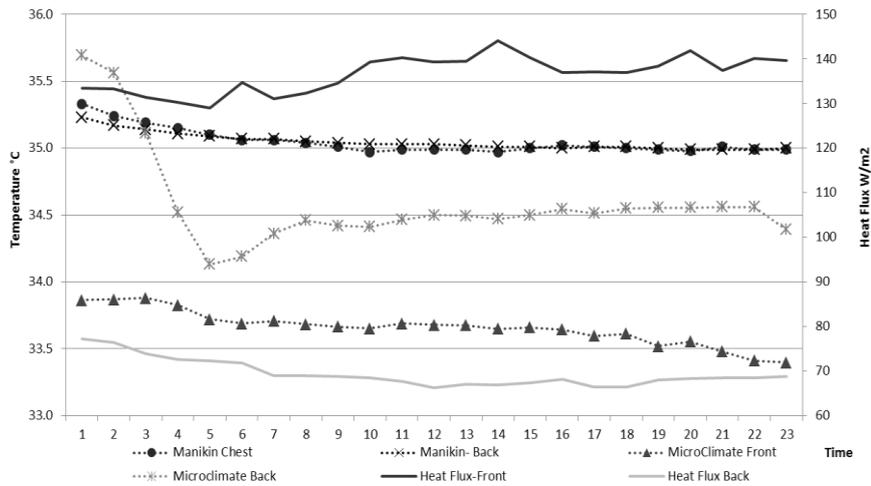


Figure 5(d): Thermal characteristics of CS, 1500 SR

This could be due to the testing of the garments immediately after the previous low level activity rate test. Also, the rise in humidity level between the microclimates could be the key factor in the change in temperatures.

## DISCUSSION

### Study findings and limitations

This study observed that the layer structure of the cotton innerwear and polyester safety vest plays a significant role in governing microclimatic changes. Along with this, the humidity level and characteristics of the fabrics also play important roles in thermal comfort. The main limitation of the study was the control of variables in the thermal chamber. For example, the wind effect on real construction sites was not modelled;

ventilation is double the wind velocity (Qian and Fan, 2006), and this affects the microclimate.

Another limitation was that non-uniform local thermal environments were not investigated. The findings might not be generalisable to all construction activities, as only three activity levels were experimentally tested.

*The multi-variable puzzle, lack of standardisation, and unrealistic regulations*

The integration of many of the variables, together with an appropriate regulatory framework that considers the effects of work intensity, acclimation and clothing will be important in real world set-ups. While a standardised heat stress index is a clear gap in research and practice globally, particularly for the construction industry, fundamental issues also exist in using weather forecasts (Jia *et al.*, 2016) or even on-site weather data unless an accurate index is used to interpret such data (Brake and Bates, 2002). While some policies are unrealistic (Jia *et al.*, 2016), policy gaps exist as far as recommending an accurate measurement protocol in heat stress prevention regime is concerned. Policy variations and urban heat-island effects are also under-researched. Small business accounts for slightly less than one third of the Australian economy (ABS, 2015), and this is mainly un-unionised construction, so it is also important that current practices and policies in both the unionised and un-unionised sectors of the construction industry be investigated.

*Is the Smart Safety Vest a brutal innovation?*

There is an ongoing and critical debate on brutalism in innovation in the construction industry. The concept of brutal innovation is paradoxical. Symbolising the ambition for the emerging vision of the future 'smart construction site' (Carbonari *et al.*, 2011) on one hand, the Smart Safety Vest project can, on the other hand, be perceived as a beastly manifestation to the industry's poor performance in innovation. Innovations embarked upon with good intentions, advancing approaches to solving existing problems or to improving current practice, should also take measures to minimise brutalism. Systematic technology validation through standardised developmental processes, such as TRL (Mankins, 1995), systematic user requirement analysis, and user technology acceptance methods, are critical. It is also paramount that the connections between global, local, construction-specific, and more general or macro-level factors be explored once the technologies are integrated in practice, as, for example, in an industrial product. Challenges exist in technology acceptance, diffusion and standardisation for pockets of innovation like the Smart Vest, while these innovations simultaneously contribute to a paradigm shift in an industry which is far from being a trailblazer of brave new frontiers. However, the Smart Vest has been taken through this incremental process to reduce its potential brutalism, and the aim is to continue with this approach in future work.

## **CONCLUSIONS**

The Smart Safety Vest contributes to the realisation of innovation in the construction sector while moving towards the digital age in order to achieve the vision of the 'smart construction site of the future'. This paper reported the findings of an applied demonstration of the Smart Safety Vest project. The polyester safety vest with a cotton innerwear layer showed better thermal comfort characteristics than a cotton shirt alone. Future work will include testing of the Smart Safety Vest on real construction sites to demonstrate the system under operational conditions, as well as comparison and investigation of the microclimatic conditions of the Smart Vest being linked with existing heat stress indices. Technology acceptance by potential users will also be investigated.

## ACKNOWLEDGEMENTS

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# "SMART" MOTORWAY INNOVATION FOR ACHIEVING GREATER SAFETY AND HARD SHOULDER MANAGEMENT

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"Smart" motorways are becoming more prevalent through technology-driven approaches such as active traffic management (ATM) systems, hard shoulder management (HSM) control systems and digital enforcement cameras. Such technologies are able to monitor and respond to fluctuating traffic conditions by altering the speed limit to smooth traffic flow, activate warning signs to alert users of hazards up ahead and permit the use of the hard shoulder, either permanently or at peak times. This paper investigates smart motorways as a way of reducing congestion achieving greater road safety and improving hard shoulder management. This research is one of the first which deals specifically with the topic of smart motorways, where much of the focus to date has been on smart cities alone. A questionnaire approach was undertaken with 124 members of the public relating to their knowledge of smart motorways. The results indicate that user knowledge of smart motorways was lacking in some areas and that there is an inclination to wilfully ignore some of the "smart" rules of the road which contrary to the intention of smart motorways, may increase the safety risk and CO<sub>2</sub> emissions.

Key words: innovation, management, smart motorways, sustainable infrastructure

## INTRODUCTION

The term "smart motorway" is a concept that utilises technologies and procedures such as sensors, cameras and digital displays to monitor and respond to fluctuating traffic conditions. An ATM system is often used to dictate the speed of approaching vehicles and allow the hard shoulder to be used as a running lane either permanently or during busy periods (UK Government, 2016). The use of smart motorways as a way of increasing motorway capacity is a relatively new concept implemented by Highways England (HE). While current HE studies demonstrate improved journey time and reliability (Highways England, 2016a), smart motorways have also been met with some criticism; particularly relating to user safety and increased Carbon Dioxide (CO<sub>2</sub>) emissions (UK Government, 2016). Although some research on the impact of smart motorways has been previously carried out (Highway Agency 2016; Unwin *et al.*, 2011), the varying research and arguments for and against these schemes has never been formulated into one coherent assessment. In 2016, The Transport Committee launched an

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inquiry into how policy on all-lane running should evolve. The report highlighted a gap in knowledge of the extent to which road users understand and comply with signs of smart motorways, and the changes that are needed in driver education and behaviour (Road Safety GB, 2015). As a result, this paper makes an original contribution by gathering data on the level of public knowledge of using smart motorways which could be used to inform future infrastructure management policy.

## **LITERATURE REVIEW**

### **Management of Smart Motorways**

The successful management of smart motorway schemes often relies on the use of an “accelerated programme” which can limit their construction period to less than two years, compared to approximately ten years for a traditional road widening project (Walker and Threlfall, 2016). This can be achieved due to concurrent working, standardisation of solutions and the lack of land purchase requirements as well as a “productisation” approach being taken to deliver the extra capacity required in the most cost and time-effective manner possible. However, according to the Automobile Association (2017) ATM systems are not the answer everywhere and more robust, traditional widening with hard shoulders is still needed on some overloaded sections of motorway. A pilot study of the M42 ATM project was found to be over-engineered, too resource intensive and technology reliant (Birdsall, 2014). Where smart motorways have been introduced, a principle of “design once, use many times” has been developed into best practice (Walker and Threlfall, 2016). However, this approach requires flexibility of project teams due to ongoing adaptation and innovation of best practice. Lean deployment in the supply chain is actively encouraged, with time on site limited as much as possible to reduce disruption for users (Chen *et al.*, 2012). As such, work is front-loaded at the design stage and efforts made to make the product more efficient before taking it to the roadside. Smart motorways also promote early contractor involvement and NEC target contracts, which emphasises collaborative partnering and uses a pain/gain scenario (Chen *et al.*, 2012; Walker and Threlfall, 2016).

### **Sustainable Infrastructure**

Road transport is a significant source of environmental concern, accounting for nearly 20% of total greenhouse gas emissions (EEA, 2007). It is therefore the objective of many national Governments that motorways should be managed in a way that is sustainable in terms of a low carbon future (Department of Transport (2007). Smart motorway schemes are one example of a technological solution that is being introduced in many countries internationally (Highways England 2016b). Environmentally, any addition of capacity is going to present some challenges, such as increased air and noise pollution (Walker and Threlfall, 2016). However, evidence from existing smart motorway schemes suggests no significant increase in these areas, which could be partially due to the reduction in speed and smoother flow of traffic resulting in lower emissions (Walker and Threlfall, 2016). According to Ladyman (2017) cars travelling below or above the optimal speed range for minimising CO<sub>2</sub> output (approximately between 30mph and 55mph) produce significantly more CO<sub>2</sub> than when they are used at optimal speed. In addition, Unwin *et al.*, (2009) states that one of the key environmental benefits from implementing smart motorways is that the scheme makes best use out of the existing road space when compared to traditional widening schemes which results in less impact on the environment during the construction phase.

### **Quality of Life, Accessibility and Social Well-Being**

It may be argued that transportation facilities and networks have the power to shape development, influence property values, and determine a neighbourhood's character and quality of life (The Center for Transportation and the Environment, CTE, 2008). Consequently, the transportation industry has long been concerned with gaining an improved understanding of how transportation investments and policies influence community development. According to CTE (2008) innovative transportation projects help to improve accessibility to people, places and services which could improve social well-being. For example, changes in accessibility to sites, where interaction occurs that both builds and allows people to access social capital, can lead to changes in social cohesion. However, there are concerns over the interface between these motorways and the passing neighbourhoods. According to Picardi (2014), very often vehicles speed by bedroom windows, front gardens and even school playgrounds separated only by the width of a pavement. Furthermore, the never-ending "hum" of motorway traffic is rarely mitigated and these long stretches of black asphalt raise the temperature of their local environment by absorbing radiation and contributing to a microclimate known as the urban heat island effect, a phenomenon that adversely impacts the atmosphere and energy consumption (Picardi, 2014).

### **Journey Time and Congestion**

In 2014, a smart motorway system on the M25 was introduced. For a six month period following the introduction of the scheme the journey times were assessed using data collated from a satellite navigation database and compared to data held prior to its introduction (Highways England, 2016a). A reduction in average journey time across each time of the week and in each journey time percentile was identified, suggesting that the introduction of smart motorway schemes can reduce average journey times. More specifically, it showed that 50% of journey times were more reliable when an "all lane running smart motorway" was introduced. Addressing this percentile range is significant because it addresses the journey time reliability of an "average day" rather than days where significantly increased or reduced traffic due to incidents or events has occurred. However, one criticism of smart motorways is that increased journey reliability is not necessarily a benefit and could lead to "peak contraction" whereby more journeys would occur in a smaller time frame such as rush hour due to the improvement to journey reliability (UK Government, 2016) which could counteract any reductions in traffic congestion. Another potential shortfall of such research is the reliance on data from a satellite navigation database of journeys which have the ability to re-route a journey to avoid congestion (The Automobile Association, 2015). As congestion begins to build, drivers may be diverted off the smart motorway and later re-join after the congested area. This may appear in the results as two relatively quick journeys on the smart motorway as opposed to one longer journey through congestion. Multiple occurrences of this may skew the results favourably to the ability of smart motorways to reduce journey times.

### **Public Perception of Safety**

The perception of the general public seems to be opposed to converting hard shoulders into extra motorway lanes. For example, 59% of AA members state that they would feel more nervous driving on a motorway without a hard shoulder and 85% of members state that hard shoulders make the motorway safer (The Automobile Association, 2015). Walker and Threlfall (2016), on the other hand, suggest that smart motorways improve speed compliance and are therefore safer through the use of overhead mandatory speed limits, driver information, CCTV coverage and enforcement. However, particular

questions have been raised regarding the use of the hard shoulder as a running lane by services that traditionally made use of it to reach their destination more quickly, such as the police or ambulance services. This is emphasised by Cambridge (2016) who states that some drivers refer to the lay-bys which have replaced hard shoulders as “death zones”. Thomas (2016) also suggests that HGV drivers from overseas are unaware of how smart motorways work, and often take breaks in the lay-bys. Additional concerns range from insufficient lighting and signage informing drivers of the new layout, refuge areas being too far apart and a lack of communication between HE and the emergency services (Dunn, 2016).

### **Parliamentary Objections**

The House of Commons Transport Committee (2016) published a report claiming that the conversion of the hard shoulder into a running lane was a “radical change” and an “unacceptable price to pay” for journey improvements. Whilst accepting that the network needs updating to prevent unmanageable congestion by 2040, the House of Commons Transport Committee (2016) argues that there are major concerns over the safety of converting the hard shoulder into a running lane. The cause of concern is due to 28% of those surveyed feeling that the M25 was less safe following the conversion to an all lane running smart motorway. However, perceived safety and actual safety are two different things (Loewenstein et al., 2001). Furthermore, while 28% of those surveyed felt less safe, 72% felt equally safe or safer. The House of Commons Transport Committee (2016) accepts that all lane running schemes increase capacity.

However, it may be argued that this is a “short term solution” with regards to the net effect on journey times. For example, as congestion is reduced, people tend to travel greater distances which results in the same average journey times as before the scheme was introduced (Thomson, 1968). Instead, it is suggested by Winston and Mannering (2014) that more emphasis should be placed on technological advances as a cost effective way to increase network capacity. This is potentially an argument for the introduction of smart motorways, as these utilise the latest technology in an effort to control traffic flow and this investment will serve as a catalyst for improvement and advancement.

According to Metz (2016) "you can't out build congestion"; instead it is suggested that further innovation and investment in technology advancement is the only long-term solution. Consideration of technological advancement becomes even more important as cars evolve, which is likely to include "accelerating autonomous driving technology, advances in artificial intelligence, sensors, cameras, radar and data analytics" (Silver, 2017) which can transform not only how road users drive but also overcome some of the potential drawbacks of smart motorways. This argument is underpinned by Power (2016) who states that any new vehicles will require the ability to communicate, both with other cars and with the passing infrastructure.

## **METHOD**

### **Sampling and Data Collection Approach**

This research analysed opinions in order to explain the current knowledge and behaviours of members of the public in order to assess the use of smart motorways. A questionnaire technique was selected to primarily gain an understanding of the underlying views of motorway drivers. A questionnaire was identified as the most appropriate method to draw valid conclusions from targeting a large and varied sample (Sue and Ritter, 2007). The questionnaire was created using Google Forms and distributed via email to respondents of varying ages (between 18 and 65 years), backgrounds and professions,

who were known to the research team (including past employers, colleagues, friends and relatives). The decision to end the questionnaire after only three days was determined by the high response rate, where 124 questionnaires were returned which upholds the normal statistical distribution rule.

### **Questions Asked**

The questionnaire was divided into three sections. The first section collected general background information about the participant including age range; time since the participant passed their driving test; how often the participant drives and how often the participant drives on a smart motorway. Conclusions could then be drawn on how the performance of smart motorways may change over time or as they become more commonplace or how new/experienced drivers should be further advised on their use.

Section two included multiple choice questions to identify the participant's level of the knowledge and understanding of smart motorways. Questions included; what does the red "X" above the lane indicate; whilst driving on a smart motorway, if your vehicle experiences difficulties e.g., a warning light appears, what should you do and; when should you use the refuge area.

The final section was designed to ascertain if the participant was likely to intentionally disregard the rules of the road, which provided a distinction between a lack of understanding and lack of discipline. Questions asked such as; do you ever choose to ignore the displayed speed limit were subsequently followed up asking why, again using a multiple choice technique. Respondents were typically asked to select an answer from six options (including a "don't know" response).

### **Analysis Technique**

The survey was carried out on an anonymous basis which was imperative as it required road users to potentially admit to wrong doing (Stangor, 2014). One of the benefits of using Google Forms was that all of the responses were collated onto a single spreadsheet. Simple coding was used for each multiple choice option followed by calculating basic response frequencies and percentages. However, further statistical analysis would have allowed for stronger conclusions to be made.

## **DISCUSSION OF RESULTS**

### **Level of Knowledge**

The results show that 61.3% of those surveyed were aware of what is meant by the term "smart motorway". This is indicative and serves as a barometer of how successful the HE and UK Government have been at informing the population about smart motorways. Although it is an indicator of the awareness of the population, it is not an indicator of the ability of the population to use a smart motorway as it is intended. According to The Royal Academy of Engineering (2012), the majority of smart infrastructure systems use a feedback loop which collects data, processes it and presents it in a way to help a human operator make a decision. As a result, road users play a crucial role in successfully completing this loop, which can only be achieved with increased levels of user knowledge.

Of those surveyed, 89.5% understood that the refuge areas are only to be used in an emergency when there is no hard shoulder. However, this contradicts research carried out by the RAC which revealed that 52% of respondents did not know what an emergency refuge area was (RAC, 2017). One of the criticisms of smart motorways relates to them being unsafe because of the potential for a car to be stopped in a live lane (Dunn, 2016).

Moreover, the research by the RAC (2017) states that 64% of respondents did not know what to do after stopping. If the refuge area is perceived as something that should never be used (3.2% of those surveyed thought this) or as something to be used for a break (4% of those surveyed thought this), then there is an increased possibility of a car becoming stopped in a live lane. This is due to a driver either refusing to use a refuge area in an emergency, or being unable to because it is fully occupied with those who believe it can be used to take a break. Of those surveyed, 71% understood that the hard shoulder should be used only when directed to. Therefore, it may be argued that the safety of smart motorways could be hindered due to a lack of understanding regarding use of the refuge area. However, HE (Highways England, 2016a) state that smart motorways have no adverse effect on safety. The challenge here lies in establishing the various positive attributes of smart motorways from a safety, infrastructural and technological perspective (Smart Transportation Alliance, 2015). Furthermore, internationally recognised best practices should be followed when maintaining, upgrading and modernising existing infrastructures (Smart Transportation Alliance, 2015). This also aligns with that of Walker and Threlfall (2016) who emphasises the importance of a collaborative approach in reducing road mortality and injury rates.

The results indicate that there is a relatively significant lack of knowledge surrounding key aspects of smart motorways. This lack of knowledge could indicate that value may be added with relevant education and the publication of further guidance related to driving on smart motorways. However, this assumes that drivers would use the smart motorway as intended if they properly understood how to.

### **Driver Behaviour**

The discipline of drivers on smart motorway tends to vary depending on which rule is being proposed. The vast majority of drivers never choose to ignore the red "X" which identifies that a lane should not be driven in. However, 47.6% of those surveyed admitted to ignoring the speed limit at least some of the time. In addition, "motorists across the UK have faced up to £526 million in fines, after 210,538 drivers have been caught exceeding the limit, which can drop from 70mph to speeds of just 20mph, with more variable speed zones planned across the UK as part of so-called smart motorway schemes" (Rodger, 2017). This willingness to ignore a rule that is fundamental to one of the main benefits of a smart motorway, suggests a strong possibility that overall performance is being hindered. This aligns with the results of the UK Government (2016) which states that "poor compliance with Red X signals is a grave concern that not only puts motorists at risk, but also places vehicle recovery operators, emergency services, and traffic officers in harm's way". This highlights the wider implications of non-compliance of smart motorway instructions.

Furthermore, 15.3% of those surveyed admitted to ignoring the hard shoulder when it is being displayed as a running lane at least some of the time. The use of the hard shoulder as a running lane is a fundamental part of smart motorways as it is the method of increasing capacity without widening. The reasoning given for the refusing to obey the speed limit implies that the majority of drivers do this consistently when certain criteria are met. For example "the traffic is not sufficient to warrant a reduced speed limit" was the reason given by 52.5% of those who admitted to ignoring the speed limit. This was followed by 29% who said that they ignored the speed limit "to keep up with the flow of speeding traffic". The results show that there is a proportion of drivers that willingly choose to ignore the rules of the road. It is therefore suggested that an improved performance of smart motorways may require increased enforcement of the rules of the

road. This suggestion is further justified by some of the reasoning that participants gave for ignoring the speed limit as 11.9% of participants who admitted to ignoring the speed limit did so because speed limit was not enforced.

### **General Observations**

It was observed that those aged between 21 and 39 were more likely to ignore the rules which are important to the performance of a smart motorway.

When the participants were categorised in terms of the length of time since they passed their driving test, a negative trend between this and their level of knowledge of smart motorway. This could imply that the design of smart motorways is not very intuitive for drivers with significant experience driving on standard motorways prior to their existence. It could also imply that there is a level of complacency within drivers with regard to taking on new driving rules which increases over time subsequent to passing ones driving test. It is suggested that drivers should not be considered as homogeneous and that a multi-faceted approach is needed going forward. This is also supported by the Transport Committee (2016) who states that the HE should target their awareness campaigns at "different groups, including disabled, elderly, novice, or drivers of any gender".

### **CONCLUSIONS**

The published literature on smart motorways emphasised improvements in both journey times and journey reliability but there is currently a lack of information on the reduction of CO<sub>2</sub> emissions.

Although some perceived benefits of a more reliable journey time were identified, it also raised the question of "peak contraction" which arguably counteracts any reductions in traffic congestion. One of the most important considerations raised by the research is that of user's safety, particularly, with regards to the use of the hard shoulder. With regards to user compliance on smart motorways, the results showed that a significant proportion of the drivers surveyed willingly choose to ignore the rules of the road. It is therefore suggested that an improved performance of smart motorways may be brought about by increased enforcement.

It was identified that knowledge of how to drive on smart motorways tends to decrease as the time since passing ones driving test increases. It can therefore be assumed this trend is related to the intuitiveness of the design of smart motorways, a complacency that drivers acquire over time or a combination of the two. A link between the frequencies of driving of the participants and their knowledge of / behaviour on smart motorways was not observed, however the sample size for those who said they drove rarely or very rarely was very small. As a result, a more quantitative classification would enable a more scientific conclusion. Instead, this research has identified the level of public knowledge surrounding the use of smart motorways. By continuing to improve the skills and attitudes of drivers, the UK Government has the opportunity to improve traffic congestion and safety standards and further reduce the personal cost to people affected by road collisions.

### **Future Research**

Future research is needed to determine the relationship between how many road users fail to use the hard shoulder as they should, and the performance of the smart motorway to establish more accurately the impact that a lack of knowledge or discipline has on performance. Furthermore, additional monitoring of smart motorways is required in order to determine their tangible benefits (such as cost savings).

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# ENERGY-EFFICIENT WINDOW RETROFIT FOR EXISTING HIGH-RISE RESIDENTIAL BUILDINGS WITH THE CONSIDERATION OF MUTUAL SHADING

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Upgrading the window glazing can help minimize the energy consumption through a reduction of solar heat gain in summer or indoor heat loss in winter. On the other hand, the mutual shading caused by surrounding high-rise buildings could affect the energy performance of the window glazing. In hot climate, mutual shading could further reduce the solar heat gain. In cold climate, overshadowing lowers the solar heat gain in winter resulting in greater demand for space heating. To explore the most energy-efficient window glazing for different climates, it is imperative to integrate mutual shading with window retrofit measures when evaluating the thermal performance of a building. This study applies a computer-based simulation program known as DesignBuilder to assess the building performance. The energy model is based on a typical high-rise residential building, and four common double energy-efficient glazing alternatives were employed in lieu of single clear glass. The results show that the optimum window retrofit solution vary with different climatic conditions and there are different choices for upgrading window glazing in the same building with and without the consideration of mutual shading due to the mutual shading effect on the energy use.

Keywords: energy efficiency, retrofit, energy analysis, mutual shading, building simulation

## INTRODUCTION

Hong Kong is famous for its high population density and it is filled with close high-rise buildings. The street canyon with packed tall buildings is a typical urban feature in this region (Chen *et al.*, 2012; Ng, 2009). Similarly, over 40% of existing dwellings are high-rise buildings in megacities of Mainland China due to the rapidly increasing urban population (Ekblad and Werne, 2015; Hui, 2013; Li *et al.*, 2011). Shanghai is a typical megacity in China and its population density is the highest one in Mainland China. Existing high-rise housings account for about 44% of the total residential blocks in Shanghai (Yang *et al.*, 2010). High-rise residential building is becoming much denser due to the limited available land (Pan, Zhao, Chen, Liang and Sun, 2008). The highest population density in Beijing is over 25,000 persons/km<sup>2</sup> which occurs in some districts and the average population density is more than 20,000 persons/km<sup>2</sup> in its urban areas, and high-rise buildings made up around 78% of existing buildings in urban areas ("High-rise Buildings of Beijing," 2016).

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The mutual shading effect due to surrounding high-rise buildings helps reduce up to 14% cooling demand in Hong Kong (Lam, 2000a). If shading effects from nearby buildings are neglected, the energy use of the control building would be over-predicted in this region (Lam, 2000b). The mutual impact among proximal buildings should be considered into the building energy analysis because the energy demand in a building without surrounding shading is underestimated by up to 23.1% during summer period and overvalued by 44.8% in winter compared to the same building considering the mutual shading from its neighbouring buildings in the United States (Pisello *et al.*, 2012). The nearby obstructions strongly affect the energy consumption for cooling and heating (Pisello *et al.*, 2014). Energy savings achieved through retrofit measures with the consideration of mutual shading is higher than reductions observed for stand-alone buildings (Xu, Taylor and Pisello, 2014). Although mutual influence is helpful to reduce energy use for cooling in summer, it still can increase the heating demand in winter due to the less solar heat gain. It can increase the heating demand by 30% in a typical building located in a real urban context with adjoining high-rise buildings in Japan (KAWAI *et al.*, 2014). It is a key parameter to assess the real building performance in a real building environment because the difference of energy consumption in a building with and without surrounding buildings is up to 10%.

However, most previous studies focus on the mutual shading effect or building retrofit respectively. Little literature took the mutual shading effect into the energy-efficient building refurbishment. Most of them ignored the effect of overshadowing of surrounding buildings while they selected building retrofit solutions to save energy in existing buildings. But inter-building effect among nearby high-rise buildings is an important factor to affect the building energy consumption and it can offset or enhance the energy performance of a certain retrofit measure in different climates. Therefore, this study is to identify the mutual shading effect on the window retrofit solutions based on previous studies related to individual mutual shading and window glazing upgrading of high-rise buildings. The purpose is to find the most energy-efficient window glazing for high-rise housing to reduce the annual energy consumption of cooling and heating in different climates.

The annual energy consumption of a 30-storey residential building is simulated in the DesignBuilder program with and without surrounding buildings in four types of climatic conditions including mild summer and cold winter, hot summer and warm winter, hot summer and cold winter, severe cold. Four common 6/13mm double window glazing with 13mm air filled are selected to substitute the existing window system to improve its thermal performance based on a stand-alone building and a building network in this study. They are listed out as generic tinted pane and internal generic clear pane(GTGC), glazing with exterior generic clear pane and interior low-e clear pane(GCLC), glazing with exterior low-e clear pane and interior low-e clear pane(LCLC)light, glazing with reflective tinted pane and interior low-e tinted pane(RTLT). Quantified energy saving caused by window glazing and the effect of mutual shading on building retrofit are presented in this research and suitable energy-efficient window glazing is recommended for different climates based on the mutual shading effect.

## **METHODOLOGY**

### **Primary Study Procedure**

The case study was first modelled and simulated without any window glazing upgrade to provide assessment of building thermal performance as the baseline of energy requirements in the typical building. Then, the possible energy-efficient window glazing

for the building envelope retrofit was used to substitute the glazing system of the base model and a series of simulations were conducted to predict the energy consumption of the improved building.

The major research step is shown as following: the first step is to build up a baseline mode of the stand-alone case building in DesignBuilder; the second step is to identify the common proximity between buildings and make assumptions for such space based on literature review; the third step is to evaluate the thermal performance of the case building which applied different double glazing with and without mutual shading; the fourth step is to analyse the effect of the mutual shading on the energy reduction caused by window glazing alternatives ;the fifth step is to find the most energy-efficient and appropriate glazing system in a real building context in different climates.

### **Computer-based Simulation**

DesignBuilder was used to predict the energy consumption in this study, which has a powerful database and complex models to evaluate the energy performance of buildings (Tronchin and Fabbri, 2008). It can provide abundant templates for various types of building parameters and it can help users select most appropriate parameters for energy analysis (Wasilowski and Reinhart, 2009). It is based on the simulation engine of the latest EnergyPlus. This simulation engine has become one of the state-of-the-art and most powerful energy analysis tool for professionals (Henninger, Witte and Crawley, 2004). Many previous studies have applied DesignBuilder to evaluate the thermal performance of buildings and they have proved its accuracy and adaptability (Fasi and Budaiwi, 2015; Radhi, 2010; Reinhart and Wienold, 2011).

### **Validation of the Base Model**

After developing the base energy model, the validation procedure was carried out by following the ASHRAE Guideline 2002 and DOE 2008. The primary purpose of the validation is to reduce the difference between the simulated energy consumption and realistic building performance. The validation process is useful to identify the improper assumptions in the base energy model and adjust them to match the realistic indoor temperature set, operation schedule, and local weather conditions. The validation procedure contains an iterative process including simulation run (first step), calculation and comparison (second step) and fine tuning (third step) and then repeat the same process again until the discrepancies between the simulated results and real energy consumption was reduced to meet the requirements mentioned before.

Since the energy bills of this case building are confidential, this research adopts publicly available sources for the validation of baseline model. Hong Kong Energy End-use Data and the public housing statistics are published annually that can reflect the energy consumption in public residential buildings. The average annual energy consumption per floor area can be extracted from the public data and it was used for validating the simulated energy consumption of the base model of the typical building. According to published energy use in public dwellings, the annual energy use for each floor area is appropriate 273kwh/m<sup>2</sup> for space conditioning, domestic hot water, lighting and others that consumes about 21%, 19%, 7% and 53%, respectively (Cheung *et al.*, 2005; EMSD, 2015; Bojic *et al.*, 2001). For the simulated baseline model, the annual energy use per floor area is around 285kwh/m<sup>2</sup>. The predicted energy use in the baseline model is very close to published benchmark of energy consumption in public housing in Hong Kong. In terms of the simulation result, the energy distribution ratios are 25% for cooling

demand, 17% for domestic hot water, 8% for lighting and 50% for other building loads, which is very close to the real situation in this type of building.

### **Description of a Case Building**

A typical 30-storey high-rise residential building in Hong Kong was chosen for the energy simulation by using the DesignBuilder program. The same case is also applied to predict the mutual shading effect on building thermal performance in other climates. There is no insulation consideration in the reference building since most existing old high-rise buildings did not consider insulation when they were built in selected cities including Hong Kong, Beijing, Shanghai (Yang, Lam and Tsang, 2008; Yu, Yang and Tian, 2008). Its window-wall ratio is 30% and the window glazing is 6mm single clear glass with the aluminium frame without the thermal break. There is no shading device on the typical building. The major structure of wall is cement plaster, concrete block and cement plaster from the outer side to the inner side. The configuration of roof is complicated and there are seven layers in all. The outermost and innermost material is clay tile (10mm) and cement plaster (20mm). Meanwhile, the functional components include the polyurethane foam (50mm), bitumen sheet (1mm) and the reinforced concrete (150mm) from the top to the bottom layer. The cooling operation period of the case building is set from 1pm to 7am of next morning (Bojic *et al.*, 2001; Bojic, Yik and Sat, 2002). To meet the indoor thermal comfort and reduce the energy use, the temperature set point of air conditioning is assumed as 24°C in selected cities (Cheung, Fuller and Luther, 2005).

There are several neighbouring high-rise buildings surrounding the typical building on its four directions. The aspect ratio (building height-to-width ratio between buildings, H/W) is a direct parameter to reflect the density of high-rise buildings and the thermal environment of the reference building. It has a close relationship with the mutual shading effect of nearby buildings. The aspect ratio (H/W) of the reference building is larger than 2.0 on each direction and this study assumes that the canyon H/W ratio is 2.0 for the case building's thermal environment on four major orientations in order to simplify and simulate the mutual shading effect of adjacent buildings. The same H/W on different directions was a hypothetical situation but it is beneficial to model the outdoor thermal environment in a simplified way and it can help identify the mutual shading from the surroundings. After modelling the nearby space, the study focuses on the thermal performance of upgrading reference building with and without mutual shading in term of its energy consumption for heating and cooling.

## **RESULTS AND DISCUSSION**

Mutual shading effect on thermal performance of window glazing in mild summer and cold winter climate. To describe the potential effect of mutual shading of nearby buildings on the energy-efficient window retrofit in cold climate, the annual energy demand for cooling and heating in a typical building located in Beijing was evaluated. The double glazing applied in this study has two layers of different type of glass including low-e glass, generic glass and reflective glass with a 13mm air filled in between two glass layers as described in table 1.

In cold climate such as Beijing, the overall cooling demand is less than its total heating demand. When considering the energy demand during summer and winter, energy analysis is observed from June to August for cooling and from November to March for heating. When the typical building is stand-alone, there is no nearby obstructions surrounding it and the mutual shading effect of adjoining buildings is not considered. In

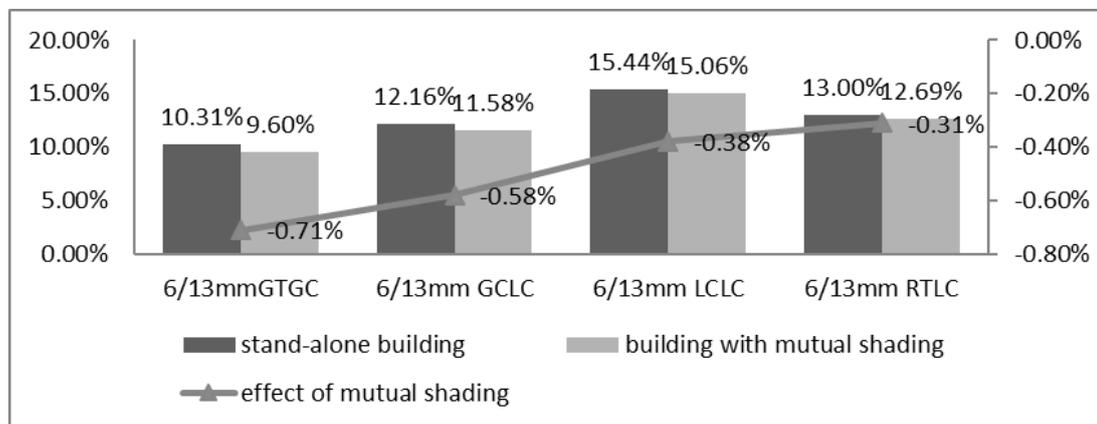
this outdoor thermal environment, the employed four types of double window glazing can reduce energy consumption by around 10.31% (GTGC), 12.16% (GCLC), 15.44% (LCLC) and 13% (RTLTL).

But if taking the mutual shading of the surrounding buildings into account, the total energy reduction caused by window glazing GTGC, GCLC, LCLC and RTLTL are 9.6%, 11.58%, 15.06%, 12.69%, respectively. There is no significant difference of the overall energy consumption including heating and cooling in the case building with and without overshadowing from nearby buildings as shown in Figure 1. The effect of mutual shading on the building performance with different glazing is negative in the cold climate but the impact is less than 1%, therefore, it is reasonable to ignore such effect in this region when evaluate the effect of retrofitting measures on heating demand. Obviously, this overshadowing is beneficial to reduce the cooling demand in summer but such impact is not significant, therefore, it is reasonable to neglect this positive effect of overshadowing when evaluating the effect of window upgrading. In all, the mutual shading of nearby buildings can be ignored when analysing the thermal performance of building window retrofit solutions in the cold region.

Table 1: Thermal characteristics of 6/13mm double window glazing

| Type                                       | Name  | External pane       | Internal pane     | U-value                  | SHGC  |
|--|-------|---------------------|-------------------|--------------------------|-------|
| 6/13mm double glazing with 13mm air filled | GTGC  | 6mm generic tint    | 6mm generic clear | 2.66 W/m <sup>2</sup> •K | 0.501 |
|  | GCLC  | 6mm generic clear   | 6mm Low-e clear   | 1.91 W/m <sup>2</sup> •K | 0.568 |
|  | LCLC  | 6mm Low-e clear     | 6mm Low-e clear   | 1.35 W/m <sup>2</sup> •K | 0.483 |
|  | RTLTL | 6mm reflective tint | 6mm Low-e tint    | 1.69 W/m <sup>2</sup> •K | 0.122 |

Figure 1: Energy reduction caused by different window glazing and mutual shading effect in mild summer and cold winter climate



**Mutual Shading Effect on Thermal Performance of Window Glazing in Hot Climate**

In hot climate such as Hong Kong, the dominated energy consumption originates from cooling demand throughout the whole year and there is no heating need in winter due to its warm climatic conditions. To assess the impact of mutual shading on the building thermal performance, the energy consumption in the stand-alone case building is the baseline and the changes caused by window glazing upgrading is given as percentage. The results are summarised in Figure 2. As seen in this figure, inter-building effect has a significant impact on the thermal performance of the typical building. When the energy analysis ignores the mutual shading of nearby buildings, upgrading existing window glazing can reduce only less than 10% of the total energy use no matter which double

type of the window glass is chosen in the range of conventional ones. The most energy-efficient one is RTALC with external tinted reflective pane and internal tinted low-e pane, and it can help reduce energy use by 9.3% for a stand-alone building.

But if put the typical building in a building net-work, there will be some mutual shading which is beneficial to reduce the solar heat gain and lead to a bigger positive effect of window glazing on the energy saving. For instance, the energy-saving effect of LCLC glazing can be increased by around 7.5% while consider the inter-building effect. The mutual shading can lead to an increase of the building energy-efficiency and the most dramatic change is up to 7.84% as depicted in Figure 2. Inter-building effect plays an important role to present the thermal performance of window glazing and thus it is an important factor to predict the overall thermal performance of the applied window glazing. Based on this consideration of mutual shading, the best choice for the window retrofit would be changed compared to the stand-alone building. In this hot climate, the energy reductions caused by LCLC and RTALC are very close to each other while taking the inter-building effect into account. On the other hand, the tinted reflective glass may cause some light pollution and it can lead to the lighting demand. In addition, the low-e glass is expensive and thus it is not as practical as other conventional glass pane from the viewpoint of cost. Combining the energy reduction with other important factors, the best solution for window retrofit may be the GTGC glazing while considering the mutual shading which is completely different from the choice in a stand-alone building.

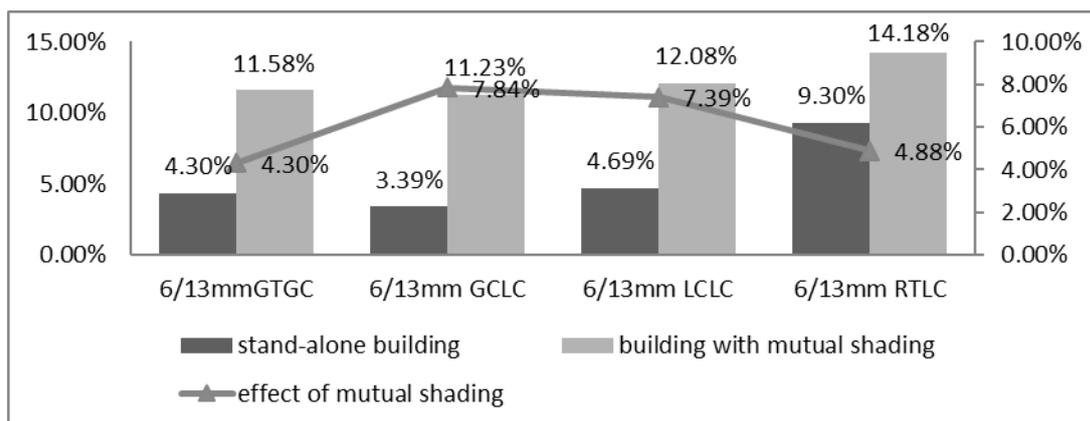


Figure 2: Energy reduction caused by different window glazing and mutual shading effect in hot summer and warm winter climate

### Mutual Shading Effect on Thermal Performance of Window Glazing in Hot Summer and Cold Winter Climate

In hot summer and cold winter region such as Shanghai, the indoor environment requires heating in winter from December to February and cooling in summer from June to September. According to the traditional assessment of building thermal performance, the typical building is deemed as a stand-alone building without any mutual shading from its surroundings and the annual total energy consumption in such building is as shown in Figure 3. It is depicted that the biggest reduction is generated by RTALC and it is up to 14.23%, but the glazing GCLC has a lowest contribution to the energy reduction among the selected four types of glass in the stand-alone building.

However, if the case building is in a building context with the mutual shading, the effect of the double window glazing on the energy consumption will be changed as seen in Figure 3. The result shows that glazing GCLC has a better thermal performance with the consideration of mutual shading and it can reduce around 14.77% of the overall energy

used that is close to the reduction caused by GTGC. Although they have similar thermal performance based on the consideration of mutual shading, it could be better to use GTGC for the window retrofit since low-e glass would lead to a higher cost. Meanwhile, the overshadowing is beneficial to improve the impact of LCLC on the building energy consumption and thus the energy saving generated by LCLC was increased by 16.8%. Compared to the most energy-efficient glazing RTLC in this region, there is no significant difference for the energy reduction between them since the disparity is around 2% in a building network. This means that LCLC and RTLC have similar effect on the energy consumption in a building environment with overshadowing, thus it is reasonable to choose any one of them for the building window retrofit. But if ignoring the mutual shading, this difference could increase to 4% and it is impossible to choose LCLC for the improvement of window glazing system.

Regarding the different types of glazing, mutual shading has different impact as seen in Figure 3 but these effects are positive and significant in this climate. The most significant one is to increase the energy reduction by 6.97% and the lowest one is around 4.58%. This positive effect is beneficial to enhance the building energy efficiency and it is necessary to take it into account when evaluate the thermal performance of the building window retrofit measures.

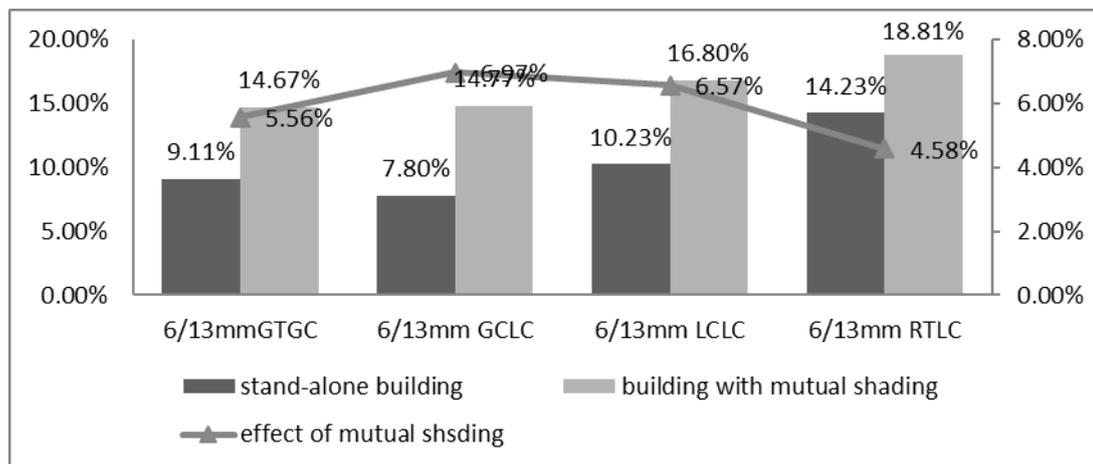


Figure 3: Energy reduction caused by different window glazing and mutual shading effect in hot summer and cold winter climate

### Mutual Shading Effect on Thermal Performance of Window Glazing in Severe Cold Climate

In severe cold region such as Harbin, the cold winter lasts for 6 months from October to April but the summer is short and mild without cooling demand. The predominated energy use is caused by heating demand in this climate. To identify the effect of mutual shading on the energy consumption, there are two groups of energy reduction generated by different types of double glazing in the stand-alone building and the same building in a real urban context, as shown in Figure 4. Both with and without mutual shading, the glazing LCLC has the best thermal performance in this region but it can produce more than 20% energy saving in the stand-alone case building. The significant energy reduction is beneficial to improve the building thermal performance and it is rational to choose this glass to replace the existing one.

Obviously, the inter-building effect has a negative effect on the thermal performance of window glazing in this severe cold region. No matter what type the glazing is, the consideration of mutual shading easily weakens its energy performance. This means that

the ability of the double glazing to reduce energy consumption in a real building environment is not as good as that in a theoretical urban context without any nearby obstruction in this region. If taking the mutual shading into account, the energy reduction generated by glazing GCLC is very close to that of glazing LCLC as we seen in Figure 3. There are different impacts of mutual shading on window glazing performance that ranges from -2.85% to -7.58%. This significant negative effect of mutual shading cannot be neglected when evaluating the building performance during the process of building window retrofit.

It will be practical and reliable to combine the inter-building effect with the thermal properties of possible glazing alternatives while selecting the most energy-efficient window retrofit measure in such specific climate. It may be practical to use GCLC instead of LCLC when considering the mutual shading effect since the low-e glass is very expensive. But if ignoring the urban context of the case building, there is no doubt that the LCLC is the best choice due to its much bigger energy reduction. Particularly, any of existing buildings is a real building which is definitely in a real building environment and it is essential to consider the mutual shading from its neighbouring buildings into the energy performance prediction when evaluating energy savings caused window retrofit solutions.

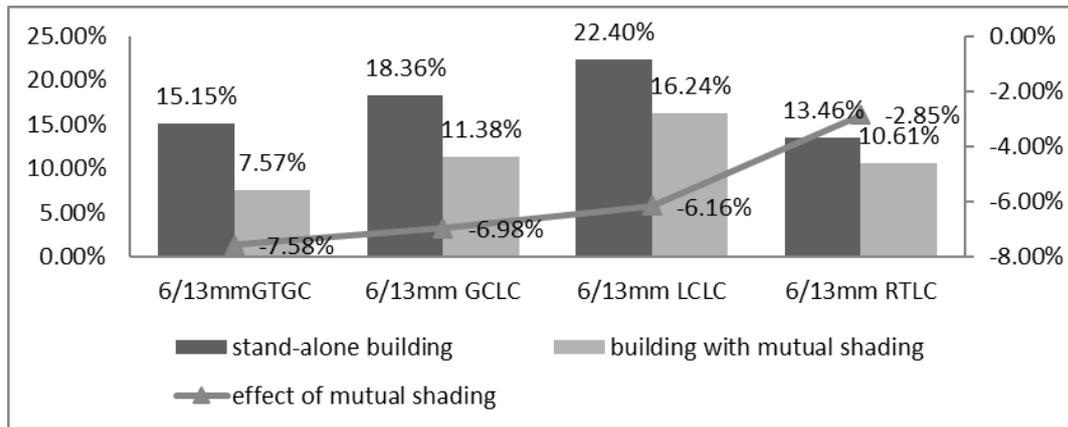


Figure 4: Energy reduction caused by different window glazing and mutual shading effect in severe cold climate

## CONCLUSIONS

The findings of this study indicate that mutual shading from neighbouring buildings has a significant impact on the annual heating and cooling demand of a high-rise building. In cold winter and mild summer climate, it almost has no effect on the energy savings produced by the selected double glazing. Apparently, it is unnecessary to take mutual shading into account while evaluating the thermal performance of window retrofit measures in this zone. In hot summer and warm winter climate, the mutual shading is beneficial to reduce the solar heat gain through windows and thus the overall energy reduction caused by the energy-efficient window glazing in a building with mutual shading is far more than that in the same stand-alone building without nearby obstructions. Based on such enhancement, it is convinced that upgrading window glazing can help existing buildings save much energy in hot region. In the hot summer and cold winter region, the effect of mutual shading is close to that in hot summer and warm winter. The overshadowing plays an important role in the assessment process of window thermal performance and it can increase the energy reduction generated by double glazing by up to 6.97%. This significant positive effect provides more choices for decision-

maker to select more appropriate window glazing. In severe cold zone, mutual shading has a negative effect on the building energy consumption and the energy saving would be decreased by 7.58% while putting the case building into a real urban context with overshadowing. Double glazing cannot lead to a dramatic energy reduction in severe cold region if deeming a building as a real case located in a real building environment with the mutual shading of neighbouring buildings. Therefore, it is worth evaluating the mutual effect on the building thermal performance while predicting the energy-efficiency of window retrofit measures. It is better to combine the mutual shading effect with the assessment of building thermal performance into making policies or recommendations of building retrofit. From the viewpoint of decision-maker, retrofit designers and other stakeholders, it is highly recommended that choosing energy-efficient building retrofit solutions would better consider the effect of mutual shading of the surrounding obstructions on the target building other than deem a building as an isolated one when evaluating the energy savings produced by retrofit measures in order to guide a practical retrofit direction, make some real energy-efficient designs, promote effective energy-saving methods and so forth.

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# EXPLORING VISUAL ASSET MANAGEMENT COLLABORATION: LEARNING FROM THE OIL AND GAS SECTOR

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Visual Asset Management (VAM) is defined as a visual, collaborative and cloud-based database application for project sharing, viewing, delivery, operation and maintenance. VAM provides a platform that contains multiple visual data sources of an infrastructure project, including Building Information Models, associated asset documentation and 360° photographic images of the asset. This research presents three cases of the use of VAM in major oil and gas platforms in the North Sea, identifying the challenges resolved using VAM, the benefits realised as well as the opportunities for learning and transfer of VAM to the construction industry. The findings demonstrate that VAM can be used effectively to support decision making process during infrastructure project planning and development. The case studies further demonstrated that VAM will be particularly beneficial in facilities management and built asset operation, thereby, ensuring the accuracy and reliability of information for operations and maintenance. Due to the increasingly complex nature of projects in terms of size, information technology and security, realizing these benefits would require a learning process for all stakeholders involved in procuring and managing assets. This research proposes stepped change and learning opportunity for built assets value maximization and delivery, management and operation efficiency using VAM.

Keywords: collaboration, BIM, Visual Asset Management

## INTRODUCTION

Efficient collaboration and productivity within the construction and energy sectors has always been crucial to business profitability and sustainability, with both sectors shifting their focus in relation to projects delivery, away from the chain of production activities towards developing and applying efficient collaboration and innovation in the creation, sharing and collection of relevant information among interdisciplinary professionals (Eastman *et al.*, 2011, East 2016, Oil and Gas Authority 2017, Leon *et al.*, 2015). The reason for this shift of paradigm is located in productivity difficulties and operational inefficiencies, compounded by the increased complexity of the project requirements. The result of these challenges are large cost overruns, project delays, rework in addition to

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operational bottlenecks when the asset is in use (Bordat *et al.*, 2004, Love *et al.*, 2016, Ahiaga-Dagbui *et al.*, 2017). To tackle these issues, both industries are focusing on adopting innovative digital technologies, including Building Information Modelling (BIM) and other visualisation tools, to aid the planning and delivery of projects in an attempt to tackle some of the difficulties identified above. At the core of these technologies are the concepts of collaboration, visualisation and cost efficiency. The specific research builds upon Lobo and Whyte (2017), Hobday *et al.*, (2005), Ewenstein and Whyte (2007), Leon *et al.*, (2015) and Bucciarelli (1994) who noted that the development of innovative, digitised and disruptive technologies for multi-firm collaborations will be very crucial for tackling issues of efficiency and maximised value-creation. Tackling the potential uncertainty in multi-firm projects carries risks that most companies are unwilling to take (Hobday *et al.*, 2005), which in turn challenges effective collaboration. However, disruptive technologies present a real alternative to the way we approach these challenges, such as communication and management applications within Internet of Things (IoT) and cloud technologies. Embracing disruption and introducing alternative digitised services for managing assets can reduce operational disruptions and provide new opportunities to address poor productivity and projects inefficiency.

Collaboration, productivity and cost control have been developing as a central theme both for oil and gas and construction, highlighting the importance of shared decision making, informed projects evolution and data openness and sharing for successful projects completion (Marquardt and Nagl 2004, Oil and Gas Authority 2017, Eastman *et al.*, 2011, Leon *et al.*, 2015). This research acknowledges that collaboration between different teams with varying expertise can be greatly enhanced by the use of visualisation tools and techniques. Visual representations and their impact on problem finding and design solutions development has been examined in great detail in previous research. Schön's (1991) seminal work claimed that visual material can substantially support cognitive abilities while Lawson (2005) noted that design thinking is promoted with the application of visual representations and stimuli depicting varying levels of details and design scales. Research by Ewenstein and Whyte (2007) explored visual representations as 'knowledge artefacts' applicable for communication and ideas development. These visual means of communication are important for a wide spectrum of sectors, from engineering (Pahl and Beitz, 1995; Bucciarelli, 1994) to design (Schön, 1991).

Both oil and gas and construction industries struggle with collaboration, productivity issues and cost control and have sought after technologies and processes that might be able to help them circumvent the problem. As a result, they have adopted visual collaborative platforms, like VAM and BIM accordingly. BIM, in addition to other disruptive technologies, have been introduced in the construction industry to help with collaboration and collect operation data during construction. On the other hand, oil and gas industry is beginning to apply VAM, which is a digitised collaborative project delivery and asset management platform for minimal disruptions when maintaining or inspecting assets by allowing an aggregated view of a project, its elements and its lifecycle. In this paper, we introduce VAM as a complement of BIM processes that are already transforming the way construction projects are delivered and operated. VAM accommodates collaboration, shared visualisations and understanding for asset management to achieve a high degree of synchronised actions and information flow, and to further support efficient collaboration among partnering companies. The research is also focusing on assets management, which is becoming a central theme of projects organisation and planning since it is a vital parameter for ensuring project delivery within the required time, cost and quality.

Based on the theoretical discourse described above, this research presents a VAM framework with the implementation of a hybrid collaborative platform that provides a visual front end asset management and incorporates accurate 3D representations and data. The technology provides a facility that enables the supply chain to collaborate, and improves data capture, information management and project coordination and planning. The rest of the paper is structured as follows: a review of collaborative practice enhancement using visual stimuli is presented, together with an overview of VAM and some common challenges between oil and gas and construction. Afterwards, three different case studies are presented where VAM was applied, thus demonstrating transferable capabilities and applications across the two industries, energy and construction. The paper concludes with recommendations for further research and development on VAM systems.

### **Theoretical Framework: Collaborative Practices Enhancement by Visual Stimuli and VAM**

#### **Impact of Visualisations on Collaboration**

Why visualisations are so important? Visualisations contain the potential for ideation, reflection and projects' development, hence, teamwork and interdisciplinary collaborations can be strongly supported with the implementation of visual representations (Ewenstein and Whyte 2007, Leon *et al.*, 2015). By taking into consideration the fact that design solutions will develop in an adaptive and iterative manner (Schön 1991), collaborative teamwork can only enhance this process through the acquired knowledge and team members' contributions. When it comes to the energy and construction sectors especially, design problems are ill-defined by their nature and they are considered moving targets that quite frequently 'do not have a solution but only a resolution' (Arias 1995), hence, multidisciplinary teamwork can support successful changes, conflicts and adaptations. Having the support of visual representations further enhances these collaborations (Leon, *et al.*, 2014a). Most importantly, this research is showcasing how digital and virtual sharing of information and visualisations can be a facilitator for collaborative design and assets management, by assisting interdisciplinary professionals externalising and communicating their ideas, hence leading to cost and time savings in major projects.

#### **Visual Asset Management**

VAM is a digital platform that supports 'visual management' i.e. visualisation tools for information sharing, asset operation, security management and improving understanding of customer needs and organisational principles (Tjell and Bosch-Sijtsema, 2015; Eppler and Burkhard, 2007). 'Visual' refers to representations that transfer information within any type of design projects for digitally enabled coordination and delivery (Whyte and Lobo, 2010; Lobo and Whyte, 2017) as well as 4D Building Information Modelling (BIM) that connects temporal and spatial aspects of a project. This integration is thus supporting viewing, scheduling and communicating of a project (Eppler and Burkhard, 2007; Eastman, *et al.*, 2011), whereas, project digital delivery, similarly to Integrated Project Delivery (IPD), is defined as integrated software both within and across firms, supported by extranets, management and computer aided design types of software (D'Adderio, 2001, Poirier, *et al.*, 2016). 'Asset Management' refers to aligning operational and business strategies for reliable assets function, optimum performance and overall site productivity, characteristics that are shared between construction and oil and gas (Tezel, *et al.*, 2009, Fuggini *et al.*, 2016).

Complex problems solution-finding can be supported with the application of collaborative practices, as described by Fischer (2000), who argued that the creation of shared understanding among stakeholders can lead to ideation and development of innovation. These processes can further flourish with the application of Computer Supported Cooperative Work (CSCW), which provide appropriate project information through digital mechanisms and avoid cognitive overload (Bucciarelli 1994). These types of system can embrace interactions with users and visual data, thus enabling data exchange and exploration and allowing space for production, coordination and communication (Tezel, *et al.*, 2009; Leon *et al.*, 2014a). From this base, the VAM studied in this research has expanded to build upon CSCW technologies, assisting in the analysis and evaluation of virtual prototypes in a realistic manner and quite often more effectively than physical or visual models. This research is moving forward from examining visual, pictorial, geometric and scripted elements of assets portfolios to considering the dimension of project planning and most importantly, the multi-firm and multidisciplinary perspective of contemporary projects creation and development with a global view of assets and their specifics. Access to this information would enable minimising disruptions, for reasons like maintenance or inspections, and it would maximise assets usability and efficiency. Linking different ideas on visual data, multi-firm and interdisciplinary collaborations and project planning casts light on VAM as an intrusive technology framework for project planning and asset management, thus, enabling added value and strategic collaborative decisions by allowing an aggregated view of a project, its elements and its lifecycle.

### **Industry challenges and applications**

Application of the aforementioned technologies within infrastructure projects would be useful in maintaining a fit-for-service condition of an asset, thus ensuring safety, efficiency and reliability for operations and clients cost effectiveness. This can have considerable cost saving implications particularly from a facilities or asset management perspective. In the case the O&G, cost efficiency and productivity optimisation has mainly be achieved through applying design, engineering and operational integration (Marquardt and Nagl, 2004). The industry is characterised by quasi-static processes that the subject of slowly varying constraints (Fuggini *et al.*, 2016). However, the recent lower-for-longer oil price environment within O&G industry demanded for enhanced efficiency within the industry, similarly to the crises within infrastructure projects (Eastman *et al.*, 2011). As a result, professionals in both industries are required to move from a deterministic approach to a probabilistic approach with uncertainty and variability reduction, more precise estimations of failure points and adoption of condition based monitoring, thus optimising asset management (Neumann and Krieger, 2012). *Therefore, building project lifecycle intelligence of a built asset within a digitised framework would not only allow more accurate cost predictions but it would also promote health and safety within operations.*

### **VAM framework: From Oil and Gas to Construction Industry**

This research studied the application of a specific VAM platform in the Oil and Gas (O&G) industry, namely R2S Mosaic® by Return to Scene (R2S). R2S Mosaic (VAM R2S) is used predominantly by international energy companies as a VAM to record, operate and manage complex assets, particularly in offshore locations. VAM R2S enhances planning, collaboration and presentation by consolidating, contextualising and presenting multiple forms of information in a user-friendly, visual form (Figure1). The VAM framework involves the capture of 360-degree high definition photographs of remote assets that are developed in Plant Design Management System (PDMS) files and

combines these with a software interface to create virtual, interactive walk-throughs. Associated data can then be added and accessed from within these images, providing a highly intuitive method of recording, editing, sharing and presenting information. Such an inclusive and visual platform not only encompasses multiple types of information, but also allows both synchronous and asynchronous, face-to-face and distant collaboration, communication and planning (Figure 2), thus augmenting understanding for assets management. When linked to other client systems, databases and live data feeds, R2S becomes a knowledge portal, through which multiple participants, departments and disciplines can collaborate and learn. Even though some of these systems are relatively well developed in industries such as O&G, there has not been the uptake of these technologies in the construction industry. Thus, the challenges of poor coordination, information exchange, collaborative and front-end planning are still pervasive in the industry (Ozorhon and Cinar 2015, Adam *et al.*, 2017).

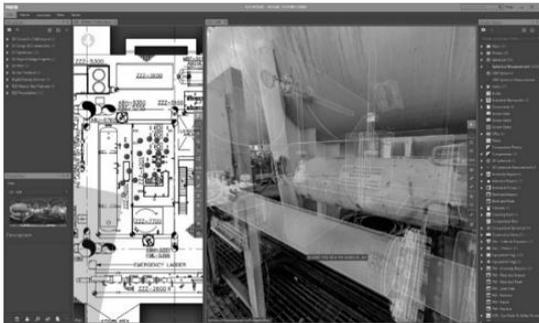


Figure 1: VAM R2S graphical user with 360-degree photographs & databases interface



Figure 2: Asynchronous and distant collaboration using VAM in R2S

## RESEARCH APPROACH

This research adopts a case study approach by appraising three examples of the application of VAM in the O&G industry so as to present learning opportunities for cross-industry knowledge transfer to construction and infrastructure projects. Case studies are appropriate where an in-depth knowledge of an individual example is more helpful than fleeting and superficial knowledge about a larger number of examples (Gerring 2006). The purpose of the study, at least in part, is to shed more light on the larger population by critically examining the phenomenon in one, or a few. It is preferred research strategy when the phenomenon and its context are not readily distinguishable and when a deeper understanding of practical issues on how things actually work is required (Denzin and Lincoln, 2011). Within this research, case studies provide the insight regarding VAM applicability within real-life context while they share some important characteristics (precision, quantification, objectivity and rigor). The first two projects cover the planning and actual delivery of projects while the third case study is chosen to demonstrate the utility of VAM for project team collaboration in a data hub and the shared approach was related to drawing out themes or findings which might be more readily transferred to construction.

## VAM CASE STUDIES

### *Case study 1: Chevron's Erskine offshore Oil and Gas platform - Reinstatement*

The first case study focussed on the application of R2S VAM for efficient asset reinstatement of an offshore O&G platform in the North Sea (Christie, *et al.*, 2015). A fire on Chevron's Erskine offshore O&G platform in the North Sea in early 2010 resulted in operational shutdown, and a fire on a Normally Unmanned Installation (NUI) led to an

eight month restoration effort. Having been made aware of the benefits of VAM technology by a tier-one service provider, the Offshore Installation Manager (OIM) for the asset proposed the application of R2S. In using VAM, the OIM noted:

...we faced pressure around bed space, so the visualization capture allowed us to plan, capture, build, deliver and manage a solution to this challenge. It also meant that we could limit the number of offshore surveys required in the project because we effectively had a pair of eyes on the installation at all times thus reducing the numbers required on board.

This VAM system proved valuable for Chevron during the reinstatement process that the impact to the business was realised beyond the scope of the original project. Chevron has since completed the roll out of the spherical Photographic VAM system across its North Sea assets identifying it as a step change in providing benefits relating to maintenance, reliability and integrity management including improvement in planning work for turnaround coordinators (Christie, *et al.*, 2015). It also allowed for staff or visitors to explore work areas prior to mobilization for campaign maintenance, strengthening defect identification and work pack pre-population for reliability.

#### *Case Study 2: Magnus Life Extension and Eastern Trough Area Project- Life Extension Project Planning*

The second case study examined the application of R2S VAM for planning purposes. British Petroleum (BP) applied R2S in 2016, within the North Sea for the Magnus Life Extension Project (MLXP) and Eastern Trough Area Project (ETAP) Life Extension Project (ELXP). A saving of 75 man years in time was made - equating to almost \$20 million saved on items including office space, flights, beds and other associated travel and accommodation costs. As Little *et al.*, (2016) explained, the North Sea Renewal Campaign commenced in early 2014 and incorporated two assets which form the focus of this case study. The renewal campaign was undertaken to tackle integrity and reliability issues to improve operating efficiency and avoid larger interventions (Maslin, 2013). These non-shutdown life extension projects sought methods of maintaining production while considerably increasing fabric maintenance, modification and general maintenance work done, with a view to establishing a more sustainable operating model with offshore-onshore collaborations.

Working closely with the R2S project leads, BP ensured minimum impact on limited offshore accommodation (bed space). To complete the R2S virtual capture of assets, a high density of 360° spherical photographs was required. On the Magnus platform for example, over 7000 positions were photographically captured, to cover all areas required. A vivid, intuitive photographic walk around environment of each facility was then created using the spherical photography taken, built within the VAM software system. This provided the ability to place tags within the images to identify equipment, link to documents and databases, enabling users to search the virtual facility by tag number (Little, *et al.*, 2016). This enabled BP to show onshore employees a detailed view of the facility for context, reducing travel requirements and improving access to vital information. During this case study, a number of tangible benefits were realised largely due to the use of visual collaboration platforms, all of which could be readily transferred to construction. These included an immediate return on investment after deployment of the VAM system (the return amounted to over 20 times the initial deployment cost on this single renewal project alone, as noted in Little, *et al.*, 2016). On the MLXP and ELXP project, BP further recorded a 10% improvement in planning and resource efficiency in the reducing of staff requirements in isolated sites, improved designs accuracy, more effective and efficient communication and collaboration between the different teams and expertise involved.

### *Case Study 3: Collaboration, Data Hub*

The Magnus Life Extension Project and Eastern Trough Area Project Life Extension Project is further analysed in the context of developing a collaborative Data Hub. The VAM was applied as a central hub for a variety of systems also utilized in relation to a particular asset (Christie, *et al.*, 2015). Maintenance management systems (MMS), equipment management systems (EMS) and conditioning monitoring systems (CMS), for example, can all be linked within some VAM technologies. This creates a central point, a hub, for data that is held within disparate systems that relate to the same asset and thus presenting a significant opportunity and platform for collaboration. It also gives visual context to the data held within these systems that makes the information clearer to understand. Christie, *et al.*, (2015) explained that each task was tagged within the system with a corresponding symbol to identify the kind of job and then each work pack, which featured photography images from the VAM system, was attached to the tag. Visually this made it very easy to see the spread of tasks that were required within the campaign on the particular asset. The operator went a stage further to include the MMS data for each task within the corresponding tag on the VAM system. They then set up the tags to change colour depending on the criticality of the job, as dictated by the MMS. All of this planning and work pack creation was done from the office, using the VAM technology. What this provided was a highly visual representation of the maintenance campaign which assisted the operator to ensure that very urgent tasks were handled first and to ensure consistency across asset systems. This example shows how VAM technology can provide a collaborative environment for existing and future systems. The technology has also been shown to increase collaboration between operators and their contractors both in operations and the supply chain.

As mentioned, the measurement capability within VAM technology enables areas to be investigated and analysed without the requirement to physically visit the asset. Some operators have reported that they use their VAM technology to further advantage, in competitive bid situations. By allowing contractors/third parties to access the visualization of their asset, operators can receive accurate and competitive estimates for work without the expense and inconvenience of having additional visitors to their assets. This also enables the typically challenging bid process to be expedited and streamlined. Furthermore, equipment vendors have been given access to the visualizations of some operators' assets in order to discuss and identify issues with plant. Images, sound recordings and video can be added as tags in some VAM technology and this enables users to communicate faults with vendors as an initial step before a visit to the asset. In some cases this may mean visits to the asset to fix the faulty equipment are reduced.

## **DISCUSSION**

Having instantaneous access to information at the right time and in the right format improves productivity, reduces costs and enables more effective decision-making (East 2016, Whyte and Lobo 2010, Leon *et al.*, 2015). The application and benefits of VAM detailed above could be significantly beneficial to the construction industry, particularly in terms of facilities management and operation of built assets (Bordat *et al.*, 2004, Love *et al.*, 2016, Adam *et al.*, 2017). Major infrastructure projects like underground mass transport systems, airports and tram systems are particularly becoming very complex and must accommodate several smart technologies and integrated systems in order to meet the demands of the 21st century in terms of security, energy usage, climate change and rapid population expansion. The PAS 1192-3 'Specification for Information Management' for operational management of an asset can for example be used with VAM to develop

digital plan of deliverables, which can be specified in a contract and delivered using Construction Operations Building Information Exchange (COBie) (East, 2016).

We see increasing application of digitisation in the construction industry, and a desire to realise the aspirations of Integrated Project Delivery (IPD) with the consequential embracing of complexity in projects, promotion of understanding, support for visualisations and improved reliability. However, as with many new technologies, a great number of challenges and issues can occur, these related to collaborative challenges, to synchronous/ asynchronous communication and, most importantly, to tackling risks and uncertainty regarding costs and lack of on-site information. VAM systems, such as R2S, offer the potential to support a transfer of this knowledge to the built infrastructure and construction industries. Infrastructure projects are typically driven by tight budgetary constraints and high operational and maintenance costs. VAM can be used as a mechanism to capture the data needed to deliver a consolidated operations and maintenance manual, which can be imported directly into computerized maintenance management systems and asset management package. This could be a crucial step in 'future-proofing' critical infrastructure (Love *et al.*, 2017). Planned and unplanned shutdowns and system failures can now be efficiently and cost-effectively executed as all the requisite systems needed for these operations integrated into a single VAM platform.

## CONCLUSIONS

VAM technologies applied during project initiation and early phases of projects in the O&G industry enabled asset familiarisation, reduced time spent on engineering surveys, reduced travel time to and from sites, problem solving platforms between onshore and offshore teams as well as reduced the disruption caused during engineering surveys. *VAM enhanced horizontal collaboration between operating and non-operating partners*, thus, saving on valuable time, since all involved stakeholders had access to a virtual model of the project and thus negating the need for site visits to isolated and often harsh weather environments in the North Sea. On the vertical supply chain axis, a highlighted feedback was that VAM provided subcontractors with no previous experience on specific tasks or sites, with the ability to visualise the work site and accurately plan the work without the requirement for a time consuming and costly visit. VAM application during the tendering process allowed contractors to provide a more accurate cost to their clients. Effectively, VAM application de-risks unknowns and surprises once onsite that could impact on work scope, time and billable costs.

Could VAM actually change our perception of IPD, collaborative projects delivery and facilities management? BIM and COBie have been welcomed pacesetters to the needed technological inputs that might help reduce some of the inefficiencies in the industry. Based on the evidence and benefits realised from the case studies presented from the O&G sector, the research suggests that VAM does indeed hold significant potential for construction infrastructure delivery and operation. The findings of the paper draw on three case studies and indicate significant potential for stepped change and learning opportunities in the way built assets are currently delivered and managed. Therefore, future research within this on-going research will focus on applications of VAM technologies on real-world infrastructure projects. These applications would intend to monitor group dynamics and collaborative practices when developing and encompassing as-built models within R2S, as well as the using VAM for operations and maintenance of infrastructure projects.

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