



ASSOCIATION OF RESEARCHERS IN **CONSTRUCTION MANAGEMENT**

**THIRTY-FIRST
ANNUAL
CONFERENCE
2015**

September 7-9

Lincoln

Volume 2

Association of Researchers in Construction Management (ARCOM)
Proceedings of the 31st Annual Conference

Edited by Ani Raidén and Emmanuel Aboagye-Nimo

First published 2015

ISBN: 978-0-9552390-9-0 (2 vols)

Published by
ARCOM, Association of Researchers in Construction Management
c/o School of Construction Management and Engineering
University of Reading
PO Box 219
Reading
RG6 6AW, UK

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ARCOM Declaration:

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

FOREWORD

Welcome to the 31st Annual Association of Researchers in Construction Management (ARCOM) conference. As we settle into the new decade of activities, ARCOM has extended the online provision of materials and embraced international collaboration. For the first time, we have prepared a 'live programme'. This is an interactive version of the conference programme, available via MyARCOM (https://secure.arcom.ac.uk/view_prog_whole.php?id=24). We will use this tool to provide up-to-date information about the conference and give access to the papers being presented in Lincoln online.

As the world of research becomes increasingly digitised and our conference proceedings are less often read in hard copy form, it felt that the papers weren't perhaps getting the same attention they once were. At the time when a hard copy of the conference proceedings was accessible to all delegates, many browsed and read papers during the sessions to find additional information while others perused the proceedings to seek interesting presentations to attend. Often delegates did a bit of both! I wanted to bring back this easy access to the full papers. The authors whose papers are included in these proceedings have worked very hard, in many cases years, to conduct the research they publish here, and so their work should be available, in full, to all at the conference. ARCOM provides an open access source for the conference proceedings and the abstracts of several leading construction management journals and PhD theses within the CM Abstracts database (<http://www.arcom.ac.uk/abstracts.php>). We will continue to provide all year round access to relevant publications in the field. We hope that this new tool, the 'live programme', will help you navigate your way through the many parallel and plenary sessions, and smoothly access the full papers via MyARCOM during the conference.

In these proceedings we present the rich variety of contributions to the conference. This year our delegates come from 33 different countries with a diverse range of backgrounds, interests and expertise. Sustainability; planning, productivity and quality; building information modelling; and health, safety and well-being continue to draw a large number of submissions. Procurement and risk management also feature as important themes in the conference, together with house building which is increasingly popular topic. Decision-making modelling emerges as a new area of interest.

We present to you 127 papers that were accepted for publication. This is the result of an intense three-stage double-blind review process through which we have been able to maintain high quality standards. Our initial call led to an astonishing 357 abstracts and 192 full papers being submitted. The Scientific Committee have worked very hard to select the final papers for presentation. If your paper is included in these proceedings then you should feel very proud of your achievement!

In addition to the research papers we welcome to the conference our keynote speakers and debate panellists: Professors John Connaughton, University of Reading; Alan Penn, The Bartlett, University College London; Martin Loosemore, The University of New South Wales, Australia; and Deborah Pullen, Building Research Establishment. The debate will address: *'This house believes that the widespread insistence on justifying investment in research with reference to the 'business case' inevitably perpetuates current modes of working and hence hinders innovation.'*

The Langford Lecture this year will be presented by Jemma Bridgeman from Construction Youth Trust, Cymru. And, as a follow on from the debate on method in

Portsmouth last year during the 30th Annual ARCOM Conference, we are most pleased to introduce a new Spotlight session on Comparative Studies. Professors Henrik Linderöth, Jönköping University, Sweden, and Chris Harty, University of Reading, will chair this discussion of comparisons by country, industry, stakeholder, competences, task, and process.

Putting together the academic programme for the conference is a collective effort, and I thank the ARCOM committee and wider Scientific Committee for their voluntary contribution to making the conference such a success year after year. David Boyd, Paul Chan, Scott Fernie, Chris Harty and Simon Smith in particular have been instrumental in supporting the planning and managing of the conference over the past eight months.

I wish you an enjoyable and inspiring three days in Lincoln; enjoy the diversity of research presented at the conference and proceedings and make the most of the many networking events.

Ani Raidén, ARCOM 2015 Conference Chair, Nottingham Trent University, UK
On behalf of the ARCOM Committee

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CLIENT'S PRESENCE DURING DESIGN: A STUDY ON ROLES, PRACTICE AND VISUAL MANAGEMENT

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From earlier studies we know that communication between clients and the design team can be difficult and needs and wishes of the client are not always understood. Studies related to integrated design processes, cooperative work approaches and collocation support a better cooperation between the client and the design team. Furthermore, visualisation is known for being supportive of sharing information and knowledge embedded in practice. The aim of this article is to explore how the physical presence of the client and application of visual means influence practices for sharing information and collaboration toward realizing the client's needs and wishes in the final design. The research applies a multiple case study of three qualitative cases in an Integrated Design Team (IDT) setting. All three cases were followed throughout the entire design process, where the design teams were semi-collocated. Based on empirical data we found the following: (1) the physical presence of the client in a IDT environment influences (i) the relationship between the client and the IDT, (ii) and the client's role towards being an active member during the design process. (2) The client applies a traditional way of sharing their information in contrast to the work practice and potential for visualization within the IDT (3). There exists potential for increasing the use of visual means and possibilities of visual management to enable the understanding of the client's needs and wishes in an IDT.

Keywords: client's role, collaboration, collocation, design and visual management.

INTRODUCTION

Construction design is a complex process with many actors and often crosses multiple disciplines and organizational boundaries (Bosch and Henriksson 2014). Information transfer and communication are often problematic during the design phase (Dainty, *et al.* 2006), within the design team but also between the client and design team. In project-based teams with members from multiple organizations with different priorities, embedded practices and domain knowledge, it can be difficult to share knowledge and information. However, the process of sharing information and knowledge between the client and a design team is crucial for the compliance of the final product with the needs and wishes of the client. The knowledge and information, which is important to share during the design is often specialist knowledge that is situated, embedded and situated in practice (Beth 2003; Orlikowski 2002). In a project context, sharing of embedded and practice knowledge becomes a challenge.

In project-based industries the sharing of embedded knowledge is often found problematic and many studies focus on how to support knowledge sharing of embedded and practice knowledge. Some studies focus on different work approaches

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in which the design team collaborates closely in a specific environment, with the use of visual and technology means and in which knowledge is shared through interaction and practice. A number of concepts have been studied and tested that emphasize the importance of working with structured and visual methods supporting joint problem-solving and concurrent collaboration, e.g., BIG Room concept (Liker 2004), extreme collaboration (Garcia *et al.* 2004), integrated concurrent engineering (Evbuomwan and Anumba 1998), Integrated Product Delivery methods (Cohen 2010). These approaches have been found to embrace the complexity of a construction project, eliminate misunderstanding, improve reliability in the design team and support visualization of the mutual needs and wishes of both the design team and client. Studies based on these approaches have focused on the physical location, different methods and techniques applied, and benefits and challenges of these concepts. Although, many of these studies show the benefits of increased understanding within the design team and improved interaction and joint problem-solving, few studies discuss in detail how the physical presence of the client as well as the use of visual means impact the design team in terms of sharing information and knowledge practices. In our research we apply the term Integrated Design Team (IDT), which is a combination of the earlier terms used.

The aim of this study is to explore how in particular the physical presence of the client and the use of visual means influences knowledge and collaboration practices in a collocated environment towards the realization of the client's needs and wishes. The IDT's investigated included the design team as well as the client. In this context, the client is an in-house commercial client, whose profession is to invest and sell properties - the client is not the owner of the finalized property. The contractual relationship between client and the contractor is a standard design-build contract. The paper is structured as follows; the relevant literature is discussed in the "*Visualization in design*" section. In the methods section we explain the qualitative comparative case study method applied for executing this research and in the findings and discussion sessions we discuss the findings and relate the findings to the literature.

VISUALIZATION IN DESIGN

One of the main purposes of construction design is that the client shares their needs and wishes with the design team. The design team in turn needs to interpret these requirements and executes a set of actions to satisfy these needs and wishes to buildable documentation (Bowen and Edwards 1996).

To enable this sharing of information and knowledge between the design team, the project manager and the client are crucial (Boyd and Ezekiel 2006; Cherns and Bryant 1984). It is important that the target value plays a central role in the discussion throughout the entire process and in particular during the design. Often the client directs their needs and wishes through the formulation of a design brief, a 'mind model' of the project. The design brief functions as a medium of instruction between client and design team, a means of stimulating communication, a record of decision-making process and a tool for evaluation (Bowen and Edwards 1996). The quality of the brief is of importance for final client satisfaction, but has been described as inadequate or dependent on the client (Kamara *et al.* 2001; Ryd 2004). Literature primarily discusses the briefing process from the early initiation until the concept and scheme design. However, few studies discuss how the content of the design brief from the client is shared with the design team.

From earlier studies we know that especially information transfer and communication are often problematic during the design phase (Dainty, *et al.* 2006). In recent years there has been more focus on collaborative and integrated work in construction to improve performance (Xue *et al.* 2010). Although there are a number of different types of collaborative and or integrated work approaches, we focus on integrated design teams (IDTs) in which all actors, including the client, are participating (i.e., Garcia *et al.* 2004; Liker 2004). Many articles study on virtual design collaboration and technology supporting this type of design. However, other studies discuss the importance of collocation of the design team - either in a hybrid form or full-time - which supports face-to-face interaction, time spent together, facilitates both formal and informal communication and increases the chances to discover problems and solutions in line with the client's requirements (Garcia *et al.* 2004).

However, the application of integrated design creates new challenges. In these IDTs, where the design team spends more time together, either collocated or virtual, and new relationships arise and the group dynamics change. Traditionally, the client has shared information regarding their needs and wishes through the architect and the project manager to the design team (Foley and Macmillan 2005). In the IDT environment, the client is facing the design team more strait forward and has now the responsibility for making sure that the design team has understood and received the information regarding the client's needs and wishes (Bowen and Edwards 1996). While the presence of the client together with the design team enables faster and improved sharing of information and knowledge, it is important that the design team has possibilities for sharing the members' embedded and practice knowledge as well. Especially sharing embedded and practice knowledge is supported by collocation and visualization, in which it is possible to observe actions and practices (cf. Orlikowski 2002).

Another media that supports team member's possibilities for sharing information and embedded knowledge is visual communication. From studies on visual illustrations we know that the human brain is faster in processing visual illustrations than text and spoken language, and is capable of handling more visual information than non-visual information (Greif 1991; Barry 2005). For sharing knowledge and practices, the use of visual means has been studied from different perspectives and supports learning, sharing of knowledge, as well as the development of new work practices (Boland *et al.* (2007; Henderson (1991; Nicolini 2007). Visual means are already applied in the construction industry in terms of visual representations as well as visual planning methods.

Visual means are often perceived as visual representations that support the visualization of a construction through 2D sketches, drawings or 3D models (Ewenstein and Whyte 2007; Henderson 2007; Nicolini 2007). Other visual means are the use of methods like visual planning or visual time scheduling, which originate from lean methods (Ballard 1999; Ballard and Koskela 2009; Santos *et al.* 1998).

While the construction industry applies some visual means, in other industries this has been more common. Especially in manufacturing, the term visual management is applied and is defined as a holistic system supporting visualization of information to help teams and individuals to gain a better understanding of their role and contribution within the larger frame of a project (Liff and Posey 2004; Eppler and Burkhard 2007). Through such a system, knowledge and information can no longer be treated as an asset, but information and knowledge become available for everybody (Greif 1991;

Liff and Posey 2004; Galsworth 2005). This creates transparency as well as motivation among the employees in order to understand underlying motivations for various activities.

METHOD

The carried out study was a comparative qualitative case study (Easterby-Smith *et al.* 2014), in order to explore the client's role in an IDT and their abilities to collaborate and share information and knowledge with the design team, both with and without the support of visual and technical means. The study was based on qualitative cases of three ongoing design projects. All three cases were in-house residential housing projects and had a design-build contract. The cases were selected based on their similarities regarding work method, size, geographical semi-collocation and physical setting for the IDT. The IDT teams worked in a collocated environment for one full-day per week and was supported by structured methods and multiple visual means to support sharing of information and improving the mutual understanding between the client and IDT.

All three projects were followed throughout the entire design process and more than 22 semi-structured interviews were held with key members of the three projects and interviews were recorded, transcribed and coded. We applied a qualitative methodology for coding derived from grounded theory (Lincoln and Guba 1985). As well as interviews and secondary data collection, we performed continuous observations of more than 100 hours of the collocated design sessions based on a structured observation guideline.

The studies were conducted at one of the largest contractor companies in the Nordic EU-countries. Case study A consisted of a design team of 6 -13 members, Case study B had a design team of 8 - 12 members and Case C had a design team of 8 –10 members. All teams had the following disciplines represented at every collocated session: client, architect, structural engineering, heating, ventilating and air conditioning (HVAC), electricity and project manager (PM). Occasionally subcontractors, Virtual Design and Construction (VDC) coordinator, fire, cost estimation, and site manager were also present. All three cases designed residential houses in the Gothenburg area in Sweden, based on design-build contracts and we followed the projects during two phases: (1) the design and (2) the detailed design phase.

Both for the design and the detailed design phase the IDT collaborates for one full day per week in a collocated environment. The team follows a structured agenda during the collocated sessions and begins with a review of the protocol followed by a review of a visual time schedule and then the “*To-and-From*” matrix which visualizes questions and responses within the IDT. These activities combined took usually between half an hour and a little more than an hour. After this, the team began their coordination work, where they continuously applied the decision list, A3's and the building information modelling (BIM) models (see Tjell and Bosch-Sijtsema 2015 for a detailed description). In this study the main focus was on the use of the A3 method, which is a visual tool representing e.g., parts of discussions that take place in the IDT. In two of the projects we observed that sketches of design solutions, ideas and changes were made by multiple actors to gain a common understanding in a discussion and support the decision making process. From session to session the PM is digitalizing both the A3 and the decision list and attaches them to the protocol.

FINDINGS

The findings section is structured around three themes: 1) Impact of the client's physical presence during the design. 2) The client's way of sharing information and knowledge with the design team. 3) How the client uses and embraces the available visual means.

Physical presence of client impacts relationships and roles

We found from both the observations and interviews that the physical presence of the client plays an important part during the IDT meetings in a number of ways. The presence of the client during the IDT meetings makes the design teams focus more on the needs and wishes of the client *“Using this method, there is focus on the client's needs and wishes – just for that simple reason that they (the client) are present!”* (Structural engineer)

As well as creating a clearer focus on the client's needs and wishes, the clients also have the possibility to steer and direct the design process when they are physically present during the process. This was both mentioned in the interviews, but primarily observed during the design sessions. In these sessions the client could comment, ask questions and receive detailed information and sometimes clearly state that this is not what s/he wanted to obtain.

However, the client's physical presence alone is not enough, according to the interviewees. The clients' representative has to be actively engaged in the design process otherwise the presence of the client can even create some frustration among the IDT. *“I mean there are some clients' representatives who are physically present in the IDT meetings, but while they are sitting there, they are doing other things not related to the project and only answer single questions, and then according to me they have totally missed the point with the IDT meetings”* (Structural engineer)

On the other hand as well, when the clients' representatives are both physically and actively engaged in the design and the design process then the clients' representatives can receive a better understanding of the ongoing challenges the IDT is facing and adjust their request and demands. In several interviews the personality and behaviour of the client was mentioned as important to succeed in an IDT concept. *“If it is a good client, then I think the needs and wishes are communicated very clearly. Absolutely, what is the goal, what is it that we want etc. ... But it has to be someone (client) who is active; you cannot have someone who says, “Here you go” with the design brief and then leave the rest to the project manager.”* (Structural engineer)

The relationship between the client and the IDT has changed from being an abstract role to a real person. *“I did not know the consultants in the same way as I do now, where we even sometimes have lunch together”, “Maybe I have become more visible to the other consultants and they know that it is me who is in charge in the end if they want to change anything. Earlier, I think it has been more that the PM has had to say I have to ask the client. Now when I am there, they can ask directly”.* (Client)

The presence and focus on the increased collaboration between the client and the IDT, also lead to a change of the clients role and IDT's expectations to the client. *“I mean we are setting requirements to our client in a totally different way, you (client) have to deliver an answer because we need it, otherwise you cannot move in, in two years. That is creating a whole new understanding but also a requirement on the client's role, which we have never had before so clearly. And this becomes very clear if you have a client, who does not understand what they have to deliver. When you are*

sitting in an IDT environment, it becomes very powerful when it is outspoken that “you” have to deliver something next week, it becomes very powerful – it becomes a whole new role”. (PM)

The client’s role is therefore changing from being secluded from the design team to be an active member of the IDT.

Sharing of information between client and the design team

The official communication between the client and the IDT is formulated by the client in a design brief. The brief is a written document and, according to the client, is written before the design and detailed design *“I write (client) the design brief to the architect, we do that already in the programming phase. The design brief is a detailed program that very clearly describes the overall business case. So we are really trying to communicate that this is what we want them to design for us”.* (Client)

Even though the client has the impression that this design brief is very detailed and clearly communicated, this is however not the case according to the IDT members. Many interviewees mentioned that they either do not know about the content of the design brief, or they have not read it. Several interviewees state: *“I cannot say that anyone in particular goes through the design brief”, “I do not even look at it, sorry but honestly I do not look at it.... I think that it is the client's responsibility – it does not really interest me!”* (PM)

The client's sharing of information with the IDT through a written design brief corresponds to conventional ways of sharing information in a conventional design setting. The IDT setting however offers a variety of ways to share information and knowledge, particularly orally or visually. This is also discussed during the interviews as well as supported by observations.

“It (the design brief) is the overall information regarding the specific project, but I think with the application of the IDT concept the need for reading the design brief is declining, at least for me who receives information through the spoken language easier than the written. ... It is easier for me to gain a deeper understanding of the design brief when the PM is going through thoughts and ideas when the client is present, the PM and client have discussions and then parts of information are shared earlier, and not only towards the end of a project, which was the case earlier in a conventional project when the team gathered a lot less frequently” (Structural engineer).

The client's sharing of information through a written design brief is therefore not reaping the full potential of IDT setting.

The use of visual means to share the client’s needs and wishes.

During the design the IDT as well as the client apply a number of visual means to support and facilitate their mutual sharing of information and knowledge. The application of visual means is enabled by the physical setting of the IDT and impacts how people work. *“I think when you have a room like X (the room where all the three observed cases have taken place) where you have all these visual tools; you become more focused on this specific project than in a conventional project. And obviously if you are in such a room you are using the tools on the walls, so it does influence how you work.”*(Client)

Based on our observations, the IDT members are applying a number of visual means, where some of the most frequently applied are the visual time schedule, *“to and from matrix, decision list and the A3’s.”*

It is a combination of all the visual means that facilitate the visual environment which influences the IDT work processes. “So the fact that we in the IDT are working so much with the visual aspect not only in terms of the model and the time schedule, makes it much easier to discuss things, because it becomes visible what we are discussing. So it becomes better because everybody talks about the same thing,”(PM)

One of these visual means has facilitated the client’s abilities to communicate their needs and wishes more clearly to the IDT, this is the A3’s. *“I do remember something regarding “door-automatics” where we wanted to regulate something regarding the electrical installations. Then we did that on an A3, we sketched and explained how we were thinking, to show that it was not a huge change. Because as soon as we from housing (internal client) change anything then it costs a lot because we are working with a design-build approach.”*(Client)

Through the observations and interviews it is perceived that the vision and management of the project is hardly visualised or discussed. One aspect is the lack of sharing information from the design brief, but also the unexplored possibilities that an IDT setting can provide. *“Today it (vision) is not really communicated, it would be better if we had more drawings and visualization of the vision or something similar. It is obvious that we could put more effort into those parts, so that everybody is on the same page.”* (Client)

“It would have been nice if there would have been something on the walls here in the IDT from the design brief. Because as it is now, it is only something that we quickly go through in the beginning.” (Structural engineer)

DISCUSSION

The paper studied how the presence of the client in an IDT setting is affecting the relationship between the client and the IDT. Both in terms of knowledge and information sharing regarding the client’s needs and wishes as well as how this is supported by visual means. Based on three comparative case studies we contribute with the following: (1) the physical presence of the client in an IDT environment influences (i) the relationship between the client and the IDT, and (ii) the client’s role towards being an active member during the design development. (2) The client applies a traditional way of sharing their information through a design brief to the IDT, which is not embracing the opportunities of the visual setting of the IDT. (3) There exists potential for increasing the use of the available visual means and possibilities for visual management to share their needs and wishes between client and IDT. These contributions are discussed in more detail below.

Presence influences the client’s role and relationship with the IDT

According to Boyd and Ezekiel (2006); Cherns and Bryant (1984) understanding of the clients wishes and needs and involving the client during the design is crucial for the success of a project. Based on the data from our three comparative case studies we found that the physical presence of the client in a collocated IDT setting improves the clients understanding of the IDT work processes and challenges during the design. Furthermore, it affects the relationship between the client and the design team positively as the client becomes visible to the design team.

We also found that the client's role is changing in IDT projects. Traditionally, the client has been almost secluded from the design team, allowing the client to pursue the role of giving demands. In the IDT context, the client becomes an active member of the design team. The physical presence is however not enough. The engagement of the client is a cornerstone in the development of this new way of working and role of the client in an IDT setting. Since this role is not well defined, it becomes important that the client understands that their role is changing in an IDT setting. From the findings the task of a client in an IDT context is to be an active member of the design team, sharing their needs and wishes with the team, as well as continuous contributions in the decision making process. Literature concerning integrated project work and design discuss the importance of the integration of the client (Bowen and Edwards 1996; Kamara *et al.* 2001), but does not highlight the impact of the physical presence of the client in terms of relationship and role. Especially, how the role of the client is changing in these new contexts would be beneficial to study in future work.

Clients' communication practices require change

An IDT environment provides the client with new ways of sharing their needs and wishes with the design team. We found that in the studied cases, that on the one hand the client still applies conventional practices to share information regarding the design requirements. While on the other hand the design team does not follow this traditional practice. In the IDT setting the client shares their information regarding their needs and wishes with the IDT through a design brief, which is accessible on a common server for the project. The design brief is hardly communicated either orally or visually at any given point in time during the design process. The client's communication practice concerning the requirements is still following the conventional communication patterns through the architect and the project manager to the design team (cf. Foley and Macmillan 2005). The client's way of sharing information is in contrast to the way of working of the IDT in which various possibilities for sharing knowledge and information orally and visually are possible. The interaction in our cases during the design phase is therefore still critical (Dainty, *et al.* 2006) and more engagement from both the client and the design team is needed in order to improve the mutual understanding and interest for sharing and receiving knowledge and information regarding the client's needs and wishes.

Use of visual means for sharing information

The collocated setting of the IDT supports visualization through multiple visual means. One tool in particular has enabled the client to share and transfer information regarding the design progression more clearly and straight forward to the design team, i.e., the A3 method. Through this visual method, the client has been able to share ideas regarding possible changes within the team and make decisions based on the visual representation. The application of visual means supports the sharing of information and knowledge between the client and the design team (Boland *et al.* 2007; Henderson 1991) and the visual means have enabled the client and design team to gain a shared understanding (Greif 1991; Liff and Posey 2004; Galsworth 2005). The visual environment of IDT is opening up for new ways of sharing information particularly regarding the coordination of the progression of the product, but also for visually managing the project. It would therefore be of interest for further research to explore the possibilities of visual management (Liff and Posey 2004; Eppler and Burkhard 2007) and guidance of the design through the design process, in order to enable the IDT to have an ongoing focus on the client's needs and wishes. Visual management

combined with the available visual means supports the knowledge and information sharing process between the client and design team to deliver the right quality at the right time.

CONCLUSION

Through a multiple case study design we have studied the impact of the physical presence of the client and use of visual means in a collaborative collocated design team. Based on our findings, we contribute with the following: (1) the physical presence of the client in an IDT environment influences (i) the relationship between the client and the IDT, (ii) and the client's role towards being an active member during the design process. (2) The client applies a traditional way of sharing their information in contrast to the work practice and potential for visualization within the IDT (3) There exists potential for increasing the use of visual means and possibilities of visual management to enable the understanding of the client's needs and wishes in a IDT. The study focuses only on clients working from a design-build contract and it would be relevant for future studies to explore the interaction between clients and IDTs in other contractual relationships as well as in more hybrid and virtual environments.

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TRACING CLIENT INTERESTS IN THE COURSE OF THE PROJECT: WHY ARE SOME CLIENT INTERESTS INCORPORATED WHEREAS OTHERS ARE NOT?

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Many construction professionals and policy-makers would agree that client expectations should be accommodated during a building project. However, this aspiration is not easy to deal with as there may be conflicting interests within a client organization and these may change over time in the course of a project. This research asks why some client interests, and not others, are incorporated into the development of a building project. Actor-Network Theory (ANT) is used to study a single building project on a University campus. The building project is analysed as a number of discussions and negotiations, in which actors persuade each other to choose one solution over another. The analysis traces dynamic client engagement in decision-making processes as available options became increasingly constrained. However, this relative loss of control was countered by clients who continued the control over the timing of participants' involvement, and thus the way to impose their interests even at the later stage of the project.

Keywords: client organization, actor-network theory, decision-making process, stakeholders.

INTRODUCTION

Policy-makers, practitioners and academics have often encouraged the construction sector to shift its attention away from simple product delivery towards satisfying more general client needs. In such a client-focused climate, the accommodation of client expectations throughout projects emerges as a significant topic of study. This paper explores the way different and changing client expectations are accommodated in the course of a project. A basic assumption of this paper is that a building develops through successive discussions and negotiations between a number of actors including clients, project team members and material objects. Thus, the paper explores client engagement among the range of actors without privileging clients and their expectations. The analysis provides insights into the way clients impose their expectations over others.

LITERATURE REVIEW

Several construction management researchers have drawn attention to the complex nature of construction clients. For example, Cherns and Bryant (1984) note that there may be cooperation and conflict between individuals inside a client organization (i.e. clients) and that their project goals may change depending on project situations. A

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number of authors in the construction field acknowledge the diversity of client needs. For example, Chinyio *et al.*'s (1998) work, on how to best support clients in their choice of procurement strategy, highlights the diversity of client needs. Their focus on a single decision point leads them to treat these needs as fixed and stable. In contrast, Kamara *et al.*'s (2000) study of the briefing process traces the ongoing clarification and specification of client requirements over time. However, their analysis offers a linear model with little attention to unexpected changes in client requirements. Other authors have explored client-consultant interactions. For example, Green and Simister (1998) and Luck (2007) documented the ongoing emergence and change of client expectations. Clients are influenced by other clients or architects during interactions. Various clients' perspectives are clarified, and the relationships with consultants or their skills influence changes in client expectations. These studies highlight how client expectations emerge and change under the influence of specific people. However, their focus is limited to client-consultant interactions during briefing and design. This paper builds on these observations but expands on them by exploring the way that client interactions, with each other and with members of the project team and external stakeholders, may shape the impact of clients on a building project.

The focus on client engagement in the course of a project builds on a number of studies, each of which focuses on different types of processes. Connaughton (1993) explored how clients change their organizational goals mid-project to better reflect their business activities. He illustrated the impact of client engagement on changing project decisions. However, the author did not specifically account for the impact of project team members' perspectives which are different from those of clients. Winch, Usmani and Edkins (1998) studied the project process as an information process that takes into account the transformational influence of decision points on client goals and expectations as the process unfolds. However, both of the above studies focus on client organizations' rational procedures and did not involve observations of the individual behaviours of client personnel. In contrast, Hedgren and Stehn (2013) explored clients' dynamic engagement in successive sub-processes of decision-making, which includes an information process of the kind discussed by Winch, Usmani and Edkins. Hedgren and Stehn assessed the types of client engagement in each sub-process: rational, judgemental or managing multiple meanings. They took into account both organizational rational procedures and individual behaviours of clients, which were iteratively observed during a decision-making process. They aimed to trace dynamic client engagement. However, they did not study clients' specific goals and requirements. These studies highlight aspects of dynamic client engagement, but none traces specific client organizational and individual requirements being influenced by project team members during interactions, due to their exclusive focus on particular types of process.

Interactions are often studied with a particular focus on participants who have different perspectives, regardless of the types of process. For example, Newcombe (2003) proposed mapping out stakeholders who had different expectations and were likely to influence project decisions. The aim of his study was to enable project managers to predict and avoid potential conflicts. In contrast, Liu and Walker (1998) characterized project participants' interactions more positively, as a process by which they mutually understood each other's different perspectives. They argued that these participants continuously adapted project goals to reflect their respective expectations. Notably, studies by Ivory (2004) and Bresnen (1991) deal with the ways that

participants resolve conflicts and adapt their respective expectations. They studied participants' persuasion and negotiation processes at design and construction stages.

Such studies highlight how clients and project team members influence each other's expectations through interactions. Also, these interactions result in the accommodation of participants' expectations in project decisions. Building on these studies, this paper views a building project as a series of negotiations in which project participants with different expectations persuade with each other, as a result of which some of their expectations are accommodated. The incorporation of different and changing client expectations is analysed within this framework.

THEORETICAL FRAMEWORK

This study adopts actor-network theory (ANT) to explore the incorporation of various and often shifting client expectations into the development of the building project process. The fundamental assumption of this approach is that a wide range of social, scientific and technological factors are involved in the development of scientific claims and technological artefacts (Law 2012: 107). Proponents of ANT often argue that it is not a theory; instead ANT offers a method to follow a number of actors who successively interact with each other during the development of an artefact or claim. A distinct feature of ANT is its treatment of material objects as actors in the same way as people.

A number of ANT researchers have studied the development of knowledge or technological artefacts in project contexts. They particularly analyse the way actors attempt to engage and persuade each other (Callon 1986; Law 2012). More specifically, actors who support one direction of the development of an artefact or a claim and those who resist that particular direction negotiate or persuade with each other. This paper applies ANT to explore how actors in a building project persuade each other to choose certain alternatives over others, and how differing and often shifting actor expectations were incorporated.

In particular, three analytic concepts 'problematization', 'translation' and 'interest' were used for this analysis. The first concept, problematization, refers to an actor's attempt to resolve a particular issue, and encompasses the network of relevant actors involved in that actor's proposal (independent of whether they agree to participate or not) as well as the interests and tasks that constitute this attempt. In response, the relevant actors may or may not accept the problematization. Any change of a network resulting from its problematization, or the relevant actor's response to it, is referred to as a translation of that network. Finally, the term interest refers to actor expectations, concerns, motivations and goals with respect to a particular issue. Interests are analysed in networks which are formed through problematization; the actors who are involved act, based on these interests ascribed in the problematization or advocate for certain positions on issues in response to the problematization.

Ivory's study (2004) of a social housing project is useful to illustrate the use of these concepts. In his case study, the architects proposed an acrylic wall rendering and a novel curved roof for a residential building project. They then attributed various actor interests in their proposal, or problematization, including their own interests in bolstering the firm's reputation for innovative design, the tenants' interests in the extra space afforded by the proposal, and the housing association's interest in funding the scheme. The architects then attempted to convince the tenants and housing association to adopt the proposal. In response, the tenants supported the architects' proposal by

accepting their assumption that they wanted extra space. In addition, new tenant interest in the aesthetics of the design emerged, which supported the proposed design. However, the housing association preferred a more conventional design based on their interests in ease of maintenance. In the end, based on tenant support, the housing association was compelled to accept the design scheme. This analysis reveals how relevant actor interest emerged and preferences changed in response to the architects' proposal (i.e. translation). In this way, the three ANT concepts allow for the analysis of different and changing interests in both actors' problematizations and other actors' response to them. ANT is applied with a particular focus on actors' interests in this research, which traces the configuration of actors, their proposals and their interests as a network that develops around a particular issue.

There are examples of ANT being applied in construction management research. Among other things, such work has shown how multiple actors, including clients, architects, engineers and contractors as well as architectural plans and engineering drawings are involved in various construction project discussions. For example, Tryggestad *et al.* (2010) studied the way that project decisions successively changed during a design process. While they particularly use ANT to study the roles of material objects as carrying information or translating project goals, they also highlighted the effect of particular decision-making processes on subsequent issues (i.e. knock-on effects). Building on that work, this paper investigates the incorporation of actor interests in decision-making processes about successive issues. The application of ANT provides a way to explore why some actor interests are incorporated whereas others are not, over the course of a project. Besides, the role of material objects is explored in terms of the way they influence the incorporation of client interests.

This research addresses the following questions;

- What are different and changing actor interests in solving a particular issue?
- How are actor interests incorporated into project decisions?
- What impact does client engagement have on the incorporation of client interests?

METHODS

A university campus building project, in which the client organization members were actively engaged in decision-making processes, was selected for an empirical study. The medium scale of this project allowed for the study of various participants' interests in detail across the building process from the initiation to the completion. This building was designed to house facilities for the University's School of Film and Drama (SFD), and as such required the construction of special facilities, including theatre, film and TV production spaces. A project feasibility study was conducted in 2007 and construction was completed in 2011. To maintain confidentiality, the names of the University, the building project and all participants have been changed for this study. The selected building project is referred to as "*the SFD building*" on a fictitious Colmer University campus, set in the UK.

The background of the project helps to explain the clients' level of active engagement. At the time of this project's inception, the University's Estates Department had overseen the construction of several campus buildings, and thus had already developed guidelines for the involvement of University members and for procurement methods. The nature of the building's performance and specialized teaching spaces

called for the SFD's direct involvement on the project team to help shape these facilities to meet its expectations. Consequently, the project team members were motivated to meet the SFD's expectations in a collaborative team environment.

ANT was used to analyse the building project as a number of discussions in which relevant actors negotiated their proposals for different issues, which arose in the course of the project. The interview data was collected in 2013 both to identify issues that are subject to such discussions and the actors involved. To begin, client organization members (i.e. University members) were interviewed, and the names of additional interviewees were identified through these interviews. In addition, each interviewee provided applicable project documents useful to the study. In total, 13 interviews were conducted with project participants and a number of documents were collected from them. Other project participants, such as the BREEAM coordinators and external PM were not interviewed, as discussions or negotiations they were involved overlapped with other participants, or their participation in decision-making processes were limited in terms of their influence on project decisions. Interview data and project documents were analysed to further identify a number of key issues for closer analysis. Then, qualitative analysis software was used to record the coding of the data and to support the identification of the key issues that related to project participant negotiations.

Throughout the coding process, interdependencies between issues were analysed. For example, the SFD chose a ventilation system for the theatres, which influenced the services engineers' calculation of the size of mechanical size. These issues were grouped and coded as a single theme, i.e. "*mechanical space size*". In this way, most of the issues were grouped into four "*topics*", which involved complex processes of the incorporation of actor interests, and thus were suitable for this research analysis. As a result of the data analysis, three groups of issues – building location, space allocation and mechanical space size – were selected as main topics of decision-making processes, which were most frequently discussed by interviewees as well as those rich in project documentation. Also, different and changing actor interests – particularly client interests – were clearly analysed from the available data for these topics.

FINDINGS

The analysis of three topics traced a range of actor interests involved over the course of the project, and explored why some interests were incorporated whereas others were not. The analysis highlighted dynamic decision-making and client engagement processes in the course of the project. It provided insights into how clients impose their interests among the range of actors.

A number of actors and their interests were involved in decision-making processes about three topics. The main clients (i.e. the University members) included: 1. the SFD members (user groups), 2. the Estates Department members, 3. University administrators and 4. the project managers. The project team members included: 1. architects, 2. services engineers, 3. structural engineers, 4. an acoustician, 5. a contractor and 6. a brick supplier. The material objects included: 1. floor plans, 2. an option table, 3. project budgets and 4. services ducts. The range of different and changing actor interests including both clients and project team members were traced. Multiple clients with different interests were involved at different times, and a single actor had different interests depending on particular issues at hand. Also, project team members had interests which often conflicted with client interests. In addition, the

“*interests*” of material objects were also analysed, as they influenced the incorporation of clients and project team members' interests. The analysis resulted in the documentation of the incorporation of selective actor interests into final project decisions.

Building location decision

The first topic, building location, involved a number of different University members (i.e. clients) who successively changed their preferences with respect to the location. The analysis traced how different client interests were raised and impacted on their choice of the building locations.

During the decision-making process, clients were presented with a range of options for building sites and chose from options based on their own preferences. For example, the master-plan architect suggested two possible locations and the University administrators chose one over another. After this initial choice of preferred location, in order to satisfy the local authority's requirement, a public consultation was held for the development of the campus master-plan, in which the preferred location for the SFD building was indicated. During the public consultation, there was opposition to the proposed SFD building site, which was presented as one of the planned future building projects in the campus master-plan. As a result, after the consultation, many of the University members changed their preference to a newly proposed site, which was supported by the Vice Chancellor. However, the Dean of the Faculty still preferred the previously proposed site. In the end, the newly proposed site was chosen. Stated differently, the Vice Chancellor's interest was incorporated, while the Dean of the Faculty's interest was overruled.

In this topic, a number of clients preferred different building sites at different times. They made alliances with each other with respect to their preferred options, resulting in the incorporation of some client interests over others. Apart from clients, other actors were also engaged in decision-making processes; the master-plan architects recommended a particular site as a preferable option. Also, the public consultation led to a change in some of the clients' preference. However, the clients were in charge of choosing from options and thus were able to impose their interests over others.

Space allocation

The second topic, space allocation, involved discussions regarding the size and relative location of a number of spaces within the building footprint. The analysis shows the effect of interdependencies between design features on the incorporation of client interests. More specifically, it shows how decisions regarding the area, location and function of spaces were intertwined such that decisions on the one limited the options for decisions on the others.

During the discussions, actors mobilized different concerns to specify or modify their proposals for specific decisions. For example, the SFD required double-storey performance spaces (three theatres, TV studio and a screening space) on the ground floor of the building. This constrained the accommodation of other functional spaces due to the large size of the performance spaces, which was presented in the architectural floor plans. The architects proposed the single-storey height of Theatre 1 and its relocation to the first floor, based on their interest in making the ground floor more open. The SFD did not prefer this proposal as the School representative was concerned about heat from lights affecting performers in such a low-height theatre. However, this proposal was accepted when the architects proposed locating the

storage space between Theatre 2 and 3, where Theatre 1 used to be. The SFD supported this proposal as it made the storage space larger and the manoeuvre of seating and rostra to Theatre 2 and 3 easy, although this proposal in fact required the SFD's compromise on the height of Theatre 1. As a result, the architects successfully persuaded the SFD to accept their proposal about a single-storey Theatre 1, and thus, the architects' interest was incorporated into the decision.

In this topic, the architects dictated the design of the functional relationships between various spaces, which allowed them to impose their preferences. To persuade the SFD, the architects demonstrated that locating a shared storage space between Theatres 2 and 3, which was supported by the SFD, depended on the decision to reduce the height of Theatre 1, which was not favoured by the SFD. As this example illustrates, the architects' ability to impose their interests depended on arguments regarding the interdependence between their proposals. While the clients' ability to impose their interests through the choice of some proposals over others still remained, the project team members gradually gained more ability to impose their interests in their proposals as interdependencies between issues increased. By doing so, they prioritized client interests in some spaces over those in other spaces. Also, it is noteworthy that architectural floor plans facilitated the SFD's understanding of the interdependence between the sizes of spaces under the footprint restriction.

Mechanical space size

The third topic, mechanical space size, involved successive interdependent issues. The analysis highlights how earlier fixed decisions shaped or limited the availability and appropriateness of subsequent design options.

During the decision-making process, actors sought to change fixed decisions or compromise on their proposals as earlier decisions circumscribed or conflicted with their preferred outcome yet to be determined. For example, the architectural floor plans fixed decisions with respect to locating the mechanical space. The mechanical space was located above the acoustically-sensitive performance spaces, which was not a favourable option according to the acoustician, as the mechanical equipment would potentially transmit noise to these spaces. However, despite the acoustician's proposal to change the location of the boiler room, its location could not be changed, as this decision was made in relation to the location decisions of a number of other spaces within the limited building footprint and size, which was presented by architectural floor plans. As a result, the acoustician compromised on his preference to change the site of the boiler room. In other words, the floor plans "*rejected*" the acoustician's proposal, and thus blocked the incorporation of the acoustician's interest.

In this topic, project documents shaped and limited the incorporation of the SFD's interest in the better sound proof level. Although the SFD was the client, it was not directly involved in the decision-making processes. Instead, the acoustician proposed a solution of changing the location of the boiler room based on assumptions about the SFD's interests in better sound proof levels in the performance spaces. However, this was rejected by the architectural floor plan which fixed the location of the mechanical space and other spaces. Significantly, as the project developed, project documents limited available options or rejected proposals outright by fixing several decisions. This led to compromise with respect to the incorporation of the SFD's interests. The analysis underscores the project team members' agency to propose or modify plans within project constraints. Also, material objects contributed to shaping or limiting project team members' proposals by fixing decisions. Over time, as more project

decisions were made, the relative ability of the clients to influence decisions was constrained, and the ability of the project team members and documents increased.

The analysis of the three topics illustrates how actors imposed their interests over others throughout the design and construction process as the range of options shifted over time. A key development concerned changes in who had the authority to specify the range of available options. Initially, clients shaped the range of options and selected among them. However, later on, project team members specified or modified clients' preferences as options were constrained by the interdependence between issues. As more decisions became fixed and the power of project documents increased, clients and project team members persuaded clients to compromise their interests and to alter existing decisions.

DISCUSSION AND CONCLUSION

We have explored client engagement within the dynamic networks of a range of actors involved in a building project. We have traced client interests among a range of actor interests without privileging client perspectives. Methodologically, we traced client expectations without pre-determining participants from a client organization. In this regard, the approach is similar to that of Hedgren and Stehn (2013) who attempt to study clients' decision-making processes both as organizational procedure and individual behaviours. We have further analysed specific client expectations around successive issues in the course of the project. Theoretically, the analysis of actor interactions using “*interest*” allowed us to view a building project as the product of a range of actor negotiation and persuasion processes between actors with different interests. As a result, the analysis documented the incorporation of some actor interests over others. We highlighted the shifting ability of clients, project team members and even material objects in imposing their own interests over others. Such dynamic power relations are analysed as a result of actors' negotiation and persuasion processes in terms of whether they successfully imposed their interests over others. This is in contrast to Newcombe (2003), who analysed stakeholders' power relation to predict likely conflicts.

A main finding of this research relates to dynamic client engagement in decision-making processes as available options shifted over time. At the beginning of the project, clients chose their preferred design options based on their interests. However, clients' ability to impose their interests through the choice from options decreased as the project developed; client interests were often ascribed by project team members who became more empowered to impose their interests by specifying proposals. In this way, client interests were analysed even in the absence of clients. This is in contrast to the typical approach of studies of client engagement which mainly focus on clients (Connaughton 1999). Another finding is the role of material objects in relation to the incorporation of actor interests. Documents played a role of facilitating actors' understanding of interdependence between issues, or shaping and rejecting the incorporation of actor interests. This analysis adds to Tryggstad *et al.* (2010) who analysed material objects as carrying information or translating the meaning or goals.

The findings provide a basis to reflect upon clients' relative ability to directly impose their interests by shaping and choosing from options in the project decreased over time. This effect can be related to increasing interdependence between design features and decisions, to the role of material objects in fixing decisions and to the physical absence of clients from decision-making processes. Once interdependencies between issues were established, the project team members gained more ability to persuade the

clients to compromise on some of their preferred solutions. However, it is noteworthy that the interdependence between issues often stemmed from earlier client decisions. For example, the interdependence between the height and location of three theatres was due to building size restrictions. In this case, the size of the building was influenced by the clients' earlier decision regarding building location as the site condition restricted the building footprint. Similarly, some client preferences were constrained by fixed decisions, which led to compromise in the incorporation of client interests. However, it is worth noting that some decisions fixed by project documents, again, often reflected earlier client interests. Client interests were incorporated into the decisions about the locations of a number of required functional spaces, which led to the limited options for the plant space location. As a result, this led to the SFD's compromise on the sound proof level of the performance spaces. Clients' power to impose their interests through the choice from options decreased as the emerging client interests often conflicted with earlier client decisions, which became stabilized as the project developed.

Another factor affecting the observed decline in client engagement is their physical presence during decision making. At the later stage of the project, project team members often advocated for client interests when clients were only indirectly involved. Technical issues involve tables and figures, which represented "*client requirements*". The project team members regarded them as client requirements even though they were often beyond the SFD's understanding. For example, the acoustician set the noise rating level of each performance area to represent the SFD's requirement. However, the SFD did not understand what these figures meant in the reality, and could not clarify their positions during discussions. As the project developed, clients' ability to select options became more constrained, and project team members became more empowered to speak in the name of clients in their proposals.

While direct client engagement declined in the course of the project, clients did not lose all influence; clients' control over the timing of participants' involvement could potentially be used to limit other actors' influence even at the later stage of the project. For some issues, clients made decisions or set policies to support their preferences before other project participants became involved. For example, the SFD drafted a project brief that became the basis for the concept design before the architects were hired. Also, the University established its space management policy before the project began, which limited the SFD and the architects' decisions about the size of spaces. In other cases, clients were able to decide on the timing of additional project participants' involvement. For example, the PM consulted the acoustician at certain moments during the detailed design stage. As a result, the acoustician's proposal to change the location of the boiler room was rejected when he was consulted, as the boiler room location had already been decided and could not be changed when he was involved. Thus, the PM was able to determine the timing of the acoustician's involvement based on whether the clients wanted to reflect acoustic concerns at a particular point in the project. However, the PM's intentional exercise of this strategy was not clearly examined in this project. Clients' control over the timings of participants' involvement is potentially useful in imposing their interests over others even at the later stage of the project.

As a final note, ANT application to a building project process also posed some challenges. While this perspective allowed for the analysis of a range of actor interests in the project, it also tended to blur the analytical distinction between client interests and other actors' interests, and between project team members' own interests and their

projection of those of the clients in their proposals. Also, the post-project study presented disadvantages, particularly in collecting data regarding complex and highly technical issues. Often, project team members did not recall why they chose one design option over another regarding these issues, a factor that was fundamental in analysing their interests. An additional real-time study focused on complex and technical design decision-making processes would provide insight into the dynamic power relations of a number of project team members.

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PRIORITIZING QUALITY OVER PROFIT: VALUE TRADE-OFFS WITHIN ARCHITECT-CLIENT RELATIONS

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Architectural service delivery involves a complex system of economic and quality related value dimensions, which are mutually dependent and prioritized differently by actors. Responding to professional logics as well as organizational logics, value creation goals of architects and clients are multidimensional, resulting in tensions within and across collaborating organizations. Value related tensions are evident in organizations, as has been illustrated by paradox research. However, studies on how these tensions are handled in the interaction process of collaborating organizations are still fairly limited. This explorative research focusses on value trade-offs within architect-client relations. Twenty in-depth interviews with architects and their respective clients are used to explore how economic and quality related values are negotiated by actors from collaborating organizations. Results indicate that the value negotiation process is largely dominated by tensions between profit and project quality. An analysis of two situations provides in-depth information on how architects and clients either follow an individual or mutual strategy to prioritise quality over profit. This research contributes to the theory development on value management in the construction process and helps practitioners to more consciously and efficiently handle tensions in order to improve shared value creation.

Keywords: architect-client interaction, collaboration, paradox, value.

INTRODUCTION

Over the last couple of years the construction industry and field of architecture have been characterized by a series of profound changes. Corresponding calls for new ways of service delivery and alternative modes of collaboration have deeply impacted existing organizations, requiring them to develop new business models or alter their existing ones. Architectural services are characterized by a complex system of economic and quality related (e.g. functional, symbolic and emotional) value dimensions. These value dimensions are mutually dependent and prioritized differently by actors that are involved. As one of the sectors of our cultural economy, value creation activities within the field of architecture are driven by the importance of symbolic and aesthetic aspects (DeFillippi *et al.*, 2007). While delivering a creative service, organizations involved in architecture projects are facing dual goals. On the one hand they are driven by a professional ethos to generate new ideas, on the other hand they follow organizational and corporate logics to make money. This paradoxical tension (e.g. Smith and Lewis 2011) characterizes professional service delivery and is an example of the many paradoxes that architects confront regularly (DeFillippi *et al.*

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2007, Manzoni *et al.* 2012). Previous years of abundance made it quite easy to generate plenty of economic benefits from architectural service delivery. Recent trends towards extreme competition and tight fees however, have forced organizations to carefully balance the economic and quality related aspects of their value creation. Trying to make sense of their own value creation and uncovering scenarios for improvement, actors show a growing interest in their business model design.

Besides exceptions of standard production or long-term collaboration, architectural projects are mostly unique, constantly involving new constellations of different clients, teams and people (Jones *et al.* 1998) and new value discussions between the actors. With the involvement of different stakeholders and different value grounds in construction projects, creating value often involves conflicts or tensions (Boltanski and Thévenot 2006; Lepak *et al.* 2007). These value related tensions must be handled in intra- and inter-organizational interaction processes (Bygballe and Jahre 2009).

This explorative research focuses on tensions stemming from the duality between economic and quality related value dimensions in the interaction process between collaborating architectural firms and client organizations. Architectural firms help their clients to achieve a desired outcome by mediating between the demand and supply side during the design and construction process. Although professions in the built environment have seen their roles change in recent decades (Duffy and Rabeneck 2013, Hughes and Hughes 2013, RIBA 2012), the architect-client relation is still crucial within architectural service delivery. This research investigates how collaborating architects and clients handle tensions between economic and quality related values. While acknowledging the paradoxical nature of value creation within architectural service delivery (e.g. Andriopoulos 2003, Smith and Lewis 2011), this research helps to gain insight in the value negotiation process of architect and client organizations. Based on twenty in-depth interviews with architects and clients the following research question is answered: How do architectural firms and their clients deal with the tension between economic and quality related value in their interaction process?

THEORETICAL BACKGROUND

Organizational value

Value is at the core of how organizations work. The way in which an organization creates, delivers and captures value in relationship with a network of exchange partners defines its business model (Afuah and Tucci 2001, Osterwalder and Pigneur 2010). Organizations create value in many different ways and for many different targets, such as business owners, employees, customers or clients, end-users and society (Lepak *et al.* 2007). So far, value has been conceptualized differently in various research fields. In the management and economics literature, value creation and capture remains largely focused on monetary aspects. In sociology, value is often studied from a broader perspective, including cultural, symbolic and emotional grounds as well. However, a systematic and integrative approach to think about value and valuation is still in development (Lamont, 2012; Vatin, 2013). Valuation is a vital process for any productive activity and inherently social. The process of valuation has two sides: 1) the production of value, i.e. the process of valorization, and 2) the assessment of value, i.e. the process of evaluation (Vatin 2013). Organizations will not know what the created value is worth until it is exchanged (Bowman and Ambrosini 2000). Stemming from different logics of worth, individuals justify their actions differently (Boltanski and Thévenot 2006). Boltanski and Thévenot identified six

'worlds' that define how value is created and assessed: the inspired world, the domestic world, the world of fame, the civic world, the market world and the industrial world. Something that is valuable in one world may be considered worthless in another. Due to the complex organizational nature and the different logics of worth people respond to, valuation in the activity of work involves various judgements and corresponding tensions within and outside the organization (Smith and Lewis 2011).

In architecture, the inspired world, the world of fame, the civic and the market world are closely interrelated. While value can be attributed to originality and creativeness based on logics from the inspired world, the opinion of critics, clients or users from the world of fame is necessary to build a reputation. As in other creative services a distinction between 'praise value' and 'price value' can be recognized (Hutter 2011). Civic logics play an important role as architects work from a professional ethos to serve the collective interest (DeFillippi *et al.* 2007), whereas market logics, characterized by a desire for and competition over valuable resources, are important to gain competitive advantage. The complex system of mutually dependent value grounds makes it difficult if not impossible to talk about architectural value. Value within architectural service delivery is unique for every project and continuously involves various logics, perceptions and interests of stakeholders.

Handling value related tensions

When perceptions of value and value related goals differ between stakeholders, they result in tensions within an organization or its collaborative process with other organizations. Tensions are a natural phenomenon within organizational systems, as these systems constantly change in response to competition or evolving demands and involve different stakeholders (Smith and Lewis 2011). As Smith and Lewis point out, these tensions can be dealt with in two ways. Organizations can either follow a contingency approach, choosing their most effective option, or they can follow a paradox approach, choosing to accept the existence of tensions and multiple options. This approach is the basis of paradox theory and especially usable in complex, dynamic contexts. Paradox theory provides an interesting perspective to study the process of value creation. As a field of research it aims to develop a better understanding of how tensions impact organizational life. Paradox theory assumes that tensions are both an integral characteristic of organizational systems as well as a social construction, and that tensions can be beneficial if handled correctly. Paradoxes are defined as "*contradictory yet interrelated elements that exist simultaneously and persist over time*" (Smith and Lewis 2011). They involve underlying tensions in elements that seem logical when viewed separately, but do not make sense in relation to other elements. Paradoxes are different from dilemmas and dialectic tensions in the way that paradoxes cannot be resolved. However, they can be balanced by following a 'both/and' approach instead of an 'either/or' approach (Smith *et al.* 2010).

Within organizations, tensions can be allocated to four categories of paradoxes: paradoxes of belonging, learning, organizing and performing (Smith and Lewis 2011). Based on earlier research by Poole and Van de Ven, Jarzabkowski *et al.* (2013) identify four examples of strategic responses to organizational paradoxes. The first response, splitting, involves separating elements temporally or spatially. With the strategy of suppressing, organizations pursue specific elements over others. The third opposing response, is used when different organizations support contradictory elements. Finally, the adjusting approach involves accommodating each other's needs by recognizing that needs of both parties are important and interdependent. The first

three strategies are defensive and can only be used for a short-term performance. The fourth strategy is an active strategy that also enables longer-term relief. Accepting the existence of tensions and responding to contradictory but interrelated demands simultaneously can support a sustainable organizational development.

RESEARCH APPROACH

To address the value interaction process within architectural service delivery, an inductive qualitative approach is chosen (Miles and Huberman 1994). Twenty in-depth interviews with architects and their clients are used to analyse how both parties deal with the existence of multiple and possible contradictory values in their interaction process. The interview sample consists of Dutch architectural firms between 10 and 40+ people, which all have design at the core of their business model, and three types of Dutch client organizations: contractor, housing corporation and project developer. The respondents are referred to as architect A1 to A9 and client C1 to C9. Table 1 presents an overview of the sample. The interviewees were chosen from large housing projects that were realized in the Netherlands in 2013 or 2014. New housing projects are responsible for 51% of the net turnover of architectural firms in the Netherlands (Vogels 2014). Therefore, they represent an important focus for a large amount of architectural firms and client organizations. The collaboration of the architectural firm and client organization in the project was used as an entry to the conversation in order to discuss value trade-offs from an architect and client perspective.

Table 1: Overview of respondents

Respondent	Type of respondent	Type of organization
A1, A2, A3	Architect partner	Small architectural firm (10-20 people)
A4, A5, A6	Architect partner	Medium sized architectural firm (20-40 people)
A7, A8a-b, A9	Architect partner	Large architectural firm (40+ people)
C1, C4a-b, C7	Project leader or director	Contractor
C2, C5, C8	Project leader or director	Housing corporation
C3, C6, C9	Project leader or director	Project developer

Each interview lasted for approximately 1,5 hours and focused on different dimensions of value (economic, functional, symbolic, emotional) as well as their interdependencies from the viewpoint of the architect and the client. Furthermore, it was discussed how value related tensions within the architect-client interaction process were negotiated by the collaborating organizations. A semi-structured interview protocol was used to address the different topics. Archival materials were collected to prepare for the interviews, to expand the understanding of the organizational context, and to reinforce or question the findings of the interviews. All interviews were audio taped and transcribed verbatim. The transcripts were checked by the respondents and the suggestions for minor alternations were implemented.

Following the Gioia methodology (Gioia *et al.* 2013), different data analysis steps were used to enhance grounded theory development. In the first step, the technique of context mapping (Sleeswijk Visser *et al.* 2005) was used to identify and categorize informant-centric 1st-order terms, resulting in an overview of architect and client related codes. The second step involved a systematic examination of the dataset in which the 1st-order codes were organized into 2nd-order themes by the researchers.

The first and second step of the analysis generated insight into different aspects of value and their interdependencies from an architect and client perspective. An overview of the data structure is given in table 2. Thirdly, differences and similarities between the data of collaborating architects and client representatives were looked for in order to examine the value interaction process between the collaborating organizations in detail and to uncover underlying aspects and responses. The analysis presents first insights in the negotiation practices used by architects and clients to deal with tensions between economic and quality related values. Future steps include a profound analysis of the data set with the use of software program MAXQDA as a supporting tool. Moreover, the findings will be consolidated in a feedback workshop with partners from the construction industry.

Table 2: Data structure

Value foundation / logic of worth	Value component	Examples from architect perspective	Examples from client perspective
Economic	Profit	Profit is not a target, firm continuity is	Desire to make profit and nice projects in collaboration with other actors
	Firm continuity	Aim for a number of stabile assignments, firm continuity is important for clients	Objective to make something that has quality in order to guarantee continuity
	Commercial relationship	Collaboration with other partners of the value chain	Aim for trust and relationships with clients
Functional	Lay-out & comfort	Own added value consists of combined functional translation and experience	Role architect is to solve complicated functional and technical puzzles
	Sustainability	Use of good materials to guarantee long-term quality	Desire to make objects that are needed during their whole exploitation
Symbolic	Aesthetic appearance	Desire to make something distinctive in its quality	Unique appearance is not a goal in itself, but a nice additional feature
	Urban implementation	Realise objects that fit within their context and are able to realise quality of life	Infill developments with complex location conditions ask for a quality based decision concerning the choice of the architect
	Societal impact	Purpose is to create happiness by adding value for society	Purpose is to direct the liveability of a neighbourhood
Emotional	Personal driver	Look for work that fits the people and culture of the firm	Besides profit, pride of the project is an important driver nowadays.
	Appreciation	Desire to build something that is appreciated by everyone: both peers and laymen	Serve the client in the best way possible

FINDINGS

Focussing on architect-client value negotiation processes, findings show that paradoxical tensions between economic and quality related values often revolve around conflicts between profit and project quality. Respondents stress how newly restricted financial possibilities due to the global financial crisis and changes in the industry have magnified already existing tensions. Both project budgets and service fees have decreased, forcing actors to carefully balance their own financial benefits with the desire to deliver a product of quality. Regarding the tension between profit and quality, several underlying aspects were recognized. Table 3 presents an overview of these underlying aspects, as well as illustrations from the interviewees' responses.

Two situations are described in more detail to provide in-depth information about how paradoxical tensions between profit and project quality originate, evolve and are handled in the collaboration process between architects and clients.

Table 3: Tension between profit and quality

Underlying aspects of tension	Illustration
Architect is driven by a professional responsibility and personal ambition to create quality	Budget overflow is not prevented, emotion wins from financial aspects
Reputation is important for organizational continuity and dependant on the quality of projects	A good project provides a ‘boost’ around the world. Investing in a reputation is part of running a business
Internal organisation architectural firm prevents the firm from making profit	Project leaders keep on designing instead of translating the architect’s desire into realisable details
Lack of economic interest or expertise among architects	Profit should be more important, but is overshadowed by personal ambitions
Insufficient fee and too much project complexity to serve client properly	Architect wants to serve client in the best way possible, but tight fee makes this impossible

Architect’s desire to realise quality

A first situation concerns the case of architect A3 and client C3. In this case the architect did not know if any profit was made, but assumed there was not.

Nevertheless he was sure that they spent too many hours on the project. The reason why more effort was needed was related to the involvement of an external drawing office, which required additional coordination, the internal organization of the architectural firm and the people working on the project.

“The project was too complicated and the quality of their [the external office’s] drawings did not match our standards. We ourselves would never have handed it over like this. So we had to spend a lot of energy to reach the current level. If we would not have done that, it would have looked completely different in terms of quality and appearance I am afraid, and that directly concerns our reputation.” (A3)

The architect explained that creating quality was necessary for the firm’s reputation. In his opinion reputation has two sides. First, they have to show clients that their money is in good hands, realizing projects that demonstrate an ability to deliver value for money. Second, reputation has to do with the personal motivation of their people.

“I would not be able to motivate myself every day to work on a project of which I am sure the level of quality that would be possible is not reached. [...] So in that case you just work a little harder.” (A3)

This architect was willing to work extra hours to guarantee that the desired level of quality was met. He explained that everyone in the office felt that same responsibility. In his opinion this has to do with personality, but is also inherent to the profession. Other architects agreed upon the existence of these underlying principles. Architect A9 described it as a higher purpose. He just wanted to build beautiful things. While architect A3 considered the additional effort necessary, his client argued that extra efforts by architects may also cause tensions within the architect-client interaction process. He illustrated his point by using an example in which an architect made a very elaborate drawing, while the decision-making process at that time would have benefitted more from a very rough sketch.

“It is also a shame, because when you are not careful, it could even lead to frustrations. ‘Look I have spent this amount of time’, yes, but it also concerns which choices we make at that moment.” (C3)

The fact that architect A3 was not aware of the financial consequences for his firm points towards a lack of interest in the matter and possibly a lack of expertise. The organizational structure of architect A7’s firm was especially equipped to anticipate this problem. A financial director was in charge of all financial negotiations. Architect A7 suspected that fees would on average be twenty to thirty percent less if architects would engage in financial negotiations themselves. He stated that since architects are emotionally involved, they are likely to settle for less.

This first situation shows how tensions between profit of the firm and quality related values were taken out of the architect-client negotiation process to be resolved inside the individual firm. The architect deliberately chose to work extra hours to ensure the level of quality he had in mind. The process in which quality is pursued over profit, while avoiding to discuss the matter with the client, was representative for several architects that were interviewed. As architect A9 states, it could be grounded in the fact that architects pursue a higher level of quality and a more elaborate role than the client is willing to pay for. This was also recognized in different opinions architects and clients have regarding the involvement of the architect during engineering and construction. While many architects considered an extensive role necessary to realise the desired amount of quality, clients often believed that architects do not possess the right expertise or are too emotionally involved to work efficiently in these stages.

Mutual desire to realise quality

The second situation involves an extraordinary housing project developed by architect A1 and client C1 on a noisy location that did not have any quality. On request of the client the architect studied the possibilities of the location and proposed a design that would attract inhabitants through its unique sustainable atrium. Because of the atrium the design exceeded the budget by far.

“And with this printout I went to our client and said: ‘Look, in this way you could make a building for the future. I know that it is too expensive, but couldn’t you go to the municipality? Wouldn’t [the municipality] also want a building like this? [...] They could turn it into PR, but then they would have to contribute financially.’ ‘Yes’, our client said, ‘I also need to find a buyer. I could show this image to the investor that declined the first time. [...] That investor saw the image and said, ‘Yes, we also need a sustainable building for a change.’” (A1)

The architect noticed that with the design he triggered something in everyone. He saw the excitement of other actors when he showed the image and felt that there was a chance to make it happen. The location had been vacant for a long time, the buyer wanted a sustainable building and the client and architect both wanted to learn from such an experiment. With the involvement of the municipality and investor two out of three million would be covered. The architect and client recognized that the final million could be found when they would engineer the work in a very smart way. They decided to collaborate in a chain which involved construction partners as well.

“Then we said as a team: ‘Let’s be sharp in our fee. Let’s build a chain and work from the minimal amount we need to participate. So I neither want to make any profit nor any loss. These are our expenses. [...] If this works, we will have a formula and I would like to repeat it again.’” (A1)

The architect and client both needed the work to secure their reputation and organizational continuity. The distinctive design could be used as a showcase to acquire new work. They also saw opportunities for future workload with assured profit when they would be able to repeat their collaboration a second time.

In this project there was a clear tension between the financial value and the unique, sustainable quality of the design. This tension was present right from the beginning of the project and continued on during the rest of the process. By finding ways to accommodate the financial needs, the architect and client were able to realise the desired amount of quality. In their negotiation process, the architect and client agreed on the fact that they would not make any profit on the project. Although architect A1 stated that making profit is almost the only basis to establish a business, the project resulted in losses instead of profit. He already noticed that costs would get out of hand during the process, but continued on working. He wanted to finish the project, because the building was far too nice. Architect A1 illustrated that in this case emotional aspects overpowered business aspects. The financial losses would have to be compensated with another project. Client C1, who was experiencing difficulties with his organizational image being a traditional contractor, was especially driven by an aim to show the world what his organization could do. He prioritized aspects of reputation and organizational continuity over profit. Other clients made similar decisions. Client C9 hired a famous and thus more expensive architect, to make sure the project would get a unique appearance. He believed the appearance would contribute to the commercial value of the project, the city and its inhabitants. He claimed that as a result it also legitimized the existence of his organization. Aesthetic quality was also considered important for the building's exploitation (client C5).

The two situations presented above, provide a detailed overview of ways in which architects and clients handle tensions between economic and quality related value dimensions. The situations show responses from either the architect or both actors to achieve a desired level of project quality instead of (a reasonable amount of) profit. Underlying aspects of reputation, organizational continuity and personal motivation were filtered out. Although in both cases the decisions to pursue quality over profit were deliberate, respondents argued that it would have been better if the balancing act had resulted in a larger amount of profit.

CONCLUSIONS

This paper focusses on value trade-offs in the interaction between architects and clients. Findings indicate that value negotiations within architectural service delivery are largely dominated by the interplay between profit and project quality. It appears that while balancing the desire to realise quality with the organization's target to make profit both architects and clients show examples of prioritizing quality over profit. Although this prioritization was stronger in some cases than others, respondents agreed that the balancing act should have been carried out in a more informed way.

The negotiation processes used to deal with the tension between profit and quality show several underlying aspects. Architects mentioned a professional responsibility and personal ambition to create the largest amount of quality possible. The architects, working from a belief in delivering quality for society, sometimes sacrificed their own profit in favour of quality, even if the quality related value dimensions were not considered as important by the client. Besides, they believed that project quality is necessary to build or maintain their reputation. This reputation is directly connected to organizational continuity, as it is necessary to attract new clients or projects. The

prioritization of quality over profit from the client perspective shows underlying foundations of professional continuity and a concern for the project's exploitation.

Results point toward the need for a better balance between profit and quality. While profit was deliberately sacrificed for the sake of the project, respondents argued that this is not a healthy basis for doing business. New business models should be able to deal with the paradoxical tensions between profit and quality and help architects and clients to maximize both aspects simultaneously. Architects and clients need to reconsider the decision-making process in which value is negotiated in order to enable quality as well as long-term financial security.

DISCUSSION AND DIRECTIONS FOR FUTURE RESEARCH

The findings have implications for both researchers who focus on inter-organizational value management and for practitioners involved in architectural service delivery. Further research into how tensions between profit and quality arise, evolve and are handled is necessary to improve our understanding of the negotiation process and consequently improve decision-making. It would be encouraged to analyse the decision-making process in more detail and possibly identify key moments necessary to enforce a better balance between quality and profit. It would be very interesting to see how collaborating actors could help each other to gain more benefits from dealing with paradoxical tensions between economic and quality related value dimensions. For practitioners, our findings provide some useful insights in how value related tensions can be handled more consciously within inter-organizational negotiation processes. Actors' awareness of the goals and underlying principles at stake could enforce mutual and timely decisions and improve shared value creation.

This research focuses on the value negotiation process of complex housing projects in the Netherlands. Looking at other contexts, involving different ways of collaboration, legal structures or financial constraints, could generate a broader overview of the negotiation process. Standard housing projects or projects of another typology would most likely provide other results. Several respondents indicated that within standard housing projects for example, profit and quality are balanced differently. While quality is already ensured (e.g. repetition) or less of an issue (e.g. absence of a client), profit can be increased by using prefabrication or standardized building methods. Interviews included architect and client perspectives on value negotiation. Including all individual project participants is necessary to generate a more detailed understanding of the value trade-offs at play.

ACKNOWLEDGEMENTS

This study is part of futurA, an ongoing research project on new governance and business models for architectural services (www.future-architect.nl). The authors would like to express their gratitude towards The Netherlands Organisation for Scientific Research (NWO) and the consortium partners for funding and supporting the project. Also they would like to thank all interviewees for their time and enthusiasm in participating in this study.

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RELATIVE CONTRIBUTIONS OF PROJECT QUALITY TO CUSTOMER SATISFACTION IN NIGERIAN ROAD CONSTRUCTION PROJECTS

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In Nigerian construction and road projects in particular, customers continue to be dissatisfied with the poor quality of constructed roads as well as uncoordinated construction activities. Identifying the key sources of satisfaction would provide a big step towards redressing this chronic problem. Hence, statistical modelling was employed to evaluate the relative contributions of key attributes of project quality to customer satisfaction. The research involved road construction projects in Rivers State of Nigeria where a total of 503 respondents participated in a quantitative survey between August 2013 and August 2014. Stepwise multiple regression analysis was utilised to show the interrelationship between aspects of project quality (i.e. performance, reliability and aesthetics) and customer satisfaction (which was measured through contractor referral and re- patronage). The constituents of customer satisfaction were regressed against the aforementioned elements of project quality and it was established that 58.3% of the variables of project quality could be utilised to explain the variations in customer satisfaction. In addition, project performance was found to be the biggest contributor to contractor re- patronage: 43.1%; while project aesthetics contributed the largest to contractor referral: 57.1%. The findings so far suggest that cost and schedule related activities, use of professional experts, implementation of quality standards, presence of excitement factors amongst others greatly influenced the level of satisfaction obtained from road construction projects in Nigeria. Further analyses are being explored in an endeavour to ensure that construction stakeholders optimise the findings from this research.

Keywords: customer satisfaction, project quality, regression.

INTRODUCTION

Customer satisfaction in Nigeria, especially pertaining road construction has continued to gain research attention as there is an increasing need to optimise the expenditure on construction resources while executing road projects. Scholars and industry professionals have been challenged to identify construction activities that not only provide the basic need of a road, but satisfy its users, otherwise known as the customers (Okoye *et.al.*, 2015). Nigeria, a developing economy has in recent times witnessed a reduction in the expected life span of constructed roads which could be an indication of poor construction and maintenance practices (Idoro 2010). Furthermore, irrespective of the huge financial expenditure on road construction projects, construction stakeholders such as Project managers, Engineers, Architects and even the project owner are confronted with identifying critical paths where more resources

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need to be channelled to aid the construction processes. Obinna *et al.*, (2010) attribute the decline in the life span of roads to the increase in road users evident in the increasing migration of individuals to cities and urban areas. According to Obinna *et al.*, (2010) within the Port Harcourt metropolis of Nigeria, there has been an increase in the commuting needs of the growing population of people living in Port Harcourt, which is the capital of Rivers State, one of the 36 states in Nigeria. Port Harcourt hosts diverse oil companies and construction firms and hence a desired destination for individuals and firms seeking to benefit from its huge economic gains.

According to Obinna *et al.*, (2010), the UN- Habitat projected that by 2025, 60% of the population of less developed countries would be living in urban areas. However, over the last two decades, there has been a 50% growth in the population of Port Harcourt and road transportation has become the most common means of commuting (Olatunji and Diugwu, 2013). Although road construction firms within the area constantly update their construction activities to ensure satisfaction from the constructed roads, the huge traffic of individuals and machinery and the increasing commuting needs indicate that road construction projects within Port Harcourt are seemingly a never ending process. This is primarily as the government and other construction stakeholders strive to continuously meet the needs of its citizenry.

Despite the huge financial expenditure on road construction projects within the Port Harcourt metropolis, the Nigerian construction industry has been plagued with challenges that affect the quality of the finished roads. These challenges impinge on the reliability, durability, performance and finishing of the constructed roads as well as the satisfaction obtained from these (Oluwakiyesi 2011). In addition, the prevalence of referrals or re-patronising the contracting firms who built the roads is a possible indication of the satisfaction obtained from these constructed roads.

This research understudied the extent to which each attribute of project quality could predict and consequently enhance customer satisfaction. The research aimed at finding out which attribute of project quality had the greatest impact on the level of satisfaction obtained within road construction projects in Rivers State of Nigeria. Three specific attributes of project quality namely Project performance, Project reliability and Project aesthetics were studied and regressed with two attributes of satisfaction which were contractor referral and contractor re-patronage (Idoro, 2010; Masrom *et al.*, 2013; and Xiong *et al.*, 2014). The percentage contributions of the attributes of project quality that predict or enhance customer satisfaction are therefore presented to inform construction stakeholders on areas to channel their efforts while developing and managing new road construction projects, especially in Rivers state.

The construction customer

Torbica and Stroh (2000: 35) gave two simple definitions of a customer as, “*one who pays the bills*” and “*one who uses a product or service*”. Hence there exists basically two types of customers; a “*paying*” customer and a “*user*” customer. In some instances, the paying customer is also referred to as the owner or client, as most construction projects have been designed and built for a client instead of the potential users, although such client may not be a user of the construction project. Hence both the client who pays for such project and the user of the product from the construction project is termed as the customer in this respect. Similarly, Karna (2004: 69) defined a customer as “*the owner of the project and the one that needs the constructed facility*”. Karna (2004) further opined that both the client who pays for a project and the users of the project desire some level of satisfaction from the constructed facility. In the

Nigerian context, the customers refer to the users of the road construction project, and when involving government road construction projects, the customer could also refer to the government body that needs the project constructed.

The uniqueness of the construction environment and the expectations of the potential users are believed by construction professionals to have an impact on the level of satisfaction desired of the customer. Thus it is eminent to discuss the nature of the Nigerian construction industry and outline the probable challenges as well as the opportunities entailed within.

Challenges facing the Nigerian Construction Industry

The Nigerian construction industry alone, accounts for 1.4% of its GDP (6.6% in 2011) (Oluwakiyesi, 2011). Oluwakiyesi (2011), reports that despite the growth seen in the Nigerian construction industry, its contribution to GDP has remained at abysmally low levels in the past three decades. This is as a result of the presence of barriers that hinder the progress and success of construction projects in Nigeria such as corruption, technical expertise and general laxity (Obunwo *et al.*, 2013). Sanni and Windapo (2008), highlight that the Nigerian construction industry occupies a significant portion of the capital base of the Nations' economy, adding that its success or failure has positive or negative impacts on the nation's economy. Odediran *et al.*, (2012) elucidate that the Nigerian construction industry is still at an infancy state of development, a state where the government is the major client to construction activities across the nation, with construction projects that provide basic amenities such as shelter, roads, water, electricity, etc. Odediran *et al.*, (2012) further decry the poor growth of indigenous construction firms in Nigeria, due to preference of international firms although this is responsible for the impressive growth of the Nigerian construction industry through enhanced government spending. Despite these challenges, as well as the growing transportation and commuting needs, Nigerian construction firms seem to be misinformed on areas that need extra attention when delivering road projects in Nigeria generally and in Port Harcourt specifically. This developed the need to understudy areas of construction management that need stronger attention especially by identifying the relative contributions of the attributes of project quality to customer satisfaction and the predicting capability of each attribute.

Opportunities within the Nigerian Construction Industry

Notwithstanding the aforementioned challenges, improvements in the construction activities in Nigeria entail a number of benefits. Oluwakiyesi (2011) opine that construction projects aid economic developments as they provide jobs, enhance trade of materials and supplies as well as develop the technological capacity of the organisations involved in construction within the domain. According to Okoye *et al.*, (2015), the contributions of construction to GDP, especially in developing economies such as Nigeria could increase by 10% annually if adequate attention and scrutiny are employed to construction activities. Similarly, the reliability of road construction projects, which is the expected life span prior to failure (Masrom *et al.*, 2013) can be optimised through improvements in the construction activities in Nigeria.

Construction stakeholders are therefore endeared to develop strategies that identify critical areas where resources could be channelled to enhance the quality of constructed roads, benefit from its economic opportunities as well as improve on the nature of satisfaction recorded by its customers.

RESEARCH METHODOLOGY

Saunders *et al.*, (2009) defined research methodology as the theory of how a research should be undertaken and should include the theoretical and philosophical underpinnings upon which the chosen methods were selected. A positivist philosophical stance was maintained in the course of this research as the research entailed the development of a single objective truth on the contributions of project quality to customer satisfaction from a large population. Collis and Hussey (2009) however state that quantitative research methods are based on the positivist claim to knowledge which suggests that there is a single objective reality or truth in the world out there. The quantitative method thus entails the generation of numerical measurements of observations and verification of the theories/ laws that govern the single objective reality in the world. The epistemological consideration in a quantitative research suggests that the researcher detaches himself/ herself from the subject matter to avoid bias and subjectivisms in an inquiry (Creswell, 2009). The researcher hence assumed the objective existence of quality and satisfaction and accordingly embarked on a quantitative study.

Consequently, a quantitative research methodology using survey research methods was adopted for this research. This method was employed to obtain information on the quality of road construction projects within the Port Harcourt metropolis and the satisfaction derived from these. The units of analysis consisted of employees of contracting firms involved with road construction projects in Port Harcourt, as well as road users with relevant knowledge of road construction. The adopted research methodology took into consideration the type of data needed, its location, means of obtaining and mode of data analysis in order to obtain relevant information to solve the research problem (Saunders *et al.*, 2009).

In order to obtain data for the research, a questionnaire was developed based on the attributes of project quality; Performance, Reliability and Aesthetics, and customer satisfaction; Contractor Referral and Re-patronage identified from an extensive review of literature. Respondents were asked to rate their perceptions on a 5- Point Likert scale which ranged from 1 for strongly disagree to 5 for strongly agree and 1 for highly dissatisfied to 5 for highly satisfied. This strategy was adopted to obtain ordinal data as well as a true and realistic view of the respondents' preferences to satisfaction in road construction projects.

A pilot study was carried out to ascertain the relevance of the questions asked in the survey to the research aim as well as to visualise the trend of the anticipated responses. Consequent to the pilot survey, the instrument was refined and a comprehensive survey was carried out to obtain primary data for the research. A total of 600 questionnaires were distributed to employees of road construction companies within Port Harcourt, and 518 of these were returned. However, only 503 of the completed questionnaires were found useful, the discarded questionnaires were either incomplete or lacked coherence; representing a response rate of 83%. The organisations surveyed were obtained from the list of registered road construction companies in the Rivers State ministry of works, while a demographic assessment of the respondents aided in ensuring that the right people were surveyed while carrying out the research. Despite the considerably low response rates recorded in quantitative research within construction management, the high response rate could be attributed to the long period of data collection as well as the choice of personally distributing and retrieving the questionnaires.

To evaluate the relationship between the dependent and independent variables and hence the contribution of each variable of project quality to customer satisfaction, Step-wise Multiple Regression Analysis (SMRA) was employed to analyse the data obtained while the statistical tool SPSS was used to ease data presentation and computation. Soetanto and Proverbs (2001) opined that SMRA was a valuable means of predicting satisfaction in construction research and could be employed when the need arose to predict the value of a variable based on two or more other variables. The coefficient of determination (R^2) which is a statistical measure that indicates the relevance of the regression line in the approximation of real data points was thus calculated. The model summary and regression coefficients are presented in the preceding tables.

Relationship between Project quality (Performance, Reliability and Aesthetics) and Customer satisfaction (Re-patronage).

Table 1. Model summary of stepwise regression analysis on the relative contribution of project quality variables to customer satisfaction (Re-patronage)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.657a	.432	.431	9.17885
2	.730b	.533	.532	8.32937
3	.742c	.550	.548	8.18379

a. Predictors: (Constant), Performance
b. Predictors: (Constant), Performance, Reliability
c. Predictors: (Constant), Performance, Reliability, Aesthetics

Table 2: Regression coefficients

Model		Unstandardized Coefficients		Standardized Coefficients Beta	T	Sig.
		B	Std. Error			
1	(Constant)	20.921	2.525		8.285	.000
	Performance	.720	.037	.657	19.529	.000
2	(Constant)	5.816	2.712		2.144	.032
	Performance	.557	.037	.508	15.061	.000
	Reliability	.343	.033	.351	10.412	.000
3	(Constant)	4.555	2.680		1.699	.090
	Performance	.460	.043	.419	10.778	.000
	Reliability	.257	.038	.264	6.795	.000
	Aesthetics	.192	.044	.198	4.353	.000

a. Dependent Variable: Repatronage

$$R_p = 20.921 + .720P_f \quad (1)$$

$$R_p = 5.816 + .557P_f + .343R_y \quad (2)$$

$$R_p = 4.555 + .460P_f + .257R_y + .192A_s \quad (3)$$

Table 3: Regression ANOVA^d

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	32132.392	1	32132.39	381.387	.000 ^a
	Residual	42209.934	501	84.251		
	Total	74342.326	502			
2	Regression	39653.122	2	19826.56	285.774	.000 ^b
	Residual	34689.204	500	69.378		
	Total	74342.326	502			
3	Regression	40922.064	3	13640.68	203.670	.000 ^c
	Residual	33420.262	499	66.974		
	Total	74342.326	502			

Table 4: Excluded Variables^c

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	Reliability	.351 ^a	10.412	.000	.422	.820
	Aesthetics	.359 ^a	8.833	.000	.367	.596
2	Aesthetics	.198 ^b	4.353	.000	.191	.435

a. Predictors in the Model: (Constant), Performance

b. Predictors in the Model: (Constant), Performance, Reliability

c. Dependent Variable: Re-patronage

Information in Table 1 confirmed that from the respondents surveyed, project performance was the best predictor of contractor Re-patronage among construction companies in Rivers State when compared with Performance and Reliability. It showed project performance alone accounted for approximately 43.1% of the variance in Re-patronage ($R^2 = .432$, Adjusted $R^2 = .431$). Table 2 (Coefficients) gives the predictor variables in the regression equation, the Beta values, and significant T corresponding to the variables regressed against the dependent variable. A glance at Table 2 (Coefficients) reveals that the Beta values for performance, reliability and aesthetics were found to be highly significant ($\beta = .720$; $t = 19.529$, $p=0.00$), ($\beta = .343$; $t = 10.412$, $p=0.00$) and ($\beta = .192$; $t = 4.353$, $p=0.00$) respectively. The equations 1, 2 and 3 respectively indicate that any increase in the value of any of the independent variables will yield a resultant increase in the value of re-patronage. However, when considering contractor referral, the other attribute of customer satisfaction, project aesthetics alone accounted for approximately 57.1% of the variance of Referral ($R^2 = .572$, Adjusted $R^2 = .571$). According to Bedeian and Mossholder (1994) the R^2 value varies between 0% and 100%. Whereas an R^2 value of 0 indicates that the model explains none of the variability of the response data around the mean, 100% indicates that the model explains all the variability of the response data around the mean. Thus, an R^2 value of 57.1 indicates that project aesthetics accounted for more than half of the variability in contractor referral and on a wider

scale, customer satisfaction. Tables 5-8 present the findings from the stepwise regression analysis on contractor referral.

RELATIONSHIP BETWEEN PROJECT QUALITY (PERFORMANCE, RELIABILITY AND AESTHETICS) AND CUSTOMER SATISFACTION (REFERRAL)

The preceding tables highlight the computations from the stepwise regression between the attributes of project quality and contractor referral. Referral in this context denotes the recommendation of a road construction contractor for further construction activities based on recorded successes. Although there is often a tender and bid process in construction contract procurement, referral aids in ensuring that competent contractors are prioritised when contracts are being awarded.

Table 5: Model summary of stepwise regression analysis on the relative contribution of project quality variables to customer satisfaction (Referral)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.756 ^a	.572	.571	8.70086
2	.787 ^b	.619	.618	8.21573

a. Predictors: (Constant), Aesthetics

b. Predictors: (Constant), Aesthetics, Performance

Table 6: Regression Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	14.012	2.345		5.975	.000
	Aesthetics	.802	.031	.756	25.884	.000
2	(Constant)	5.431	2.468		2.200	.028
	Aesthetics	.612	.038	.577	16.151	.000
	Performance	.337	.043	.281	7.869	.000

a. Dependent Variable: Referral

Regression equations

$$Rf = 14.012 + .802As \quad (5)$$

$$Rf = 5.431 + .612As + .337Pf \quad (6)$$

Table 7: Regression ANOVA^c

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	50721.660	1	50721.660	669.991	.000 ^a
	Residual	37928.197	501	75.705		
	Total	88649.857	502			
2	Regression	54900.741	2	27450.370	406.683	.000 ^b
	Residual	33749.116	500	67.498		
	Total	88649.857	502			

a. Predictors: (Constant), Aesthetics

b. Predictors: (Constant), Aesthetics, Performance

c. Dependent Variable: Referral

Table 8: Excluded Variables^c

Model		Beta In	T	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	Performance	.281 ^a	7.869	.000	.332	.596
	Reliability	-.029 ^a	-.781	.435	-.035	.599
2	Reliability	-.040 ^b	-1.120	.263	-.050	.599

a. Predictors in the Model: (Constant), Aesthetics

b. Predictors in the Model: (Constant), Aesthetics, Performance

c. Dependent Variable: Referral

Despite the fact that project Aesthetics accounted for approximately 57.1% of the variance of Referral ($R^2 = .572$, Adjusted $R^2 = .571$) project Performance and Reliability did not enter the equation at 0.05 levels of significance in the first interaction. This revealed that the project performance and Reliability were weaker predictors of Contractor Referral when compared with Aesthetics. The prediction model-1 contained only one of the three predictors with two excluded and the result on Table 7 (ANOVA-1) further indicated that project Aesthetics was a significant predictor of contractor Referral ($F_{(1, 501)} = 669.991$, $p = 0.00$). Consequently, Performance and Aesthetics accounted for about 61.8% of the observed variance in Customer satisfaction (Referral). That is, only project Performance accounted for about 4.7% to the variance in Referral ($R^2 = .619$, Adjusted $R^2 = .618$).

DISCUSSION

On subjecting the data obtained to stepwise multiple regression and considering the variables of project quality, performance was found to be the best predictor of re-patronage (variable of customer satisfaction). Project performance entails the financial and schedule related attributes of a construction project. These include activities such as cost management, innovative project designs, organisational team work, project supervision, employee training, avoidance of project abandonment as well as employee motivation. Project reliability on the other hand refers to the time frame a system consistently performs its intended function without degradation or failure under specified environmental conditions (Oluwakiyesi 2011, Olatunji and Diugwu 2013). Hence, reliability in road construction projects would involve clear design specifications, use of professional experts, pro-active maintenance culture benchmarking, as well as constant inspection of the construction processes. Project Aesthetics refers to the implementation of quality standards, the presence of excitement factors, the durability of the finishing employed as well as health and safety considerations while using the constructed road. The SWMA also revealed that performance and reliability accounted for 53.2% of the variance in re-patronage while performance, reliability and aesthetics jointly accounted for 54.8% of the variance in re-patronage. Consequently, as the regression equations uphold, any change in the constituents of performance, reliability and aesthetics would have a concomitant effect on the nature of satisfaction obtainable from the constructed road.

Admittedly, project quality alone is not responsible for customer satisfaction in road construction projects. This is because road construction involves activities embedded in Engineering (Civil, Electrical, Structural, etc), Land and quantity Surveying, Architecture, Construction project management, amongst others. These activities all

have their key performance indices and requirements for satisfaction of their intended customers. Unlike the activities mentioned above, construction project management which encompasses the attributes of project quality discussed in this research involves all the construction activities that occur throughout the project life cycle, that is from the initial conception of the project to the project handover or even post project maintenance. The aforementioned activities are however not included within the scope of this research. The contributions obtained from the statistical modelling are nonetheless not a “one size fits all” implying that there are other construction factors that could enhance customer satisfaction which account for the variations in 100% R² value. Nevertheless adherence to the constituents of project performance, reliability and aesthetics are a step in the right direction for firms and construction stakeholders who intend to optimise construction activities and ensure that the intended customers are satisfied with the constructed road.

CONCLUSIONS

By means of statistical modelling through stepwise multiple regression analysis, the impact of project quality on customer satisfaction in road construction projects has been highlighted. Construction stakeholders are therefore enjoined to focus their attention on the attributes of performance, reliability and aesthetics if the desire is to deliver a durable road project that meets the commuting and transportation needs as well as the satisfaction requirements of its users. These attributes include cost management, innovative project designs, organisational team work, project supervision, employee training, avoidance of project abandonment, employee motivation, clear design specifications, use of professional experts, pro-active maintenance culture, bench marking, constant inspection of the construction processes, implementation of quality standards, presence of excitement factors, durability of finishing employed as well as health and safety considerations.

Agreeably, road construction involves a great deal of Civil Engineering activities, project success is however greatly embedded in the nature of construction project management employed while carrying out the road construction. Whereas project performance was averred to be the highest predictor of re-patronage (43.1%) while aesthetics was the highest predictor of referral (57.1%), 58.3% of the combined variables of project quality (performance, Reliability and aesthetics) jointly influence customer satisfaction. It is therefore expedient that construction companies as well as stakeholders revisit the implementation of the attributes of project quality in their organisations in order to optimise its benefits in enhancing road construction within Port Harcourt, and enhancing customer satisfaction from constructed roads.

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CAUSES OF DELAY ON INFRASTRUCTURE PROJECTS IN QATAR

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The construction industry is of high importance to the economy of most countries. However, it is notorious for projects overrunning time and cost. A plethora of research has been conducted to define causes of delay in completing construction projects. These studies employed a wide variety of analytical methods to statistically conclude the most precise ranking of causes of delay. Moreover, the delays for construction projects differ from one country to another and even between types of project within the same geographic location. The aim of this study is examining factors contributing to delays of infrastructure projects in Qatar.. A comprehensive quantitative literature review was carried out on neighbouring Gulf countries. The causes of delays are identified from literature and used in exploratory interviews with industry experts in Qatar to investigate the relevance of each cause. A survey questionnaire was prepared and was subject to pilot interviews prior to issuing it to practitioners, including clients, consultants, and contractors. Results shows that over 80% of infrastructure projects suffers from delay with an average delay of 25% and the top factors were: long response times from utility agencies; major changes in design during construction; ineffective planning and scheduling; ineffective control of progress, and; changes in the scope of projects. Construction projects need to adopt planning and scheduling methods that deal with its dynamic and changing nature to create robust programmes with buffers to deal with uncertainties.

Keywords: construction planning, delay causes, infrastructure.

INTRODUCTION

Construction projects are notorious for overrunning time and budget. The percentage of delayed projects reported in Assaf and Al-Hejji's (2006) study exceeded 70% in Saudi Arabia and 60% in UK (Davis *et al.* 2014). Extensive research efforts to identify the reasons and causes of delays were conducted in different countries, and the findings were reported in several studies. Emam *et al.* (2014) argued that causes of delay vary from one geographical location to another. These variations are due to bespoke location factors such as availability of resource, efficiency of public authorities, and local regulations. The delay causes in countries with high populations might be the unavailability of trained personnel (Doloi *et al.* 2012). Meanwhile, in countries with low populations, usually availability of labourers is the dominant resource related reason. Consequently, the treatment of causes of delays shall be dealt with on an individual case basis.

Construction activities are currently booming in Gulf Cooperation Council (GCC) countries in general and Qatar in particular. Qatar construction activities are expected to considerably increase in the coming years, due to the award of the World Cup 2022. The government of Qatar has announced plans to spend 205 billion US dollars on

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infrastructure projects over the next five years. The planned investments in infrastructure include highways, railways, underground metro, and tunnelling projects.

The lead author is a practitioner working in a major infrastructure project in Qatar where cost and schedule overruns are often observed in construction operations and the motivation for the research is to avoid this wastage in future. This study focus is on infrastructure projects with repetitive serial activities i.e. projects with repeating activities geographically such as pipelines, highways, roadways, tunnels, and railway projects (Hegazy and Wassef 2001). The main objectives are: (1) identify, assess, and rank the reasons for delays in infrastructure construction projects in Qatar; (2) suggest solutions to mitigate the impact of the identified causes; (3) conduct a comparative study with other GCC countries on causes of delay, and (4) propose future research efforts required to mitigate or eliminate the impacts of the causes of delays.

LITERATURE REVIEW

A quantitative systematic literature review was chosen to ensure comprehensive coverage of earlier studies published in relation to causes of delays in construction projects within the GCC countries. Identified papers resulted from the search were subject to filtering for their validity for inclusion. In the papers found to be valid, their references and citations were used to determine availability of any further literature that did not appear by applying search criteria. It was found that there are 28 published studies on causes of delay topic. These results were filtered for their relevance to the current causes of delay. In addition, citing and referenced publications were reviewed for relevance. The final number of relevant was 18 papers.

The summary in Table 1 shows that Saudi Arabia is the most studied GCC country for identifying causes of delay followed by UAE in the second place with a total of seven and five publications respectively. Qatar had a single study of the causes of delay. The recognised studies were categorised by type of projects that were investigated. This classification gives granularity and demonstrates differences between projects nature in relation to factors causing delays. In order to identify literature gaps, a quantitative matrix of publications was developed. The matrix maps publications to types of projects and country under consideration.

Table 1: Mapping Types of Studied Projects by Country

	Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	UAE	Total
Buildings	-	2	-	1	1	-	4
Construction	-	-	1	-	4	3	8
Oil and Gas	-	-	1	-	1	1	3
Pipeline	-	-	-	-	1	-	1
Road	1	-	-	-	-	-	1
Infrastructure	-	-	-	-	-	1	1
Total	1	2	2	1	7	5	18

Saudi Arabia is ranked first amongst GCC countries in the number and diversity of causes of delay studies and only particularly considered pipeline projects. Seven papers focusing on causes of delay in Saudi Arabia were found in the literature. The studies breakdown shows one publication for building (Assaf *et al.* 1995), one for oil and gas, and one for pipeline (Al-Khalil and Al-Ghafly 1999) projects. Meanwhile, general construction was the most frequently studied with four papers (Assaf and Al-

Hejji 2006; Al-Kharashi and Skitmore 2009; Albogamy *et al.* 2012; Mahamid 2013). These studies have variations that are discussed in this section. Assaf and Al-Hejji (2006) investigated causes of delay for large construction projects in Saudi Arabia. Al-Kharashi and Skitmore (2009) study was inclusive of different project scales and was not specific to geographic areas within the kingdom. Albogamy *et al.* (2012) criticised the previous studies for not considering variation due to geographical location and conducted specific research on five Saudi cities. Mahamid (2013) narrowed his study on investigating the perspective of owners on the causes of delay.

The United Arab Emirates (UAE) is ranked as second in frequencies of studies and was the only country with a particular study on delays on infrastructure projects. The five identified studies are categorised as one for infrastructure and one for oil and gas projects, whilst the remaining three studies are related to delays on general construction project. Salama *et al.* (2008) considered reasons for delay in the oil and gas industry within the UAE. Halloum and Bajracharya (2012) focused their research on the causes of delay in infrastructure projects in Abu Dhabi, the capital of UAE. Over 90% of infrastructure projects in the study had time overruns using multiple linear regression. Three studies investigated general reasons for the delay in construction projects (Faridi and El-Sayegh 2006; Motaleb and Kishk 2010; Ren *et al.* 2008). The first study of construction delay causes within UAE was conducted by Faridi and El-Sayegh (2006). Their study considered practitioners from consultants and contractors groups with no participants from owner organisations. Motaleb and Kishk (2010) argued that reasons for delays are changing over time; they conducted a survey, and compared results with the earlier study of Faridi and El-Sayegh (2006) and significant differences were identified.

The cases of Kuwait and Qatar had studies related to building projects. Two studies were carried out with a focus on Kuwait building projects (Al-Tabtabai 2002; Koushki *et al.* 2005). Al-Tabtabai (2002) examined reasons for delays in building projects through surveying practitioners from contractors, consultants and government organisations. On the other hand, Koushki *et al.* (2005) explored the causes of delay in private residential rather than government projects as an earlier study by Al-Tabtabai (2002). Results from both studies show different reasons for project delays which implies that type of owner organisations may influence time over-run causes. Jurf and Beheiry (2010) considered primary delay contributors to private residential compound projects in Qatar. The study focused on compounds built between 2000 and 2005 by private developers. Consequently, the study did not consider different building projects as high-rise, mixed-use and commercial.

Searching Oman resulted in two studies of time over-run; one of them is specific to causes oil and gas (Ruqaishi and Hamdi 2013) while the other is general construction projects (Alnuaimi and Mohsin 2013). Ruqaishi and Hamdi (2013) attempted to identify reasons for oil and gas project delays. They surveyed 59 project managers from different stakeholders. The results show a good level of agreement between stakeholders. They also debated that findings are likely applicable to other GCC countries; which contradicts other studies. Alnuaimi and Mohsin (2013) considered general construction project time over-run reasons. They reported over 40% of surveyed projects were completed with delays.

Bahrain is the only GCC country with research specific to road projects. Hasan *et al.* (2014) conducted a survey containing 47 causes of delay identified from the literature and administered through industry practitioners. The study concluded that major

reasons for delays are improper planning and inexperienced manpower. While one major cause related to owners is delay in decision-making. A detailed systematic quantitative literature review can be found in Emam *et al.* (2014).

The literature review resulted in a list of potential contributors of causes for delays in construction projects within neighbouring countries to Qatar. The identified causes were used to form the basis of this study after validation. There were several factors influence causes of delays thus; project parameters i.e. size and type, client organisation type, contract arrangement, and time of study Emam *et al.* (2014).

RESEARCH METHODOLOGY

The problem to be studied is construction schedule over-runs. The study commences by conducting a comprehensive literature review. In order to ensure full coverage of literature, a quantitative systematic literature methodology was used as proposed by Pickering and Jason (2014). The methodology is based on identifying keywords related to the problem in study and systematically running electronic searches using these keywords. Filtering of results are then carried out to ensure their relevance to the subject; also references and citations are screened to ensure their inclusion. If the screening resulted in additional papers, additional keywords are generated using found papers and search queries and executed again. This process repeats until no further papers related to the topic are found. Upon completing the systematic identification of literature, results are presented in quantitative form such as frequency counts, number of publications in specific location and for different type of projects. This study literature review was for causes of delay in construction projects in Gulf Cooperation Council (GCC) countries. The search was implemented in several databases including EBSCOhost, ProQuest, Scopus, and Web-of-Science. Figure 1, shows the process adopted in the literature review.

A two-stage research method approach is adopted in this study. The first stage is based on exploratory interviews with industry practitioners and researchers. The exploratory interviews were semi-structured to discuss with the interviewees the relevance of the compiled list of delays. The interview methodology was selected to gain an in-depth understanding of the delay causes and discovering new alternatives from the interviewees' experience. The interviews included personal discussions with five industry experts representing clients, consultants, and contractors. The identified list of international causes of delays were sent to participants. The sample size of interviews is identified by saturation as a standard practice of qualitative research methods (Guest *et al.* 2006). The saturation is reached when more meetings do not produce new data. These interviews were digitally recorded along with field notes for the analysis. Upon conducting the interviews, the delay causes list was then refined and enhanced taking into account the feedback from the industry practitioners. The second stage involved the design of a questionnaire to be administered in an electronic survey format. The survey questionnaire was piloted among four industry professionals to ensure that the contents and terminology used were clear to other professionals. The survey was distributed to a random sample of 212 construction professionals. The completed qualified responses were 37, representing participants from clients (5), consultants (17) and contractors'(15) organisations. The overall response rate is 17.45%.

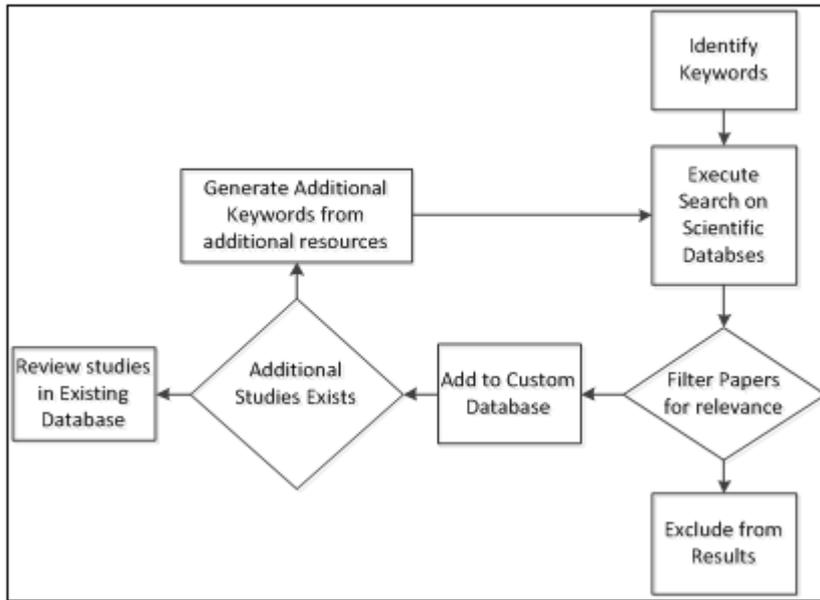


Figure 1: Systematic Search Process Flow (Emam et al. 2014)

The authors acknowledge the low client representation in the sample and therefore no strong inferences are made. The mixed research methodology was employed due to the exploratory nature of the first stage of the study which requires identification of relevant delay causes to Qatar. However, to rank these reasons for delay a quantitative approach is considered more appropriate due to using a sample that will converge to reality. In addition, by using mixed research methods triangulation is achieved by using two methodologies thus; semi-structured interviews and surveys.

Survey Design

The survey was designed in two main parts. The first part collected personal, professional and project information about participants. The collected information provides an understanding of the position of the organisation in relation to the supply chain, the seniority level of participants within organisations, and the experience extent of participants. The project related section collects data on the size of the project, procurement arrangement, contractual agreement, and project type. The second part of the survey targets collecting frequency and severity information from participants about 88 identified causes of delay in Qatar. Factors were clustered into four different groups to corresponding to which party caused the delay i.e. contractors, consultants, clients, and external factors. The frequency is measured in the second part by means of Likert-scale with the possible selections: always coded as 4, often 3, sometimes 3, rarely 1 and never 0. Meanwhile, the severity information is obtained by impact scale with the following choices; very high coded as 4, high 3, moderate 2, low 1, and very low 0.

Data Analysis

The statistical survey analysis technique and indices used in this study were severity index, frequency index and importance index as follows:

Frequency and severity indices formulas are used for the purpose of ranking causes of delays based on their frequency as selected by participants

$$(F.I.) (\%) = \sum a \left(\frac{n}{N} \right) * \left(\frac{100}{4} \right) \tag{1}$$

$$(S.I.)(\%) = \sum a \left(\frac{n}{N}\right) * \left(\frac{100}{4}\right) \quad (2)$$

where 'a' is, the constant expressing weighting given to each response (ranges from 0 to 4), 'n' is the frequency of the responses, and 'N' is total number of responses.

The relative importance index of each individual cause is calculated from the result of multiplying the frequency index (1) and severity index (2) as shown in formula (3).

$$(IMP.I)(\%) = \frac{(F.I.)(\%)*(S.I.)(\%)}{100} \quad (3)$$

Rank Correlation

The Spearman's rank correlation is used to measure the level of agreement or disagreement of each two parties based on the importance index. The used formula Eq. (4) shows the calculation method of the correlation factor.

$$r_s = 1 - \left[6 * \sum \frac{d^2}{(n^3 - n)} \right] \quad (4)$$

where 'rs' is Spearman's rank correlation coefficient between two parties; 'd' is the difference in rank assigned to variables of each cause; 'n' is the number of ranks

RESULTS AND DISCUSSION

The results obtained from the administered survey were analysed using the relative importance index (RII) method. The importance of each factor is equivalent to the product of its frequency and severity. The method used justifies importance of each factor by expressing its frequency of occurrence and impact in case the factor occurred. The factors are then ranked based on their subsequent RII for overall and for each group. The results showed that 81% of the projects exceeded the planned time with an average overrun of 25% which reinforces the significance of the problem. The top 20 factors that cause delay are listed in table 2. The party that has lead responsibility for delays are also indicted.

Client Related Factors

Amongst the top ten ranked factors, clients contributed with three causes. Two of these are related to delays in decision making. Changes in project scope and slow decision making by clients are the top factors attributable to clients and especially government organisations due to the bureaucratic nature to access public funds and centralised decision-making authority and governance. The last top factor attributable to clients is delay in approvals of samples and drawings. Interviewees stated that often clients agents assigned to projects are reluctant to issue such variations and pass responsibility to senior management. The impact of these factors can be reduced by delegating authorities from higher management down the hierarchy to a certain extent.

Consultants

The consultants had three factors out of 17 identified in the top ten ranks. The delays of design information by consultants as explained by interviewees are attributable to: contractual agreements with designers that do not hold them liable to delays and distributed physical location of personnel that lead to miscommunication and lack of urgency. These delays were also attributable to poor resource planning where consultant organisations do not have sufficient level of staff to cope with the workload.

Table 2: Top 20 Factors Causing Delay

Rank	Delay description	RII %	Party causing delays
1	Long response from utilities agencies	62.4	External
2	Major change of design during construction	60.5	Consultant
3	Ineffective planning and scheduling	59.7	Contractor
4	Ineffective control of progress	59.2	Contractor
5	Changes in the scope of the project	59.1	Client
6	Slow decision making	57.7	Client
7	Delay in issuing the drawings	56.1	Consultant
8	Delay in solving design problems	56.1	Consultant
9	Delay in approving shop drawings and sample materials	55.1	Client
10	Difficulties in obtaining work permits	53.1	External
11	Delay in issuance of change orders	53.0	Client
12	Discrepancies between specifications and drawings prepared	52.1	Consultant
13	Unreasonable project time frame	52.0	Client
14	Shortage of manpower	51.2	Contractor
15	Delay in the settlement of contractor claims	50.8	Client
16	Poor coordination with the stakeholders	50.5	Contractor
16	Poor site management	50.5	Contractor
18	Slow preparation of change orders requests	50.3	Contractor
19	Low productivity of labourers	50.3	Contractor
20	Delay in reviewing and approving contract documents	49.8	Client

Contractor Factors

The factors attributable to contractors that appeared in the top 10 ranks were two out of total of 40 identified. Contractors related factors are linked to ineffective project planning and control. Effective planning for infrastructure projects can be achieved by selecting adequate planning techniques such as linear scheduling for infrastructure projects, optimising project schedules to achieving objectives with consideration of all constraints, and allowing sufficient buffers to absorb uncertainties impact i.e. robust scheduling. Better progress control systems can be achieved by adopting dynamic scheduling methods.

Factors by External parties to Contracts

The nature of infrastructure projects, is that they cover broad geographical locations. This geographical spread consequently leads to interfacing with different stakeholders. One of the most critical interfaces is utility diversions that were identified as the most influential factor in infrastructure project delays. Late responses and approvals from utility agencies leads to delays to construction at an early stage where there are no alternative works to execute. Utility organisations need to improve their operations by enhancing their processes and procedures; then publishing them to customers with clear timeframes to allow contractors to plan works adequately.

Rank Agreement

Validation of the hypothesis that stakeholders perceive factors causing delay similarly, is tested by running a Spearman rank correlation test as conducted in earlier studies such as Moataleb and Kishk (2010). The results of the analysis shown in Table 3 demonstrates a good degree of agreement between clients and both consultants and contractor organisations. However, it appears that consultants and contractors' views on the main contributing factors to delay of infrastructure projects are not significantly similar.

Table 3: Ranking of subgroups by Different Stakeholders

Organisation Pairs	Spearman's Rank Agreement Coefficient	Probability
Client - Consultant	0.568	0.0220
Client - Contractor	0.779	0.0042
Consultant - Contractor	0.389	0.0990

Comparative Study

The earlier study of delay causes in Qatar investigated residential compound projects in the country; nine of the top ten factors were reported in Jurf and Beheiry (2010). In this section, ranks are compared with the only study about Qatar. The comparison shows considerable change in ranks between residential compounds research by Jurf and Beheiry (2010) and findings of this study on infrastructure projects within Qatar. The study was chosen to demonstrate the significant difference between infrastructure and housing projects causes of delay. Also, the lack of studies focusing on infrastructure projects within GCC countries with only one study (Halloum and Bajracharya, 2012) that employed linear regression where the results are not comparable to the findings of this study.

Table 4: Comparing Top ten causes with Previous Study by Jurf and Beheiry (2010)

Description	Rank in this study	Jurf and Beheiry (2010)	Rank Change
Long response from utility agencies	1	23	-22
Major change in design during construction	2	2	0
Ineffective planning and scheduling	3	11	-8
Ineffective control of progress	4	22	-18
Changes in the scope of the project	5	-	-
Slow decision-making	6	30	-24
Delay in issuing the drawings	7	26	-19
Delay in solving design problems	8	7	1
Delay in approving shop drawings and sample materials	9	26	-17
Difficulties in obtaining work permits	10	-	-

CONCLUSION

Examining factors contributing to delays of infrastructure projects in Qatar was the aim of this study. A systematic quantitative literature review method was adopted to ensure full coverage of previous studies and identify gaps in literature. This process

lead to identifying 120 factors that were filtered to 88 relevant to Qatar based on interviews with industry practitioners. The filtered factors were then subject to an online questionnaire where 37 infrastructure professionals from clients, consultants and contractors participated. The results were then analysed to produce ranking for each of the factors. The top ten factors were distributed amongst the stakeholders with two related to contractors, three for consultants, three for clients and two associated with external stakeholders. The top five factors were: long response from utility agencies; major change in design during construction; ineffective planning and scheduling; ineffective control of progress; and changes in the scope of the project. Rank agreement between stakeholders shows good rank agreement between clients and both contractors and consultants. On the contrary, consultants and contractors seem to perceive priorities of various factors differently. The study also compared results with previous research examining causes of delay in residential compounds projects in Qatar and found considerable differences in ranking priority.

Future research can potentially focus on further studies on delay causes in other project types such as buildings, utilities, and oil and gas, to understand causes of delay with more granularity. In addition, general studies of different project types to investigate the significance of differences between them will help to confirm the presented arguments. On the other hand, studies on resolving major causes should be conducted to enhance processes and reduce exposure. For example the problem of planning and scheduling need to be investigated for practical solutions to increase the effectiveness by implementing several techniques for optimising schedule baselines, and subsequent revision of programmes using dynamic scheduling methods. These programming techniques account for buffers to absorb impact of uncertainties, and use rescheduling techniques to adjust programmes to current project status.

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PROVINCIAL ROADS CAPEX PROGRAMME IN SOUTH AFRICA: PLANNING AND MANAGEMENT INADEQUACIES

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The management of infrastructure programmes has been challenged with poor performance in South Africa. The implementation of road projects through Capital Expenditure (CAPEX) programmes by provincial Department of Public Works (DPW) is not an exception. To understand the performance challenges and proffer suggestions, a research study with the overall aim of identifying remedial actions that can mitigate the challenges in the programme was conducted. This research reports on the detrimental effects of planning and management issues experienced in the programme. The exploratory sequential research design method, which allows the collected qualitative data to build into the quantitative data for a broad interpretation of the findings, provides insights from the study. Analysis of the statistical and textual data points to rigid bureaucratic processes as the major cause of the CAPEX programme dilemma. Inadequate planning and insufficient in-house capacity also contributed to the problems encountered on the programme. The utilisation of the management structure in the programme can be deemed to be more ineffective in terms of the time lag relative to critical decisions that may stall the programme. The research findings imply that the Department should ensure that the Roads CAPEX Programme (RCP) is well resourced in terms of expertise, and the planning processes should be detailed enough to support the flow of both programme and project activities.

Keywords: programme management, roads, South Africa.

INTRODUCTION

In an effort to address the effects of a past policy of separate development, the South African government had to invest in areas that were previously under-developed (Fisher, 2008). To do this, infrastructure projects, such as schools, hospitals and roads, consume almost 18% of the national budget allocation in South Africa (Department of Treasury, 2008). The question is how to spend the allocations properly for the realisation of the anticipated benefits. This question is crucial as infrastructure development would not only boost the economy, but it will also correct the separate development of the country (Gorghan, 2012). The government of South Africa have therefore sought to implement CAPEX infrastructure programmes through the DPW at various level of governance so as to execute projects that can uplift under-developed areas in the country. The dilemma is that though the government invests a lot of resources into such programmes, there is not much in terms of functional

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infrastructure that can be shown for the effort. This is a major concern to stakeholders. The management of the CAPEX programme at the provincial level has been a concern to all stakeholders. For instance, it has been reported that a large proportion of government projects have failed due to ineffective project management practices (Molewa, 2008). The observations of Molewa (2008) highlight the fact that management structures seem to be ineffectively utilised; and protocols were bridged in some cases. Such problems leads to misinformation that leads to errors in reports as government bureaucratic structures hinder swift and timely processing of information. The mainstream media have made case examples of several provincial programmes.

This study therefore focuses on the problems by looking into the programme in a single province that is anonymous for research ethical reasons. According to the strategic plan of the case province, the Chief Directorate Roads Management at a Head Office (HO) and District Offices (DO) implement the RCP. The HO focuses on planning, design, and the implementation of capital projects, whereas the DO is mainly concerned with routine maintenance. The importance of the mandate of the HO cannot be over emphasised as provincial roads have continued on a downward spiral even in the face of paucity of funds. The RCP is a ten-year strategic development initiative that caters for the development of additional paved roads, and the rehabilitation of existing paved and unpaved roads in the province.

The case of this particular province is unique as most projects fail to achieve their goals due to either planning or implementation issues (Molewa, 2008). Therefore, it was deemed appropriate to examine the existing management approach so as to identify the potential causes of low performance, and then, evolve recommendations that could engender improvement. However, this particular paper reports on the planning and the management related factors in the RCP. As such, the objective of this paper is to present responses to two research questions:

What are the planning problems of an RCP in a South Africa province?

What are the inadequacies relative to management structures used in an RCP in a South Africa province?

CONSTRUCTION PROGRAMME MANAGEMENT DEFINED

Shehu and Akintoye examine programme management and defined it (2010: 27) as ..”an integrated, structure-framework to co-ordinate, align, and allocate resources, as well as plan, execute and manage a portfolio of construction projects simultaneously to achieve optimum benefits that would not have been realised has the projects been managed separately.” While project management is oriented toward the goals of a single project by focusing on the management of finance, progress and quality, programme management is oriented towards strategic goals involving more than one project. However, both project and programme management focus on integrated planning, control and coordination of required activities. Just like projects, the lifecycle of a construction programme include initiation, planning, bidding and tendering, implementation and termination. In contrast to project management where the team participates in all areas of management of the particular project, the programme management team does not play direct roles in daily administration of projects that make up the programme (Chen *et al.*, 2013).

RESEARCH RATIONALE

The literature on programme management in construction realise the inclusion of multiple projects in a programme and also acknowledged a range of implementation barriers. Such barriers are not limited to the lack of clarity and understanding (Shehu and Akintoye, 2009), lack of appropriate approach to risk management (Shi *et al.*, 2014), and administrative bottlenecks that is otherwise known as bureaucracy (Jia *et al.*, 2011). Both at the pre-construction and the actual construction stages, high level planning is required for successful programme management. Apart from planning, attention should also focus on excessive hierarchical bureaucracy and control, which is difficult to achieve if the relationships between programme managers and project managers is cumbersome (Lycett *et al.*, 2004). For instance, excessive bureaucracy and control creates increased overheads for reporting requirements and a culture of blame within the team (Lycett *et al.*, 2004; Shehu, 2008). The challenges of programme management is evident in late delivery of projects, which can be due to poor risk and financial management, lack of cross-functional communication, and the lack of required resources to assign and analyse various constraints (Shehu and Akintoye, 2010).

These reported challenges mirror the experience of the RCP in South Africa where performance problems adversely affect public sector service delivery. According to Consulting Engineers South Africa (CESA) (2012), inadequate delivery capacity within government has contributed to slow pace of infrastructure development in the country. The gaps in delivery capacity are evident at the design and implementation stages, especially in relation to constant scope changes, increased project cost, delayed hand over dates, and associated rise in service delivery protest nationwide. Thus, the premise of this research is to gain insights into the challenges of construction programme management in South Africa. This paper however presents the planning and management related challenges.

RESEARCH METHODOLOGY

The findings of this study emerge through the analysis of reviewed literature, semi-structured interviews and survey research. The data collection was conducted in 2013 with the use of mixed methods so as to provide broader perspectives (Tashakkori and Teddlie, 2010). The approach enabled the collection of both qualitative and statistical data, which were used to substantiate evidences (Creswell, 2009). Face-to-face interviews were used to explore the problems, and a survey among the actors involved in the programme was conducted to confirm the interview findings. This approach is termed “*exploratory sequential design*” by Creswell and Plano Clark (2011: 69) as the interviews builds into the survey so as to engender broader interpretation of the findings. As such, the researchers collected qualitative data about the RCP through interviews and analysed the textual data to identify the planning and management inadequacies in the programme. Relying on the themes that emerged from the textual analysis, the researchers developed a survey questionnaire and used it to assess the prevalence of these inadequacies within a larger sample of the RCP participants.

Given that the fieldwork focused on a single department (DPW) in a province in South Africa, the purposive sampling technique was deemed appropriate for the selection of the participants in the study. Thus, the interviewees and survey respondents were affiliated with the RCP in the DPW. Although the participants have various job titles, they can be categorized under clients (DPW employees), consultants, and contractors.

The overarching requirement for participation in the study is the knowledge of various practices and processes involved in the CAPEX programme.

Based on the reviewed literature, the interview protocol was piloted among three principal actors in the programme. After the finalisation of the protocol, fourteen programme actors were invited to participate in the study through emails that were followed up with telephone calls. Prior to the scheduled date and time of each face-to-face interview, the protocols were sent to the programme actors that agreed to take part in the study. Although fourteen programme actors were invited and accepted to take part in the study, only nine interviews were conducted due to various reasons, which can be linked to unexpected non-availability. Among the nine interviewees, three actors work for the DPW, four actors work for project management consultancies, and two actors work for contractors involved in the programme. The interview questions were open ended, and each session span almost an hour in the designated office of the interviewees.

Thereafter, a survey was conducted among an enlarged sample of actors in the programme. Through the information retrieved from the client, 83 survey questionnaires were circulated to obtain possible confirmatory data for the study. The structured questions of the questionnaire were based on the findings of the interviews. At the end of the survey period, 39 validly completed questionnaires were returned and processed. This constitutes a 47% response rate for the survey. In terms of demographic data, 94% of the survey respondents have post-secondary school qualification, 72% of them have construction related job titles, 69% offer project management as a core service in their forms, and most importantly, 13% of the respondents have executed seven or more projects in the RCP. The data also show that 56% of the respondents have done 1-3 projects, whereas 31% of them have concluded 4-6 projects in the programme. In other words, all the respondents were actively involved in the programme, albeit at varying level of responsibility. The survey thus provides the platform for obtaining confirmatory data from the programme actors. It should be noted that the interviewees were not included in the survey.

RESEARCH FINDINGS

The discussion of the responses to the questions in this paper is based on answers that echoed the most in the nine interviews. In broad terms, the interviews sought responses to planning related matters and management structure issues in the programme. The transcribed data show that all the interviewees agree that the DPW has infrastructure projects, which must be coordinated, so that limited resources can be appropriately allocated. The interviewees also mention that the programme is also expected to assist the DPW to align its projects with government policies, especially the preferential procurement policy. According to the interviewees, the most conspicuous planning problem on the programme is poor risk assessment and feasibility studies (Table 1). The interviewees also note that there is improper scoping of projects within the programme, and this is evident in many changes that are effected at the construction stage. Another issue mentioned by the interviewees is the sub optimal management of resources. The data show that resources, most especially materials, plants and equipment, have incorrect schedules at the project phases. It was noted that management emphasis on overall works programme that show activities, time frames and cash flow projections at the expense of detailed resource, material and plant schedules, has marginalised the programme.

Table 1: Overview of major implementation gaps in the RCP

Aspect	Comments of interviewees
Planning	Poor risk assessment and feasibility studies Improper scoping of projects within the programme Resources have incorrect schedules at the project phases
Management	Bureaucratic procedures, which are rigid are common place Approvals by the client is realised through many steps Late official decisions that delay the programme is prevalent Lack of capacity in terms of expertise exists in DPW

In specific terms, the interviewees note that the causes of the encountered planning problems pertain to improper design details and specifications, which always lead to poor resource, material and plant scheduling among projects. More often, designs are not detailed enough with appropriate specifications to enable planners to prepare the right schedules for projects in the programme. The resultant effect is that delays are usually experienced on such projects. Project costing and budgeting also suffer in this regard. Another issue is the frequent changes experienced on projects in the programme. Such changes are due to improper feasibility studies that embed the need analysis of stakeholders. This leads to scope creep, financing and budgeting shortfalls that eventuate in project delays, and improper work breakdown structure also leads to the failure to identify and assign work appropriately. Scope creep, delays and financial problems may also be a resultant effect in this regard.

The interviewees were of the opinion that solutions to these problems are multi-prong. First, stakeholders should adhere to the programme communication plan. This can be effective as organisation breakdown structure is in place to perform various activities in the programme. Clearly, defined roles are assigned to every personnel in the programme. The position and reporting lines are also clearly defined. Most notably, it should be clearly stated that only the project consulting team could give instructions and communicate officially with the contractors. The lines of project communication are routinely bridged. Second, design drawings should be detailed and adequately specified for proper planning to be done in terms of resources, plant and materials. A good work breakdown structure should identify various activities to be carried out on the programme. This should enhance proper scoping of each project, which includes activities needed for the successful completion of a project. Third, expert knowledge in planning should be acquired to plan the projects in the programme. It is crucial to have the correct scope of work in place before the start of planning so as to minimise unnecessary changes at succeeding stages.

At the administrative level, the programme has been vulnerable to structural problems in its management. To this end, the interviewees mentioned that the RCP management structure was bureaucratic because often times, procedures were rigid. Such rigidity negate the need for flexibility that is required if programme managers are to make decisions that would save time and money. For instance, most of the programme managers opine that they lack authority to make quick decisions on the programme without the approval of the client. The approval of the client is realised through many steps, and even more worrisome is the lack of enough professionals in the DPW to steer the programme towards its goals. The immediate consequences of these problems are exemplified in late official decisions that in turn contribute to programme delays with cost implications. The lack of authority on the part of the programme managers prevent them from making quick decisions to solve urgent

problems that always escalate to major ones. This decision-making gap is reportedly a major issue at project implementation stage.

Because of these experiences, the interviewees suggests that the DPW should incorporate an organisational structure that is flexible, to enhance quick decision making on the programme. To allow this flexibility, procedures should be reviewed to enable programme managers to run the programme without unnecessary interference. This will enhance quick decisions, which solves urgent problems that may escalate to major ones. The interviewees note that the DPW should endeavour to develop the necessary human resource capacity to manage the programme. For instance, since the programme is multi-year, in-house recruitment of programme managers should be considered, while training current employees on the programme.

As mentioned earlier, additional data emanated from a research survey. The survey, which was conducted after the analysis of interview data, confirms the veracity of the views of the interviewees. The survey data are herein shown in Table 2 and Table 3. The survey used a 5-point Likert scale to collect, analyse, and interpret the data. A scale of 1= strongly disagree to 5= strongly agree, was used. In order to determine inferences, Chi-square tests were conducted in accordance with the decision rule in Bagdonavicius and Nikulin (2011: 32). A confidence level of 95% was set for hypothesis testing. Two complementary statements, the null hypothesis, which is a claim of no difference and an alternate hypothesis, which is a claim of a difference in the population (Bagdonavicius and Nikulin, 2011: 34) were specified for this study. In brief, the null hypothesis is accepted if $p \leq \alpha$ whereas the alternative hypothesis is accepted if $\alpha \leq p \leq \beta$. Where p is the significance level, α is the pre-determined threshold probability (5%), and β is confidence level (95%).

It is notable that the general perception of the programme obtained through the survey was not dissimilar from the views obtained in the interviewees. The perceptions related to planning as shown in Table 2 indicate that proper risk assessment is not done on the RCP and its constituent projects. This appears to be the foremost planning problem encountered on the programme. The next issues, which are also important in terms of planning, are the improper activity definition and sequencing, and the lack of justifiable business case for each project in the programme. The respondents also agree that duration estimates are not established for all activities; high-level schedule of activities is not created for the programme, and resources to be used are not well understood / specified. In terms of planning, the study established that there is a positive relationship between ‘scoping and feasibility studies’ and ‘planning’ of the RCP. The mean responses to the various statements in Table 2 are greater than 3.00, which indicate that the respondents agree that ‘improper scoping and feasibility studies have led to the improper planning of the RCP. The Pearson Chi-square test revealed significance level ≥ 0.54 . The findings in Table 2 thus corroborate the views of the interviewees (Table 1) in term of the planning related problems of the RCP.

Table 2: Inferences related to the planning related gaps in the RCP

Statement	Mean	Rank	Chi-square
Improper risk assessments are done on the programme’s constituent projects.	4.18	1	0.54
Improper definition and sequencing of activities.	3.90	2	0.59
Resources are not well understood / specified.	3.73	3	0.63
High level schedule is not created for the programme.	3.50	4	0.63
Duration estimates are not determined for each product.	3.41	5	0.71

Table 3 shows that the respondents were however; in doubt whether managers in DPW have the necessary management knowledge and skills to manage the programme successfully. The respondents were also less agreeable with the statements 'managers have the necessary authority and power to control the execution of the programme' and 'managers are allowed to attend executive meetings where programme strategic decisions are made'. In terms of management, the survey data show that there is a positive relationship between 'in-house capacity' and 'management' of the RCP. The mean responses indicates that the respondents agree that 'inadequate in-house capacity in the DPW has led to poor management of the programme'. The Pearson Chi-square test results revealed significance level ≥ 0.26 . The findings in Table 3 also corroborate the views of the interviewees (Table 1) in term of the management related inadequacies of the RCP.

Table 3: Inferences related to management related gaps in the RCP

Statement	Mean	Rank	Chi-square
There is a high level of top management commitment to the success of the programme.	3.59	1	0.26
Managers have the necessary authority and power to control the execution of the programme	3.41	2	0.26
Managers have the necessary management knowledge and skills to manage the programme successfully.	3.23	3	0.65
Managers are allowed to attend executive meetings where programme strategic decisions are made.	3.08	4	0.30

Another issue of significance pertains to communication. Though a communication plan is put in place in the RCP, little is done to adhere to it. For such a programme, grapevine model of communication is often responsible for discord among programme actors. To address this gap, stakeholders should adhere to the programme communication plan. This can be effective as organisation breakdown structure is in place to perform various activities in the programme. The existing programme shows defined roles that are assigned to every personnel in the programme, and the reporting lines are also clearly defined. Most importantly, it should be clearly stated that only the project consulting team could give instructions and communicate officially with the contractors. The lines of project communication should not be bridged routinely by programme actors.

DISCUSSION

Within the construction industry context, the implementation of a new system, such as programme management, is a challenging task (Shehu and Akintoye, 2010) because infrastructure projects are implemented in a socio-technical context in which events occur (Van Gils *et al.*, 2009). Similar to the issues discussed in the previous section of this paper, planning and management of construction programme are prerequisites for success. For instance, Shi *et al.* (2014) used the 2010 Asian Games construction programme to demonstrate the importance of risks management to programme delivery. Just as the respondents in the South African study have highlighted (Table 2), failure to address risks relative to programme schedule, coordination, communication, delay in design, design change, and resource utilisation, could severely affect the performance of a programme (Shi *et al.*, 2014). Given that the requirements for the aptitude of most contractors involved in programmes are complex (Buuren *et al.*, 2010), even in the face of possible conflicts relative to the utilization of resources and sharing of crucial information, the risks impacting on

contractors' ability to do the required work, communicate unambiguously, and coordinate activities and people, must be addressed appropriate at the programme and project levels (Alam *et al.*, 2008).

Major challenges have been encountered in the practice of construction programme management. Reported categories include strategic focus, human and communication, finance, leadership and commitment (Shehu and Akintoye, 2010). Under these categories proposed by Shehu and Akintoye (2010), the lack of cross-functional working (among projects), lack of coordination between projects, lack of training, people constraints, lack of knowledge of portfolio management techniques, lack of resources / poor allocation of resources (human and finance), lack of knowledge to evaluate risks, frequent scope changes (especially in projects), late delivery of projects (which was almost endemic), and lack of cross-functional communication; are the major challenges experienced on the case programme of this study.

Both the interview and the survey data confirm the impact of scope changes, poor planning, and lack of cross-functional communication in the RCP. Going forward, the programme would have to take care of programme alteration and unplanned changes by ensuring that at the implementation phase, all stakeholders reach a notarised agreement concerning project increases, and when major changes occurs, final approval is secured from the DPW (Chen *et al.*, 2013). Concerning communication, a programme management information system should be established to improve information sharing because managers often have to address and supervise a variety of projects at multiple stages within the programme (Chen *et al.*, 2013).

In a related South Africa study, the work of Rwelamila (2007) notes that there are strong indications to suggest that public sector organisations, such as the DPW, lack required project management competencies. Rwelamila (2007) evaluated a public sector programme, and conclude that the programme could be described as a 'white elephant' as it does not have appropriate organisation structure (herein referred to as management structure in this paper), appropriately qualified, and sufficient staff complement to fulfil its mandate. The recommendations of Rwelamila in 2007 found reverberations with this study in that the RCP in its current form will struggle to fulfil its mandate of road improvement in the province successfully without addressing its management structure in terms of competencies, qualification and management system. Similar to the work of Rwelamila (2007), the study affirms the good intentions of the DPW, but the planning and communication gaps would not be overcome without developing a structure for independent inputs, developing middle managers' ability to manage project managers, and also establishing a development programme for core staff members involved in the RCP.

The findings of this study, which resonate with the findings in the literature, demand that the problems in the RCP must be mitigated as Todorov (2014) contends that best project and programme tools and methods are able to positively impact the economic and social development of communities and countries that effectively implement them. Todorov's contention is based on the measureable positive socio-economic benefits that have accrued to Bulgaria through implemented European Union programmes.

CONCLUSIONS

This paper shows some of the challenges inherent in the management of a CAPEX programme at the provincial level in South Africa. The assessment of the RCP

through the lived experiences of actors in the programme confirms that planning and management challenges stalled the progress of the work, albeit at different stages of implementation. The findings inform that proper risk management and adherence to communication plans would better serve the interest of the programme.

The findings thus answered the two research questions mentioned earlier. In particular, the response to the planning question shows that poor plant and material schedules, poor feasibility studies, and poor assessment of risks inherent in the projects constitute major problems of the RCP in South Africa. In addition, decision-making gaps appear to be the major issue in the RCP. Such gaps are due to the lack of capacity and expertise as well as the bureaucratic nature of approval processes found in the client organisation. These gaps respond to the management structure question.

The literature on construction programmes has also highlighted some of the issues uncovered in this particular study. In relation to planning, detailed planning of activities at the programme and project levels should be done to ensure that activities are well defined and scheduled at various stages of implementation. The deployment of resources, human, material and finance, should also occur as planned. Further, programme manager requires the necessary authority to control the execution of the programme, and as such, they should be allowed to attend executive meetings where strategic decisions are made.

Although a single RCP has been examined in this study, similar on-going infrastructure programmes in South Africa should avoid the challenges documented in this paper. There are some limitations associated with this study. One of such limitations pertains to replication. The replication of the suggestions made in this paper would however carry more validity with a future study that addresses more than one CAPEX programme.

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AN EMPOWERED COLLABORATIVE PLANNING METHOD IN A SWEDISH CONSTRUCTION COMPANY - A CASE STUDY

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The construction industry has seen several takes on planning methods, both in theory and in practice. One such initiative is the planning part of the Last Planner System (LPS) of production control, which has both been theorized and implemented at various degrees. However, with new developments in e.g., Building Information Modelling (BIM), it is relevant to study how an LPS implementation can be supported and improved with help of BIM. In particular it is interesting how BIM can be used to facilitate and enhance LPS in the phase planning. Furthermore, it is relevant to explore how BIM can enhance the understanding of the project at hand. For this a study was conducted on how a method inspired by LPS planning currently is applied in one of the larger construction companies in Sweden. The aim of the research is to describe the utilized planning method and explore possibilities to enhance the method. The research was conducted through observations of three full day workshops utilizing the method, complimented with a number of interviews. Strengths and weaknesses as well as its current use were identified and analysed. The observations, interviews and literature confirmed that the method is effective as well as presented indications that the current implementation of BIM in parallel with the method leaves room for improvement.

Keywords: BIM, construction planning, empowerment, information management.

INTRODUCTION

The construction industry is regarded as proficient in planning and scheduling (Zwikael 2009), but still has problems keeping budget and schedule (Christiansen 2012, Zwikael 2009). The literature shows that efforts focus mainly on refining current methods and improving the centralized specialist planner's role in early phases as well as production, meaning that current hierarchical structures are improved and reinforced (Christiansen 2012). Specialist planners base their production plans and schedules on plans formed during the tendering stage which means that assumptions made early in the process become the foundation for later decisions (Winch and Kelsey 2005). To balance this it is argued that the site-manager should take a more active role in planning. But as Winch and Kelsey highlight, there is a divide between interest and competency between the specialist planner and the site-manager. The specialist planner holds a more strategic view spanning several projects. However, the specialist planner lacks the knowledge of the practical work methods, an area in which the site-manager excels. In contrast, the site-manager lacks the time needed to actually perform the planning. The site-manager may also have a shorter perspective, focusing

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foremost on the project at hand (Styhre and Josephson 2006, Winch and Kelsey 2005). Consequently the plans and schedules generated by the specialist planner are often seen as unachievable and used as mere guidelines at the construction site (Winch and Kelsey 2005). One way to gain a better acceptance of the plans is to use inspiration from lean manufacturing such as empowering the workers in the production (Liker 2005). Lean concepts have been adapted through lean construction and over the years, tools has been developed that address the weaknesses highlighted. One of these tools is last planner (Ballard and Howell 2003a). One of the key aspects in last planner is the fact that the detailed planning is postponed to the last possible moment. The planning is performed by the last possible person responsible for the work, hence the name last planner. This clearly exemplifies one kind of worker involvement and empowerment. But to fully gain the benefits of empowerment the reasons for being empowered needs to be understood and accepted by the workers (Dainty *et al.* 2002). When the actual stakeholders participate, the effect of their involvement gives higher quality input and better decisions in the planning processes. Especially since they bring tacit knowledge of the processes that seldom is transferred in any other way than by person to person, thus contributing with the right information at the right time (Büchmann-Slorup and Andersson 2010).

Apart from this, the literature also shows that there is a theoretical support for Building Information Models (BIM) enhancing lean concepts, and that BIM has the potential to support and enhance the implementation of Lean in construction (Sacks *et al.* 2010). One such enhancement in Sacks *et al.* (2010) is the visualization of BIM coupled with schedules, also known as 4D. In fact, Formoso *et al.* (2002) conclude that visual communication increases understanding of problems and participation of workers. However, the literature also shows that most implementations of 4D software today do not support work methods in their current form. Instead, there is a need to adjust work methods and processes to fit the tools, creating a technology push. This push hinders the use of the tools, since the time to learn new tools is not available in projects at the construction site. To address this, a tool should be adjusted or developed through current processes. By enhancing the processes the tool would create a demand, a technology pull, and thus a greater adoption (Hartmann *et al.* 2012).

This research focuses on the use of an empowered collaborative planning process at a Scandinavian contractor 'ConstructionCo'. The main aim of this research is to describe the usage of the method and study the interaction with BIM during the use of this planning method. The second aim is to explore possible areas of enhancements of the method. Thus the research questions are:

1. How does the used planning method relate to last planner?
2. How are the benefits of collaboration visible in the planning?
3. How is BIM used in the planning method?

LITERATURE REVIEW

The construction industry is generally viewed as a complex industry due to the great number of actors participating in a project. This can be traced to the high specialisation in separate trades resulting in complex work-site organisations. The complexity introduces uncertainty and to handle this uncertainty production control is introduced through planning (Dvir *et al.* 2003). Spending time on planning prior to the work on-site commences has been shown to be beneficial. The effects are shown as increased effectiveness in terms of better quality of the plans, as well as better-utilised

time and lower costs tied to planning (Faniran *et al.* 1994). It has also been argued that to increase planning effectiveness, goals as well as functional requirements of the project need to be clear as early as possible. This means that an early and continuous involvement of the end-user is critical throughout the whole construction process (Dvir *et al.* 2003). Research into the field has focused on effectiveness of the planning, but not as much into what the planners actually do (Winch and Kelsey 2005). Laufer and Tucker (1988) points out that planning is often done utilizing a specialist planner, with the rationale to reduce costs for planning (Faniran *et al.* 1994). This is criticized by Winch and Kelsey (2005) due to the fact that specialist planners can only plan to a certain level of detail due to lack of practical knowledge. To increase precision in the planning, the planners research and gather information to form better decisions. This is a time intensive task for the planner (Winch and Kelsey 2005). As a counterpart to this, the literature argues that the use of decentralization reduces planning time and increases planning effectiveness. This implies that worker involvement is beneficial.

In fact by decentralizing the planning, the one actually performing the work can contribute directly to the planning, which reduces guesswork in the planning process originating from poor knowledge of the practice of certain work-methods (Dvir *et al.* 2003, Faniran *et al.* 1994, Laufer 1992). From a more general perspective of the construction industry, it is concluded that employee empowerment is largely overlooked or ignored. This could perhaps be due to the hierarchic structures that are prevalent in the construction industry. The fact that empowerment could help counter the negative effects of the fragmented structure of the construction industry has been shown through increases in productivity and job satisfaction (Dainty *et al.* 2002, Greasley *et al.* 2005). Empowerment and involvement is a vital part in lean manufacturing and especially in Toyota's Production System where people and teamwork are central for reducing waste and increasing quality (Liker 2005). The construction industry has approached lean through the adaptation of lean construction and this has resulted in tools such as the Last Planner System of Production Control (LPS) (Ballard and Howell 2003b, Fernandez-Solis *et al.* 2012, Hamzeh and Bergstrom 2010). In LPS, planning is broken down into different detail-levels of schedules, matching the available information in different steps (Hamzeh and Bergstrom 2010). Through the use of detail-levels the schedule gets gradually refined. The closer a task is being performed, the more detailed the schedule becomes. This ensures that the schedule is easy to maintain and update at each given moment, while at the same time keeping the schedule detailed enough. The main difference from the traditional process is that detailed planning is postponed to the last possible moment. At this moment the person responsible for conducting the work does the detailed planning (Ballard and Howell 1998).

In parallel with Lean construction the rise of BIM has been seen as an opportunity to achieve a more integrated design and construction process (Eastman *et al.* 2009). Furthermore, Sacks *et al.* (2010) describes a framework comparing the principles of lean construction with BIM functionalities, concluding that several BIM functionalities directly support lean construction concepts. As such BIM and lean construction probably could benefit by parallel implementation (Sacks *et al.* 2010). Apart from carrying the information needed in the planning process, the BIM also helps in communicating up and down the organizational levels. Thus ensuring that what is being planned actually is what is being built (Büchmann-Slorup and Andersson 2010). The inherent fact that BIM builds upon digital information leads to

the tools used to consume and display the models. The digital planning tools available today mostly focus on making a more effective planning process in the traditional form. Some research has looked into how the planning could be automated, either partially or fully. However, this has received criticism since it creates a sort of 'black box' planning, where the human planner loses some control over the decisions (Waly and Thabet 2003). Waly and Thabet (2003) conclude that automation of planning decisions is undesirable and that the virtual construction environment should support the human planner in the decision-making process rather than disconnect him/her. In other research the models and schedules are merged into simulation files, but they could hardly be called planning tools since they need the plans to be constructed (Waly and Thabet 2003). In general these planning systems often prescribe planning being done in one software program and then connected to the BIM elements in another software program (Eastman *et al.* 2009). Furthermore, the new possibilities with the advent BIM have resulted in the models being pushed to the work-site without the regard of how they should be used and implemented in current workflows. This combined with new tools that do not support current work processes has led to the fact that adoption rate of the technology on-site is poor. Both these directions demonstrate a technology-centred focus rather than support for current practices. This type of development could be interpreted as technology push (Hartmann *et al.* 2012).

Summarizing, planning is used to decrease uncertainties, but the use of specialist planners distances the planning from the workers. Research has focused on planning effectiveness rather than viewing planning as an action, thus increasing the distancing of planners from the actual workers. Studies show that BIM could help remedy this distance by acting as a communication and information carrier, but the tools that are currently available do not fully support this.

METHOD

The research was conducted as a single case study complimented by initial interviews and a literature review. The research was divided into four stages. First, the literature review followed by the interviews as the second stage. These two stages served to gain background knowledge of general theories in planning and scheduling as well as knowledge of how people participate in the planning approach. The third stage included observations of the case study workshops in practice. This then led to the fourth stage, the analysis and comparison of the observations with the literature. The reason for the initial interviews were to identify how each of the sub-contractors in general approached planning of their activities, both in terms of information gathering and information processing during their planning process. The interviews were conducted as semi-structured interviews, allowing for some elaboration of details while still receiving a baseline of information among the sub-contractors. Since the project that was to be studied had not started, the interviews were held with personnel not connected to the actual case study, but involved in a similar project. The interviews were conducted with seven interviewees during one-hour interviews, which were recorded and later transcribed in verbatim. The interviews were held on-site with one worker from the prefabrication sub-contractor, two workers from the ventilation sub-contractor, one from the plumbing sub-contractor, two from the sprinkler sub-contractor, one from the electricity/safety sub-contractor and lastly one from the site supervision. An additional interview with the specialist planner behind the workshops, called Location-based Production Planning (LPP), was conducted off-site in order to understand the background of the planning method. The main stage of the research was the observations of the LPP-method, conducted in two out of three possible

workshops. The workshops were conducted as business-as-usual; the corresponding author had the possibility to participate in the daily businesses. The main objective was to observe and record the LPP-method in action. The participation enabled a deeper insight in how the method and workshop interacted. The corresponding author had a role as the model-navigator, because the intended model-navigators of the case ConstructionCo could not participate. The corresponding author introduced himself as a researcher with knowledge in the field of BIM-models and visualisation and was accepted without further questions. The workshops were documented through field-notes after each workshop. These notes together with the interviews were then coded through open coding, gathering significant keywords that pointed at key categories forming themes of interest (Flick 2009). The categories of themes found were; participation, information gathering, navigation, communication and technology. These were used to connect results to the literature.

Research case study

ConstructionCo is one of the leading construction companies in Sweden and Scandinavia, working with everything from infrastructure to housing and commercial properties. In a few projects a new collaborative planning method has been introduced and used during the last couple of years. This system for phase planning in the pre-construction stage has been successfully used in a series of similar projects conducted throughout Scandinavia. The system was put into place by one of the specialist planners at ConstructionCo, in an effort to counter the mistrust in the schedule, as it exists in projects today. The method strives to involve all actors with interest in the process in the planning and scheduling of the construction. The planning method differs from the traditional process in such a way that each sub-contractor has a representative, usually the supervisor or senior fitter, attending. In general the method could be illustrated as consisting of at least two workshops, one for the assembly of the construction schedule, and one for the adjustment of the schedule, with the digitalization of the schedule in between these workshops. Two main points are important in these workshops, the creation of activities by the participant and the collaborative sequencing of these activities. Each participant is responsible to plan and schedule quantity take-offs (QTO), resources and durations for every activity they are responsible for. These activities are then sequenced in a collaborative way where all participants partake.

Currently, five projects have been conducted with this LPP-method. All of the projects have been shopping centres throughout Scandinavia. The project studied in this study was situated in southern Norway, with ConstructionCo as the main contractor. The project was fully modelled in BIM software, but each discipline used different software programs, ranging from AutoCAD, MagiCAD and Revit to Tekla Structures. Thus the models were exchanged and coordinated in Solibri Model Checker (SMC) through the neutral file format IFC. Few of the participants were familiar with SMC, thus there was a need for a model-pilot when BIM was to be used. The workshops in this project were actual working workshops, conducted as usual in a conference room at ConstructionCo, with current architectural drawings, specifications and other documentation relevant for the project fastened on boards hanging on the walls of the room. As a compliment, two boards with the building subdivided into sub-zones and levels were present along with a coordination BIM-model projected on one of the walls in the model review-software Solibri Model Checker. All in all, the workshops had on average 16 participants, in which the client was represented as well as at least

one person from each sub-contractor along with ConstructionCo own site-supervisor and the specialist planner.

RESULTS

ConstructionCo has implemented a new way of conducting planning in a more collaborative way called LPP. The specialist planner behind the idea describes that the traditional planning process consists of the site-manager planning a schedule and then tries to sell this plan to the subcontractors and other consultants. The “buy-in” of the subcontractors and consultants is hard to get, and often the schedules are used only as loose guides at best. The LPP-method was introduced to mitigate this and to have all actors involved in the planning process. The fact that all actors are involved in the development of the schedule implies that there is no need for promoting and selling the schedule. The participants agree to the schedule at the workshop. This results in a transparent and open planning process where each of the consultants and subcontractors has their say in the timing and planning of their work. The specialist planner mentioned that experience from earlier projects that have applied this method is that there is less re-scheduling due to a greater “buy-in” and understanding of each contractor’s role in the production. The specialist planner said:

“...Even though all actors in the production are gathered one or two times for the full day workshops, less time is spent on planning. It is also done with greater accuracy due to the practice knowledge put in by the participants...”

The specialist planner further identified two main areas of improvement (1) the BIM model was not used successfully; (2) the lead-time from the planning to the digitized schedule is too long. In total, the specialist planner has seen that his time spent on each project decreases as the reworking of the schedule is reduced.

The results of the interviews showed that the sub-contractors and the site manager in general receive their information and QTO from the descriptions and drawings they are supplied with. Furthermore, the interviews showed that different information was needed, depending on where in the building process the sub-contractors were active. The prefabrication sub-contractor needed little information from other actors. The information that they would like to have, but seldom received, was to which degree their building parts were to be visible. As they reasoned the precision of the fitting of their parts could be lowered if the parts were not supposed to be exposed and visible. Another notable insight was from the ventilation, plumbing and sprinkler sub-contractors, they used both their own documents as well as coordination drawings to gain the position of the other disciplines building parts. They noted that they seldom received the section drawings they wanted, with the argument that it was too expensive to produce them. Finally, the electrician concluded that since his discipline often was the last one in the process, he needed few of the others drawings, this was due to the fact that he had to adjust his parts to what was already built anyway. In general, the sub-contractors had heard of BIM but did not use it. Some of the sub-contractor saw benefits with BIM, such as that they with some help could have views and 3D-pictures of areas they were missing adequate section drawings for. This was especially true for the sub-contractors that had a high degree of coordination between disciplines.

The workshops

The main reasons for the workshops were to collaboratively accomplish a rough plan, corresponding to a more detailed phase schedule with locations. The general layout of

the workshops was a short presentation of each participant and their role in the project, after this a short walkthrough of the project was conducted, explaining the division in zones on each floor. The specialist planner had identified that the time for the first workshop was going to be scarce, so the zones of the building were prioritized according to the importance of completion. After the walkthrough, the workshop was divided into individual work where each actor listed his/hers activities in each zone and each of the activities were specified on sticky notes. Most of this work was done individually, but as questions of certain aspects of work relating to other sub-contractors work rose, the possibility to gain instant feedback and clarification led to a high degree of interaction between the participants. When all activities were specified, the collaborative planning commenced. The zones were planned in order from the most to the least critical. This meant going through each participant and sequencing their work at each given location, thus manually assembling the project through the sequencing. The sticky notes with the activities were arranged with dependencies on large pieces of paper sheets. After the sequencing a second walkthrough followed, this time going through the activities in the order planned. The manually assembled schedule was then digitized by the specialist planner in a planning software program and sent for review to the participants of the workshop. The second workshop was initialized because not all sub-contractors could participate in the first workshop, thus the full plan could not be assembled. This made room for some reviewing of the schedule from the first workshop. The first part of the second workshop was spent going through each of the zones such as they were planned at the last workshop, both as a recap and as an orientation for the contractor that did not attend the first workshop. After each zone had been reviewed, the contractor that missed the first workshop was allowed to plan his activities, while the rest of the actors added missing activities and adjusted already specified activities. The second workshop ended with a walkthrough similar to the one in the first workshop. The third workshop was centred on the agreement of the schedule; once again the model was walked through, but this time with the schedule as the focus.

Some general observations from the workshops were that most contractors were familiar with the way the workshops were conducted, since they had worked together on similar projects that also applied the LPP-method. The ones not familiar with the method were instructed and understood the method and its meaning fairly quickly. Another observation was that due to the fact that the zones were planned in order of complexity, it was hard to identify where each zone was situated in the model, as there was some crisscrossing during the walkthrough through the model. This even led to some activities being missed altogether, as mentioned above. The orientation problem became especially apparent when the actors tried to follow along on their plotted drawings in parallel with the BIM on the big screen. An overview of the different zones was plotted, but as it hung on a wall besides the big screen, some of the participants had a hard time to see and read it. At the second workshop it was concluded that it would probably have been easier to go through each zone in sequence of their respective location, thus virtually walking through the model, since some connections had been missed in the first workshop. The specialist planner stated that the crisscrossing in the model probably resulted in these missing connections. Even though the problem with following the BIM model, the use of the model contributed to a better understanding of the building. This was exemplified by the comments and questions around certain solutions that could be clarified during the workshop. It was also observed that the collaborative planning and the workshops helped bring the team together. This was especially true for those that had performed a

couple of projects together. This showed that the planning method helped the team bond as well as produce a mutually agreed-upon-plan. The collaborative planning technique and the use of the BIM helped to further the collective understanding. A final reflection from the workshops was also that the participants mentioned that the likelihood that they would pick up their phone and call one of the other participants if questions rose increased since they all had met a couple of times, thus lowering the barriers of communication.

DISCUSSION

The aim of the paper was to describe the use of a collaborative planning method as well as to study the interaction of BIM with this planning method and if BIM could enhance the understanding of the planning being conducted. The major findings are presented below.

LPP - A truly empowered collaborative planning process.

This research primarily contributes with a description of an implementation of an empowered collaborative planning method. The observations of the LPP-method workshops showed that interaction between participants was high and that questions were clarified almost instantly. The method of manually assembling the building activity-by-activity as well as location-by-location ensured that all sub-contractors were on the same page, this supports the fact that communication is enhanced (Büchmann-Slorup and Andersson 2010). From the interviews it was found that involvement reduces the time spent on re-planning supports the claim that involvement is critical (Dvir *et al.* 2003). The involvement also enables the participants to adjust and contribute to the schedule before they accept it.

As stated during the interviews, the workshops saved overall time spent on planning. The gathering of sub-contractors for a couple of full days may initially appear time consuming but the results show that it is well invested time for both the sub-contractors as well as the planner. This further supports that engaging the right persons at the right time reduces the need for guesswork in areas where the specialist planner may lack knowledge (Dvir *et al.* 2003). It also saves time spent on gathering information trying to remedy the lack of practical knowledge. The combined use of a big screen and physical drawings resulted in apparent confusion of which zone were being planned at the moment. Finally, the workshops showed that the gathering of all sub-contractors and other stakeholders in the production meant that the workshops functioned as a team building activity. The gathering of all key participants contributes to forming team relations early in the project, thus lowering the barriers for communication. The LPP-method has similarities with LPS-method, in that the persons closest to the actual execution of the activity are the ones responsible for the planning (Ballard and Howell 2003b). Thus the method could be seen as implementing a sub-set of LPS since it mainly focuses on the phase planning. The utilisation of the foremen and leading fitters of the sub-contractors can be argued as a way to empower the workers and gain a general agreement of the plan and schedule. Thus the kind of empowerment observed in the LPP-method is supported by literature (Dvir *et al.* 2003, Faniran *et al.* 1994, Laufer 1992). The observed empowerment also shows that the benefits stated by Dainty *et al.* (2002) can be realised.

BIM – Still has weaknesses in implementation.

The second contribution of this research is the observations of how BIM is implemented in production planning. The interviews showed that the general BIM

knowledge with the workers in production is low, they had heard of it, but lacked practical knowledge in the tools. However, as stated in the interviews, even though the BIM model helped the workers to understand the work they were about to perform and plan it was not used to its full potential. The problem in the workshops was the barrier formed by not being able to fully navigate in the model. This could be related to the order of which the zones were planned, but also to the fact that the zone division was not clear for the participants since it was not visible in their plotted drawings. The mixed use of plotted drawings and the 3D model could also have contributed to the difficulty of following along. This obviously hampered the BIM's ability to enhance the understanding of what was being planned, but it is not comparable to the use of no BIM at all. The observations still support Büchmann-Slorup and Andersson (2010) in that BIM enhances communication throughout the organization, at least with regards to the on-site organisation. The use of the sticky notes on paper sheets are an effective low-tech approach to have the parties involved in the planning, but it still leaves room for improvement. Few tools for collaborative co-location planning exist and as stated earlier these are more geared towards traditional methods. The LPP-method as described in this research shows that its needs differ from the way traditional tools have been implemented, where they pair the BIM and the schedule after the plan has been established (Eastman *et al.* 2009). The observations in both the workshops and the interviews lead to the conclusion that the BIM should be able to be at the centre of the planning process. This warrants further investigation of how the planning with the help of BIM could be implemented and is supported by the statement by Hartmann *et al.* (2012) that existing processes should be aided rather than replaced.

CONCLUSIONS

This research shows that the method introduced by ConstructionCo is theoretically supported both in the general planning method as well as in the philosophy of empowerment and involvement. The method is described and documented in this research and through this the benefits of collaboration and involvement are visible. The similarities with LPS suggest that the benefits gained in LPS also are transferrable to LPP. Furthermore, strengthen the observations of LPP the contribution of LPS to the field of planning research as it shows a successful use of an LPS inspired planning method in practice. The use of BIM in the method in the observations were disappointing, the model tried to act as central medium, but the sub-contractors reliance on their plotted drawings hindered an effective use of the model. The greatest obstacle was the lack of orientation, stemming from the fact that they tried to map the location of the BIM on the big screen to where they were in the plotted drawings in front of them. Topics to explore in the future may be the interaction of BIM on big-screen with multiple users in planning and scheduling environments, possible enhancements of the activity of sequencing activities, as well as further observations of the VPP-method in different settings, especially in other types of projects.

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A FRAMEWORK OF TOTAL CONSTRAINT MANAGEMENT FOR IMPROVING WORK FLOW IN LIQUEFIED NATURAL GAS CONSTRUCTION

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In complex and concurrent construction project, numerous constraints which come from engineering, supply chains and construction work face are the main factors affecting plan reliability. Effective management of these constraints is critical to improve planning reliability and work flow. However, current constraint management approach is very fragmented and heavy relies on human's commitments and static data in constraint identification, tracking, assessment and removal. To tackle this problem, this paper proposes a framework of Total Constraint Management (TCM), which possesses four superior characteristics including: (1) collaborative constraint identification; (2) real-time constraint status tracking; (3) dynamic constraint removal; and (4) visual constraint representation. Advanced technologies, such as Building Information Modelling, barcode, and Radio Frequency Identification, are discussed to enable TCM implementation in practice. A controlled experiment was developed to demonstrate and evaluate the framework. The results showed that successful implementation of TCM could significantly improve plan reliability and construction productivity.

Keywords: planning reliability, total constraint management, work flow.

INTRODUCTION

Australia has benefited and will continue to benefit significantly from Liquefied Natural Gas (LNG) investments underway. Global Demand Forecast for LNG is 470 million tonnes per annum by 2030, which means more than 200 million tonnes in new capacity will be needed. However, rising costs in Australia mean this country risks pricing itself out of the global LNG market. For instance, current Australian project costs of LNG construction are typically 2-3 times higher than for other countries. Reliable construction plans are vital for effective collaboration across design, procurement and construction so as to reduce schedule delay and cost overrun. Numerous constraints which come from engineering, supply chains and construction work face are the main factors affecting plan reliability.

Lean construction, which comes from lean production philosophy, is a new approach to design construction systems to facilitate material and information flow, thereby minimizing waste of materials, time and effort, and improving productivity (Koskela 1992, 2000). In order to implement lean concept in practice, three different types of methods had been developed to improve construction work flow in LNG construction: Last Planner System (LPS), WorkFace Planning (WFP), and Advanced Work Packaging (AWP).

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LPS is a production planning and control tool developed to increase the reliability of planning and thereby improving construction performance (Ballard 2000). In essence, LPS enables the collaborative management of the network of relationships and communications needed to guarantee effective programme coordination, production planning and project delivery (Ballard 2000, O. Alsehaimi, Tzortzopoulos Fazenda and Koskela 2014, Priven and Sacks 2015). The process of removing constraints within LPS is sluggish and negative, such as late implementation of constraint analysis and short lead time for constraint removal (Hamzeh 2009). Another problem is that constraints which have a lead time beyond the weekly work plan window are not identified and removed in time due to poor foresight capacity of the look ahead plan (Hamzeh 2009).

Nieto-Morote and Ruz-Vila (2012) had applied LPS in a chemical plant construction. For each week, a list of constraints was identified, and, after the second week, the constraints were classified as actions or no actions. Project leaders would only be given constraints classified as actions. Two conclusions related to constraint analysis were made: (1) identifying constraints of the planned work had a positive impact on the percentage and quality of completed activities; and (2) the process of constraint identification should be conducted by all of the project leaders, supervisors and contractors. Another action research had been conducted by O. AlSehaimi, *et al.* (2014) in two large state-owned construction projects. The findings identified benefits of LPS including improved construction planning, enhanced site management and better communication and coordination between the parties involved. They also described barriers to release the full potential of LPS, including lengthy approval procedure by client, cultural issues, commitment and attitude to time, and short-term vision.

WFP developed by Constructions Owners Association of Alberta (COAA), is the process of organizing and delivering all elements necessary before work is started, to enable craft persons to perform quality work in a safe, effective and efficient manner (Slootman 2007). The main objective of WFP is to reduce schedule and cost overrun, and improve labour efficiency in mega project (Fayek and Peng 2013). The deliverables of WFP are three different levels of work packages: Construction Work Area (CWA), Construction Work Package (CWP) and Field Installation Work Package (FIWP) (Ryan 2009). Each package cannot be released until all the related constraints are removed. Examples of constraints for work packages are: drawings, workforce, materials, equipment, work space, permission and a scope definition of the work package to be executed. However, the constraint removal process of WFP has three shortcomings: (1) short time for planners to optimize scarce resources; (2) negative attitude for constraint removal due to the lack of constraint tracking, and (3) limited understanding of identification and classification of the full range of constraints.

AWP is developed by a joint venture between the Construction Industry Institute (CII) and the COAA, which aims to align engineering, procurement and fabrication with the sequencing needs of site installation and turnover to operations (Hamdi 2013). AWP is a more complete work packaging system than WFP. It covers not only construction but also the early stages of project and adds to the system more control over the breakdown of the project through its lifecycle (Hamdi 2013). The three key deliverables of AWP are CWP, Engineering Work Package (EWP) (Hamdi 2013) and Installation Work Package (IWP). Regarding constraint removal within AWP, although the scope of constraints is extended to engineering and procurement when

compared with WFP and LPS, the constraint removal process within AWP is still similar to WFP, and has the same shortcomings.

Four case studies of WFP or AWP application were conducted by CII and COAA (2013) so as to summarize their benefits, difficulties and lessons learned. Four main benefits were identified: low employee turnover, safety performance improved, lower weld reject rates, and fewer changes during execution. Two difficulties were found: lack of management buy-in, and paper IWP management system. Five lessons were learned: IWP benefits, IWPs development and support, electronic IWP management, constraint analysis, and integration of IWPs into engineering. Regarding constraint management and removal, total constraint analysis was strongly recommended to perform because currently, only the basic constraints—e.g., critical material availability and engineering completion—were monitored prior to IWP release.

In order to address these shortcomings within constraint removal, this paper developed a framework of Total Constraint Management (TCM) to improve plan reliability and construction work flow by synchronising the concepts of strategy-pull and technology-push. The proposed TCM consists of three main parts: constraint modelling, constraint tracking and constraint removing. In the modelling phase, project constraints are identified, classified and structured; in the tracking phase, a streamlined tracking process is developed to assure the real-time updating of the status of constraints; in the removing phase, different types of constraints are removed according to different removal strategy.

FRAMEWORK OF TOTAL CONSTRAINT MANAGEMENT

This section describes a framework of TCM for improving work flow in Liquefied Natural Gas (LNG) construction (as shown in Figure 1). On the top of the Figure 1, eight phases of LNG project lifecycle are listed in sequence from asset definition to decommissioning. Under the line of the project phases, process of TCM is developed which consists of six sub-processes: constraint identification, constraint-removal planning, constraint tracking, constraint removal, constraint status updating, and implementation. Each of them is explained in detail as follows.

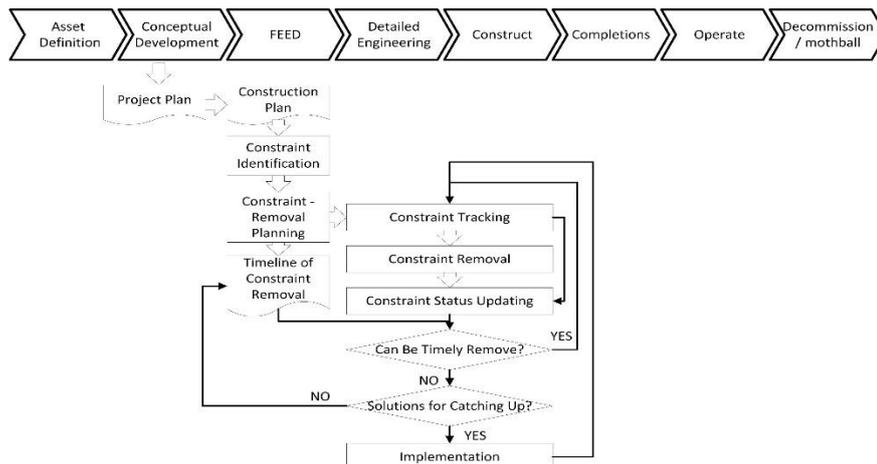


Figure 1: Framework of total constraint management

Constraint identification

LNG construction is very complicated. Numerous constraints comes from engineering, supply chains, onsite and offsite fabrication, and construction site.

Constraint modelling is a key step to enable project partners having a thorough understanding of interconnections among activities.

Traditional approaches for constraint identification are heavily rely on human's knowledge and experience. Moreover, only basic constraints are taken into consideration. In order to conduct a full constraint identification, three tools are developed: (1) constraint checklist. All the constraints are classified into three main categories: engineering, supply chains, and construction. Engineering constraints include drawings, specifications, instructions and plans. Supply-chain constraints consist of materials, equipment, and onsite and offsite fabrication. Construction constraints contain predecessor works, safety and health, work permits, temporary structures, weather conditions, workforce, construction machinery, tools, workspaces, and storage spaces; (2) Constraint relationship model. In real project situation, constraints are not independent. There are lots of connections among constraints. For instance, activity A has seven constraints which named from A1 to A7, activity B also has seven constraints which named from B1 to B7, if activity A is the predecessor work of activity B, the constraints A1-7 will have a connection to constraint B1-7; and (3) Virtual simulation, which is used to evaluate the completeness and correctness of the constraint relationship model.

Constraint-removal planning

After sub-process of constraint identification, timeline for each constraint removing need to be generated. There are two main tasks needed to be implemented during constraint planning. The first one is constraint-relationships modelling. For each construction work package, there are more than ten constraints need to be removed before releasing. These constraints are not independent and have inter-relationships among each other. Hence, having a thorough understanding of these constraints is very useful for constraint removing. The second one is deciding deadline of removal for each constraint so as to assure construction work flow and reduce time overrun.

Constraint tracking

According to the types of the constraints, different tracking processes are developed to assure the real-time monitoring requirement. There is a need to streamline the constraint tracking process by investigating: (1) the persons who are responsible for managing these different constraints; (2) the frequency of updating the constraint by the persons who are in charge; and (3) the correct ways that the updated constraint should be reported. An effective integration of virtual models and the physical construction has important implications for constraint tracking (Akanmu *et al.* 2014). A number of data acquisition technologies can be utilized in integrating virtual models and the physical construction including barcodes, wireless sensing technologies, photography, 3D laser scanners and photogrammetry (Akanmu *et al.* 2014).

Constraint removal

Constraint removal mainly executed in the stage of the four-week look-ahead planning. Constraints which have already satisfied the removal criteria or can satisfy the criteria based on forecasting, will be removed. The former one is named directly removal, the latter one is called indirectly removal.

Constraint status updating

In real LNG construction situation, the status of constraint is changed over time. The latest constraint information is very important for decision-making and constraint-free

work releasing. According to different tools for constraint tracking, the way of constraint status updating can be concluded into three types: automated, semi-automated, and manual updating.

Implementation

In real project situation, there are lot of uncertainties impact the constraints being successfully removed. When we find some constraints cannot be timely removed, solutions need to be proposed to catch up the overall progress. For example, constraints like predecessor-work delay that can be timely removed by assigning extra resource. After the solutions approved, we need to implement our ideas and evaluate the final performance.

INCORPORATING EMERGING TECHNOLOGIES INTO THE PROPOSED FRAMEWORK OF TCM

In recent years, emerging information technologies have demonstrated their capabilities in improving performance of project management. This section discusses three technologies: Building Information Modelling (BIM), barcode, and Radio Frequency Identification (RFID), and how they can be incorporated into the proposed framework of TCM.

BIM for constraint identification and removal planning

BIM is emerging as a method of creating, sharing, exchanging and managing the information throughout life cycle between all stakeholders (Eastman *et al.* 2011, Pour Rahimian *et al.* 2014, Wang *et al.* 2014). A 4-Dimension (D) model results from the linking of 3-D model to the fourth dimension of time. In the 4-D model, the temporal and spatial aspects of the project are inextricably linked, as they are during the actual construction process (Koo and Fischer 2000). Previous research had demonstrated significant benefits of BIM for project collaboration, design decisions-making, project constructability assessment, space constraint identification and so on (Mahalingam, Kashyap and Mahajan 2010).

With the help of BIM, project team can easily simulate overall construction process before field construction, and identify constraints based on the logic of the project schedule. In addition, some hidden constraints such as time-space conflicts and accessibility issues can also be detected through 4-D simulation. In addition, BIM provides a collaborative platform for project team to share their knowledge and experience so as to improve the performance of the process of constraint identification.

BIM is also useful for constraint-removal planning. Within BIM, internal relationships of constraints can be visualized and further checked by project team. Moreover, the reasonability of timeline for constraint removing can be also validated in BIM.

Integration of barcode and RFID for constraint tracking and status updating

Barcode is an automatic identification technology that streamlines identification and data collection, and the technology of barcode has been applied to construction industry since the late 1980s, such as warehouse inventory management, field material control, site equipment management, and construction document management (Hong-Ying 2009, Li, Chen and Wong 2003). RFID uses radio frequency waves to transmit data between readers and tags. A typical RFID system includes an antenna, a transceiver (RFID reader) and a transponder (Radio Frequency tag). The antenna generates an electromagnetic zone where the tag detects the

activation signal and responds by sending the stored data from its memory through radio frequency waves. RFID has recently attracted significant attention in construction areas such as material tracking, quality control, equipment monitoring and inspection, and asset maintenance (Hinkka and Tätilä 2013, Shin *et al.* 2011, Wang, Lin and Lin 2007).

Automated constraint tracking and status updating can significantly improve construction work flow and site productivity. Bar coding is widely used for tracking purpose during material fabrication stage while RFID focuses on material transportation from vendor sites to site storage locations to the final installation locations at the workforce with GPS integration. Comparing with the traditional labour-intensive approaches, barcode and RFID can significantly improve the quality of constraint monitoring, and reduce the time.

With the increasing level of competition in the global LNG market, worldwide supply chain management become critical to project success. Therefore, integrated approach of barcode and RFID can provide real-time constraint tracking and updating, which is very useful to facilitate TCM implementation in practice.

VALIDATION

In practice, it is difficult to have access to construction sites and their facilities due to confidential issues and safety concerns. Therefore, it is not quite feasible to choose a real construction project to implement the proposed framework of TCM. In this study, a laboratory test was developed and implemented based on the LNG lean construction simulation game (as shown in Figure 2) to test and validate the framework of TCM. A hypothesis was developed for the experiment: Successful implementation of TCM can improve plan reliability and construction productivity. The validation of the emerging technologies mentioned above was not included in this paper.

The objective of the simulation game is to build an LNG train. The construction tasks consist of: site preparation, module installation (the modules are manufactured off-site), pipework installation, wiring installation, and major equipment installation. Finally, the LNG train need to be commissioned by testing for correct operation.



Figure 2: the LNG lean construction simulation game

The human subjects were graduate students and teachers from a wide range of backgrounds such as computer science, construction, mathematics, architecture, and engineering. Although most of the participants had no experience of construction management, site installation, and isometric drawing, they were all trained to understand the rules of the lean game. The age range of the research students was set

as 15 years, which included young adults and mature adults. Meanwhile, there were both male and female subjects, which align to the real project team.

Experiment design

Two groups were selected to implement the experiment: A and B. The formal one applied TCM and the latter one not. There were 18 volunteers in each to perform all the roles in the simulation. Table 1 showed the roles of the people in the game. There was a basic training session for the both groups before the real test.

Table 1: The roles of the people in the game

Roles	Quantity
Project Manager	1
Plant Manager	1
Site Manager	1
Module Manufacturing	6
Civils Contractor	2
Mechanical Contractor	1
Pneumatic Contractor	2
Electrical Contractor	1
Major Equipment Installation	1
Shipping	1
Commissioning	1

In order to make the simulation game more close to the real environment, different types of interferences were added during the execution. Table 2 showed the interferences for different construction tasks.

Table 2: The interferences for different construction tasks.

Construction tasks	Weight for construction progress calculation	Interferences
Site preparation	30%	Bad weather
Off-site module manufacturing	10%	Design change
Module installation	15%	Quality unqualified
Pipework installation	28%	Material shortage
Wiring installation	10%	Labour shortage
Major equipment installation	5%	Late delivery of the equipment
Commissioning	2%	Delay of the work permit

Development of Key Performance Indicators

Two main indicators was developed to cater for TCM evaluation. The first one was Cumulative Progress (CP), which could be an indicator of actual progress. The second one was Total Construction Time (TCT), which could be used for measuring construction productivity.

Data collection and analysis

Initially, the performance of group B was measured by CP and TCT. An array of data was set up as the baseline. Next, the proposed TCM method was implemented by group A in the same experimental condition. Therefore, after the experiments, the performance data of the two groups were able to be compared so as to quantitative measure the benefits and improvement. All the data from the experiments was

collected by dedicated recorders. Figure 3 showed the execution of the simulation game.



Figure 3: Execution of the LNG lean construction simulation game

Table 3 showed the final results. Group B took 53 minutes to finish the whole construction without TCM implementation. When compared with Group B, Group A only took 31 minutes, which meant 28% of TCT was reduced.

Table 3: results of the experiment

Groups	TCT (minutes)	CP1 (in the first ten minutes)	CP2 (in the second ten minutes)	CP3 (in the third ten minutes)	CP4 (in the fourth ten minutes)	CP5 (in the fifth ten minutes)
Group A	31	21%	63%	95%	100%	
Group B	43	16%	47%	71%	92%	100%

CONCLUSIONS AND FUTURE WORK

This paper developed a framework of Total Constraint Management (TCM) to improve plan reliability and construction work flow by synchronising the concepts of strategy-pull and technology-push. The proposed TCM consists of six sub-processes: constraint identification, constraint-removal planning, constraint tracking, constraint removal, constraint status updating, and implementation.

BIM was discussed to enhance constraint identification and the development of constraint-removal planning. Barcode and RFID were proposed for providing an integrated solution for real-time constraint tracking and status updating.

A controlled experiment devised to assess the discrepancies between the traditional method and TCM was undertaken. Results from the experiment indicate a positive effect of facilitations when implementing the framework of TCM in the LNG lean construction simulation game. The findings showed: 28% of TCT was reduced by Group A as compared with Group B. The successful implementation of TCM could significantly improve plan reliability and construction productivity.

Field Test is a validation method that brings proposals into the “real world” to assess performance (Bernold and Lee 2010). When compared with laboratory test, field test requires not only an upgrading of prototype design, in order to facilitate operation by field personnel, but also the thorough understanding of field practice (Bernold and Lee 2010). Future work will hopefully lead to the implementation of the TCM into a real LNG construction project. The real improvements in performance and productivity with TCM can then be measured and quantified in a real project context. In addition, another two experiments will be developed to measure the performance of BIM for

constraint identification, and integrated solution of barcode and RFID for real-time constraint tracking. Australian LNG industry will benefit from this effective solution to mitigate the significant cost and schedule overruns in resource projects, particularly in mega-projects.

ACKNOWLEDGEMENT

This research was undertaken with the benefit of a grant from Australian Research Council Linkage Program (Grant No. [LP130100451](#))

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AN APPLICATION OF VALUE STREAM MAPPING FOR TURNAROUND MAINTENANCE IN OIL AND GAS INDUSTRY: CASE STUDY AND LESSIONS LEARNED

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Turnaround maintenance (TAM) in oil and gas industry concerns significant endeavours that deal with inspections, scheduled cleaning, adjustments, repairs and replacements of part of a plant to ensure operational reliability. It involves labour and material-intensive activities, thus is of the essence to minimize the financial impact. However, relevant research revealed that current process improvement strategies for TAM are random, isolated and scattered, improving individual activities in schedules without a systemic consideration of the entire process. Value Stream Mapping (VSM), a process of mapping the material and information flows in a value stream through systematic data capture and analysis, has showed its benefits in identifying and eliminating waste under various circumstances. This paper uses a case-based approach to measure efficiency improvement in TAM activities through VSM. The TAM project for a selected Liquefied Natural Gas (LNG) refinery plant is selected and analysed as a case study. This paper develops a current state map and a future state map to explore the wastes and root causes. The case study reveals that although some challenges and limitations, VSM is feasible in TAM project to improve the efficiency by identifying wastes in process and guiding value improvement.

Keywords: value stream mapping, lean thinking, turnaround maintenance, oil and gas industry.

INTRODUCTION

Oil and Gas industry in Australia is a major component of Australia's economy and will continue to contribute to the prosperity. To be competitive in globalization, reliable production plants and high production efficiency are essential efforts to reduce cost (Lenahan 2011). It is notable that the performance of production is heavily influenced by maintenance productivity (Parida and Kumar 2009). This is because production is supported by complex capital equipment and machinery in oil and gas industry. Major maintenance activities, such as turnaround maintenance (TAM), are prime contributors towards the overall reliability and effectiveness of the plant. The challenges of international competition have placed great pressure on maintenance system.

TAM, also known as shutdown or outage maintenance, concerns significant endeavours that deal with inspections, scheduled cleaning, adjustments, repairs and replacements of a plant to ensure operational reliability, it is carried out when plants are shutdown (Duffuaa and Ben Daya 2004). The main objective of TAM is to improve the plants to ensure optimal and efficient performance and keep maintenance

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cost effective. In oil and gas industry, TAM plays an important role in sustaining long-term stability and continuous production of plant. According to Obiajunwa (2012b)'s research, it is necessary to shut down every 2 years to avoid unscheduled breakdowns which can have significant impact on the profitability. A proper TAM can lead to increased reliability and technical integrity that leads to a more predictable workload in the industry and effective maintenance work planning. However, this kind of project is usually very costly, requiring a large number of workforces, material and supporting resources to be involved in a short duration. Again, the loss of non-producing during turnaround is added to the cost of TAM. Its peculiarities of short duration, high capital, labour and material intensity, which make it become the large complex, expensive and time-sensitive project. In order to be competitive, a well-organized management process of conducting TAM is an essential part to improve maintenance productivity and drive cost down. In this context, lean thinking has gained attentions in oil and gas industry to improve the efficiency of the TAM process from planning through to completion (Smith and Hawkins 2004).

Value stream mapping (VSM) is the most efficient tool of lean thinking and has proved its value of increasing process visibility (transparency) (Klotz *et al.* 2008), and its benefits in reducing lead time and inventory (Abdulmalek and Rajgopal 2007, Seth and Gupta 2005, Singh and Singh 2012) in different areas. On an academic and practical level, VSM has been presented as a practical method by visualising the condition and interaction of actions. However, this remarkable tool has yet to be applied in any work in oil and gas industry.

The main objective of this research is to explore how VSM can be adopted in TAM uses a case-based approach. Based on a completed TAM project schedule, the map of as-is state, proposed changes for future state, and a discussion of working plan are carried out according to the guidelines of VSM.

LITERATURE REVIEW

In TAM related research, some studies have concentrated on guideline for a structured approach for managing TAM in different phases (Duffuaa and Ben Daya 2004), some on the management skills specific towards ensuring successful TAM projects (Cui, Hayakawa and Obiajunwa 2013), others on project management in TAM activities (Pokharel and Jiao 2008). Obiajunwa (2012b) developed a framework of success measurement criteria for TAM projects. TAM success is evaluated from the perspectives of management success, perception of stakeholders and resultant benefits to the business. Project management techniques are still used to improve the efficiency of TAM, for example, risk management is used as a practical tool in TAM (Obiajunwa 2012a). It is acknowledged that project management is the main strategy used to manage and coordinate TAM in current practice, the success and efficiency of TAM project is measured by cost, time, safety, quality and scope (Ertl 2004). However, this may not be the most optimum strategy to TAM, failures are still common in practice. A new method is required for effective management of performance on TAM project.

Lean thinking is a systematic approach for identifying and eliminating waste through pull strategy in pursuit of perfection from customers' perspective. It originally came from automobile industry, developed from Taiichi Ohno's notion of 'reduce cost by eliminating waste' (Holweg 2007), which was initially well known as Toyota Production System (TPS). The early contribution of TPS is a focus on "*automotive manufacturing-based view*" (Hines, Holweg and Rich 2004) of shop-floor lean

techniques (e.g. Kanban, five-S, pull, total productive maintenance, single-minute exchange of dies (SMED), cellular manufacturing, for further reference see (Monden 1983)) to eliminate the waste. According to TPS, The seven most common types of wastes which were originated by Ōno (1988) are overproduction, waiting, transportation, inappropriate process, unnecessary inventory, unnecessary motions, and defects.

In order to set up guidelines to solve the questions been raised when non-lean production organization tries to convert to lean one, five lean principles of value, value stream, flow, pull, and perfection, as the framework for organization to understand the strategic approach of lean transformation, are summarised by Womack and Jones (2010). One of the important lean principles - value stream, is 'the set of all the specific actions required to bring a specific product' (Stone 2012), which defines the work process from the view of 'actions'. Monden (1993) divided these actions into three types: value adding, non-value adding but unavoidable and non-value adding and immediately avoidable. These actions considered information as well as physic flow within the overall supply chain. This principle focuses on the transparency of all the steps in process within the elimination of waste, providing clear value adding steps among all the participants, it awakens the awareness of drawing maps of individual value streams to holistic view the interdependence of actions.

A number of value stream tools have emerged to reduce and eliminate wastes within a value chain. Hines and Rich (1997) summarized seven mapping tools (namely, process activity mapping, supply-chain response matrix, production variety funnel, quality filter mapping, demand amplification mapping, decision point analysis and physical structure mapping). However, they are poor in revealing the links and visualizing the nature of the information and physic flows in entire value chain. VSM is an information and physical process mapping tool of lean production popularized by Rother and Shook (2003). It creates a common basis of the integral actions view in value stream. VSM is emerged as the preferred way to support and implement the lean thinking (Chen, Li and Shady 2010, Grewal 2008).

There are many studies related to VSM application in practice. VSM is used to visualise and analyse the value-adding and non-value adding activities in entire value chain from users' perspective and then redesign work system based on Lean (Jones, Womack and Shook 2003, Pavnaskar, Gershenson and Jambekar 2003, Rother and Shook 2003). The benefits of VSM are reported by Seth and Gupta (2005) for lean application and cycle time reduction. McDonald, Van Aken and Rentes (2002) enhanced VSM by simulation. Abdulmalek and Rajgopal (2007) illustrated the VSM benefits in reducing lead-time and lowing work-in-process inventory by developing a simulation model. This kind of simulation research mainly focuses on answering questions that could not be addressed only using the static view provided by VSM. Some other research concentrates on solving the limitation of VSM application. Braglia, Carmignani and Zammori (2006) proposed a new VSM approach based on seven iterative steps analysis for complex non-linear production systems. Braglia, Frosolini and Zammori (2009) proposed two alternative approaches based on statistics and fuzzy algebra respectively to include variability analysis in VSM.

Although VSM is mainly used in manufacturing environment from the literature review, Pavnaskar and Gershenson (2004) identified the differences and similarities between a productive and an engineering process that enable the adaption of VSM for use in engineering process. By a comparison to the objectives of TAM and VSM

(table 1), it is apparently to see synergic objectives of them. Therefore, it is of value to apply VSM to improve TAM efficiency in oil and gas industry. This paper uses the five steps of VSM (Tapping, Luyster and Shuker 2002) to explore the value and reduce waste in process of TAM.

1. Identify an analysis objective;
2. Current state map: graphical representation of the current state process (as-is state) of the objective;
3. Future state map: work out a future-state lean process (benchmarking) within the elimination of wastes by lean techniques;
4. Define working plan: execution strategies to narrow the gap between as-is state and benchmarking;
5. Achieve the working plan

Table 1: comparison of objectives of TAM and VSM

Objective of VSM	Objective of TAM
To visualize maintenance flow from material and information perspectives	To achieve higher corporate performance
To improve the process by applying lean techniques to short lead time	To improve efficiency and throughout of plant by suitable modification To make plant safe to operate till next TAM To reduce routine maintenances costs To upgrade technology by introducing modern equipment and techniques;
To achieve zero waste by identifying the source of waste	To increase reliability/availability of equipment during operation To achieve the best quality of workmanship
To translate customer's requirement into practice processes	To modify operating equipment to cope with legal requirements and or obligations such as environmental regulation(Ben-Daya <i>et al.</i> 2009)

RESEARCH DEVELOPMENT

In this research, a case study is applied (Yin 2013) with a statistical analysis of data obtained from one oil and gas plant shutdown project. Case study can suitably be used for theory testing and refinement. Measurements in this research examine the qualitative and quantitative dimensions of wastes: (1) the qualitative dimension analyses the reasons behind the waste; (2) lean measurements are applied to measure the efficiency of each stage in quantitative dimension. Due to the considerable financial implications of any changes in TAM, the study is conducted based on historic data of one particular past TAM project. VSM has been implemented using the historic maintenance schedules provided by Company A, an oil and gas operator.

Value stream selection and data collection

The first important thing prior to the commencement of VSM is to select a value stream. TAM in oil and gas industry concerns wide range of activities such as boilers, heat exchangers, piping and even storage tanks repair or replacement for the reasons of improvements or maintenance needs. In this case, it is about a compressor replacement, 5 types of activity are contained. The type of activity that was chosen for value stream study is spool removal. This is because on the one hand, a single map encompassing the entire process would be too large and heavy for researcher to handle. On the other hand, the actual duration (164 h) spent on spool removal is more

than twice to the scheduled duration (75 h) which caused delay of the whole process. As shown in table 2, spool removal is divided into 8 stages after considering the logical relationship between the maintenance activities, with each stage considered as an independent value stream in value chain.

Table 2: spool removal stages and attributes

Attributes	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7	Stage 8
	Remove insulation	Releasing and measuring	Removal elbow	Removal structural work	Removal transition spool	Removal discharge	Balance line removal	Removal hot gas recycle
CT	21	88	112	51	60	65	64	73
VAT	21	33	2	2	6	2	2	2
CO	0	52	86	28	34	44	51	48
Uptime	100%	41%	34%	45%	43%	32%	20%	33%

Based on the data, five key VSM measurements are calculated in table 2: (1) cycle time (CT) is the duration that a stage needs to complete its work; (2) lead time (LT) is the time that a activity needed between one task being started to the end of a task being completed. In TAM, in order to minimize the project duration, the stages are usually carried out in parallel, therefore, the total cycle time is not the same as the lead time; (3) changeover time (COT) which is the idle time that one stage needs to wait before the completion of its preceding stage; (4) uptime is calculated by dividing actual working time by cycle time; (5) actual working time is calculated by subtracting changeover time from cycle time.

Current state map

Current state map is a diagram that is created to capture working processes using rules created by Rother and Shook (2003). Value adding and non-value adding activities in the information and physic flows of a value chain are visualised in the diagram as interconnected processing steps. A list of process data such as cycle time, value-creating time are recorded at each processing step. In this way, it is possible to track orders throughout the value chain and to get an approximate valuation of the total lead time of the process.

The current state map developed for spool removal activity is shown in Figure 1. It illustrates the conventional approach using predefined icons of VSM. What the customer demand in TAM is to satisfy the duration-driven maintenance plan, site manager is the control centre of the whole process. Because of the characteristic of uncertainty of work scope in TAM, the demand can vary significantly from day to day. Therefore, the work schedule is not always the same.

A total of 8 stages are involved in this activity, it should be highlighted that the scheduling of the spool removal is not constant but variable because of the duration limitation and uncertainty as mentioned before. As cycle time delay in the first few stages, this led to variations of schedule and resources (workforce, material and facilities) in the whole process. For example, maintenance operation with low-value added like realising and measuring takes up excessive resources, which means a significant delay in the total lead time and a confusion of work schedule.

The information recorded in the data box is extracted from actual schedule which was collected by site managers. The problem of information system is that different professions plan and carry out their jobs separately; however, their jobs are highly related and overlapped that make the system much more complicated.

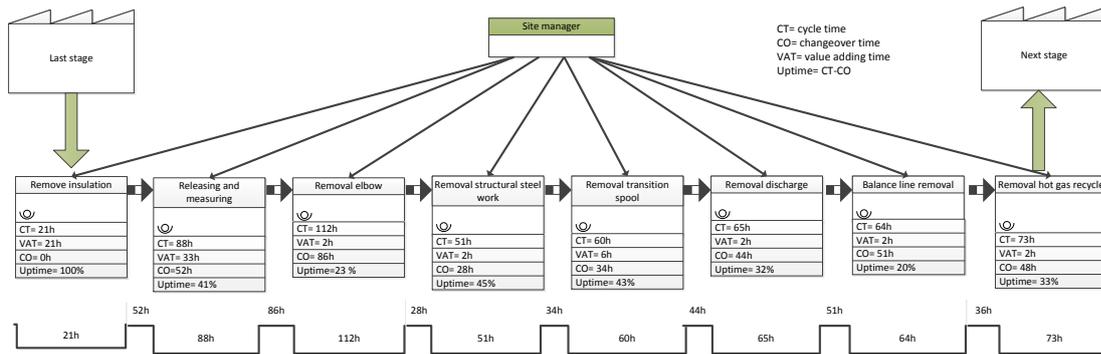


Figure 1: current state map of the spool removal process in TAM

As can be seen from the map (figure 1), the total lead time of this activity is 164 hours, which is calculated based on the start time and finish time of this activity. The total cycle time is 534 hours (total cycle time = sum of cycle time of each stage). The total value adding time is the sum of each process value adding time, and the value adding ratio is 42% (Value adding time ratio= Total value adding time/ Total lead time).

Future state map

Future state map is a result from process improvement. Lean tools are used to streamline the value chain by identifying the wastes, analysing the root causes of wastes and eliminating non-value adding activities. This ideal pull system in future state usually represents the improvement we could achieve in practice.

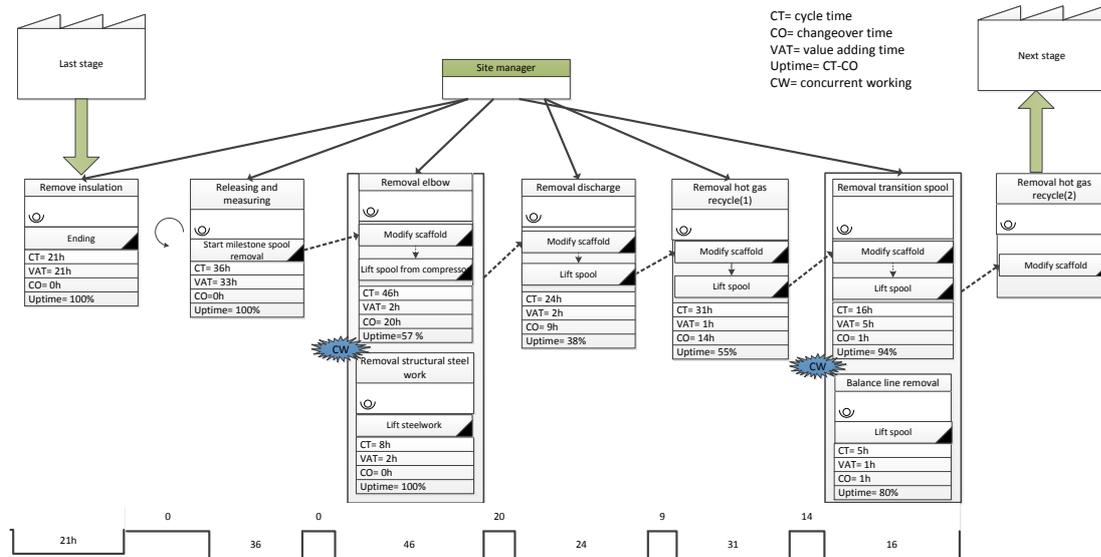


Figure 2: future state map

The maintenance process in oil and gas industry is suffering the wastes because of the uncertainty, which further causes the variability. Variability results in fluctuation of the work flow, which is the primary cause of waste. After the reasons have been recognised, lean tools are used to eliminate them in the highest possible and a future state map be drawn up. There are mainly five guidelines concluded by Rother and Shook (2003) for future improvement – TAKT time, continuous flow, supermarkets, pacemaker process and pull system. However, as discussed by (Yu *et al.* 2009) in the research paper (VSM application in house construction), continuous flow and supermarket are non-applicable in the sit-based environment as well as complex long process. This rule also could be adopted in TAM in oil and gas industry for the same

feature of project-based management. Therefore, various proposals for waste elimination have been developed in consultation with the actual work schedule. The future state depicting the various modifications of maintenance is shown in figure 2.

Value stream re-detecting: Value stream is re-detected by picking out the key impact jobs in each process to reduce the variation. By an analysis of this maintenance activity, it is recognised that scaffolding modifications for facility lift are the key path that decide the progress of the schedule. Therefore, current work state is adjusted with pull work flow and redeveloped from the point of scaffolding work.

Takt time: Takt time is a metric to measure the rhythms of production from the perspective of customer. In this case, the activity which is chosen to analyse value stream is about compressor spool removal before strip down. Here takt time is calculated according to the equation: $\text{Takt time} = \frac{\text{available working days}}{5 \text{ spools need to be removal}}$. As 162 hours are available for this activity, the takt time is 32.4 hours. It is apparently to see that cycle time in each process is higher than takt time (figure 3). In order to meet this demand, concurrent working is introduced for process improvement. The processes of removal elbow and removal structural steel, removal transition spool and balance line removal are conducted with the same scaffolding works. Figure 3 shows the comparisons of cycle time and takt time in current state map and future state map. There is a clear indication of the improvements from this statistics.

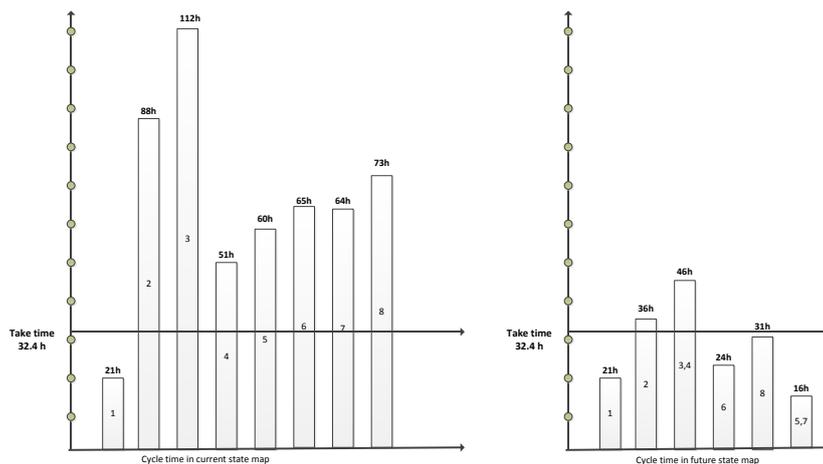


Figure 3: comparison of takt time and cycle time in current state map and future state map

Working plan

Working plan is an execution scheme deployed to meet the improvement targets based on the analysis of the future state map. It is an important step to identify the resources that are demanded to realise the benefit of VSM in real-world application. Rother and Shook introduced value-stream plan to achieve future state (Rother and Shook 2003). However, in manufacturing, few cases have ever discussed this step as the attributes of this industry - linear continuous flow of production with limited procedures. So lean staff can focus on improvements and inefficiencies be discovered by comparing the benchmarking and the data collected on-time from work floor continuous improvement. However, on the contrary, TAM in oil and gas industry is site-based production and is finished in fixed time, so working plan, the transformation procedure from current to future state, is required to allow lean tools be effectively adopted into practice. Because this case have already finished, the data and

information used for this case study cannot enable the conduction of working plan analysis, this part will be done in next upcoming case.

DISCUSSIONS

As mentioned above, these results came from two schedules: baseline and finished. The data is not enough to analyse all the waste and their reasons in this case. Improvements are measured by comparing the lean metrics based on the limited data (table 3). Total lead time of the value stream decreases from 164 hours to 121 hours, amounting to a reduction of 43 hours. All the unnecessary wastes are removed by reconstructing the work schedule. The total cycle time has a sharp drop from 535 hours to 174 hours. Therefore, it is concluded that VSM can be served as a guide and has a potential to improve efficiency in TAM.

Table 3: comparison of lean metrics in current state map and future state map

Metrics	Current state of map	Future state of map
Total lead time (h)	164	121
Total cycle time (h)	535	174
Value adding ratio (%)	42%	55%

However, some challenges to use VSM in TAM should be observed. First, the seven types of wastes are summarised based on the work in manufacturing shop floor, it would be very difficult to cover the wastes in oil and gas industry. Second, unlike manufacturing production line, the variation of process in TAM makes it difficult to draw up the sequential value stream. Third, Kanban is the tool applied for visual control to improve information management in standard VSM, while, there is a lack of information flow management in TAM for the peculiarity in the preceding part, since information flow is an important part in VSM, there should have a fundamental change to operate a lean value stream (Yu *et al.* 2009). Another important challenge is that most of the lean tools designed for future state map are hardly used in TAM environment.

Therefore, it is felt that VSM is feasible for TAM efficiency improvement because of its effective management strategy, but the full potential of VSM is hold back. The suggestions for further research are organised into two groups. First, VSM is an important tool of lean production, which is originated from manufacturing industry and has been accepted in different area, a root cause analysis of low level of usage and success in manufacturing and non-manufacturing must be done. It would be a guide to the VSM effective actual practice. Another important further development to enhance VSM would be to robust VSM with assistant tool, for example, building information modelling (BIM). BIM is a demonstration of the entire construction lifecycle that allow to redefine the work scope, and it has been widely used in engineering (Shou *et al.* 2014). The integration of BIM and VSM is of great value for improving VSM with a lifecycle perspective.

CONCLUSIONS

This research indicates that VSM is a process redesign tool that different from other management method, it is feasible in TAM project to improve the efficiency by identifying wastes in process and guiding value improvement. Some challenges and refinement advices on working plan are provided to convert the technique into one of the important tools for TAM management.

ACKNOWLEDGEMENT

This research was undertaken with the benefit of a grant from Australian Research Council Linkage Program (Grant No. [LP130100451](#))

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ARE CONTRACTORS' COST ACCOUNTING PRACTICES UP TO THE JOB OF ESTABLISHING IMPROVEMENT IN SITE OPERATIONS?

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Construction industry clients and regulators repeatedly call for the industry to reduce the cost of construction projects. Real cost reduction requires improvement in site operations. However, much of the industry expends effort in merely buying more cheaply. If a main contractor is looking to a subcontractor to undertake improvement for the sake of the supply chain, they need to be able to assess this and motivate it by a payment process that passes on the reward. Research is described that explores whether current costing methods could account for improvements in work processes. It considers cost as information and explores how contractors derive and use it. A case study of a major main contractor and two subcontractors is described that involved semi-structured interviews and document reviews. The results show that firms recognised that the costing practices they were using had unintended negative strategic and operational consequences. The research concludes that information about cost, that would be useful in a programme that seeks to improve site operations, is hidden in layers of commercial assumptions and lost when it does not cross the boundaries between organisations. A key finding is that automation of current cost management methods in BIM will not improve construction site operations. It will only produce more convoluted details that do not reflect what people actually do.

Keywords: building information modelling, contractor, cost accounting, improvement.

INTRODUCTION

The role that cost information plays in a construction project is a central one. Construction is always being challenged on cost by government who, through its client and regulatory role, has continually pressed the industry to reduce the costs of projects (Department for Business, Innovation and Skills 2014; Egan 1998). The catalyst for cost reduction most recently proposed is the adoption of Building Information Modelling (BIM) (Department for Business, Innovation and Skills 2013). Through BIM the cost of collection, storage and manipulation of information is reducing dramatically and consequently it should be easy to access integrated information that can be used to change the industry.

It is BIM's ability to automate the creation of information and communicate it efficiently through a central hub that drives the construction industry's interest in developing cost information in BIM. Academic and industry research and software development in the area of cost BIM has, to date, focused on BIM's ability to automate current estimating and tendering practices. Montierio (2013) showed that the

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most well developed software uses knowledge-based systems to extract dimensions from Computer Aided Design (CAD) models. Meanwhile, current software for Computer Aided Estimating (CAE) uses library-based systems to manipulate historical cost data to create project related data. It is now timely to explore cost as information to establish its meaningfulness prior to the move to more integrated decision making via knowledge-based CAE decision support systems in BIM.

This paper therefore explores cost as information and asks what sorts of cost information contractors currently hold? To understand this, the research explored estimating and tendering practices and narratives in a national UK main contractor and two subcontractors from their supply chain. The study analysed the derivations and uses of cost information by different people. The exploration of contractor and subcontractor cost information in this pilot study is part of a wider project to make cost information more relevant to site operation decisions through the use of BIM. Results suggest that current approaches to contractor costing struggle to provide information that is meaningful for establishing how site operations influence construction costs and hence how site operations can be improved. It is suggested that further work is needed, to look at how different costing processes from manufacturing could be applied with benefit in construction.

LITERATURE

The challenge of pricing one-off projects in construction has led to industry and country specific standard practices for project estimating and tendering (Kirkham, 2007). Regardless of the type of procurement route (such as competitive tendering, negotiation, two-stage tendering) or contract (such as lump sum, measure and value, or cost reimbursement) and regardless of the final format of the price information (formal bills of quantities, informal bills of quantities, schedules of rates, or lump sums), contractors and subcontractors all have the task of creating a project cost from three distinct types of information, namely, estimates of the cost of their own resources, quotations for work from subcontractors and the overarching strategic tendering decisions.

Greenhalgh, (2013) explains that cost estimates for work directly carried out by a contractor are often built up from 'first principles'; that is from the activities that consume internal resources of labour, materials and plant. The internal resource costs are allocated to either site overheads (preliminaries) or measured items. The estimator uses a combination of calculation and judgement to create the unit costs of measured items. For example, the 'measured item' of a brick wall has a quantity and a specification that both influence the resources required. The materials required are calculated by a simple mathematical relationship. The labour and plant required depends on judgements to optimise labour and plant productivity rates and minimise material waste. Greenhalgh (2013) argues that how a contractor makes best use of their internal resources is the main competitive differential between competing contractors. Ross and Williams (2013) identify that it is unlikely that this information on how a subcontractor makes best use of their internal resources will pass up the supply chain. Hence a contractor will not have a detailed understanding of their subcontractors' estimating processes and the decisions involved.

The second type of information used in costing is quotations from subcontractors. Fryer *et al.*, (2004) explain that subcontractor quotes make up the majority of a main contractor's costs as a main contractor typically subcontracts over 80% of their work. Ross and Williams (2013) argue that this change in the industry means the

contractor's skill in managing the subcontractor input into estimates is now a significant competitive differential between competing contractors. The process of managing the subcontractor needs unpacking. For instance Ross and Williams (2013) throw light on the usually hidden practice of price discounting. They describe the discounting 'spiral' in which the originally benign practice of expecting 'trade' discounts from subcontractors escalates in a project to the dis-benefit of subcontractors. In contrast to Greenhalgh's (2013) assertion that contractors main competitive advantage lies in how they make best use of their internal resources, Zimina *et al.* (2012) contend that the skill in commercial purchasing is a primary contributor to project profit.

The third type of information used in costing is the overarching strategic tendering decisions that convert an estimate into a tender. Greenhalgh (2013) shows that contractors make judgments about allowances for design and other risk contingencies, and the required margin to recover company overheads and earn a profit. This type of information relies heavily on an understanding of project uncertainties and market conditions. Ross and Williams (2013) point out that many contractors are guarded when it comes to conversations about margins. Others have shown how discussions about margins are clouded by decisions made through self-interest and opportunism. For example, Cattell (2012) identifies that firms may adopt weighting strategies to manipulate cashflow in their favour and Rooke *et al.* (2004) show there is a culture of planning for claims.

Two alternative procurement methods seeking to reward cost savings have been recently applied in UK contracting. The first is 'supply chain cost management' (Constructing Excellence, 2004), which is used in conjunction with early involvement in design, and seeks design savings by rewarding contractors and key subcontractors with a guaranteed total margin upfront. It achieves this by decoupling margin from each unit item in the cost model so that design savings can be made without eroding margin. Another alternative method is 'target costing' (NEDO, 1982), used when building to budget. This again requires early involvement in design, and seeks efficiency savings by rewarding contractors and key subcontractors with a pain/gain share. It achieves this by using a 'cost plus incentive fee' method that uses open book accounting to establish cost and shares the difference between target cost and actual cost. These alternatives are re-presentations of current project costing practices for budgeting and control, not new, analytical costing practices.

Construction project costing practices exist alongside costing practices in other industries, within the broader field of management accounting. Management accounting emerged to facilitate financial budgeting and control and broadened over time to encompass analytical measurement and evaluation of financial performance (Chapman *et al.*, 2007)). The main approach in this shift has been the theoretically based model of transaction cost economics (TCE), which has sought to compensate for flaws in the market-orientated view of perfect competition by focusing on how organisations can avoid dependence and deal with opportunism (Williamson, 1985).

In manufacturing and retail sectors, new analytical tools for costing that reflect transactions in supply chains emerged alongside TCE during the 1990s. LaLonde and Pohlen (1996) compared the main four tools that account for the cost of transactions in supply chains. Activity based costing (ABC) (Kaplan and Cooper, 1988) as a method of assigning accurate costs to products or services based on the resources they consume. Total Cost of Ownership (TCO) (Carr and Christopher, 1992) that looks at

the total costs between two neighbouring firms in a supply chain. Direct Product Profitability (DPP) (Kurt Salmon Associates, 1993) that considers the logistics of moving items between supply chain firms. And Efficient Customer Response (ECR) (Weeks and Crawford, 1994) that focuses on reducing whole supply chain costs through a better transfer of information, automating administration processes and unifying replenishment cycles. LaLonde and Pohlen (1996) argue that a hybrid of these techniques offers a new costing system that reflects supply chain relationships.

Despite the shift in cost accounting in the manufacturing and retail sectors and the pressure to embrace learning from other sectors such as aerospace (Green *et al.*, 2005) and automotive (Egan, 1998), project cost accounting in construction has remained largely within the realm of budgeting and control with few exceptions. Staub-French *et al.* (2003) applied ABC to account more explicitly for the cost of design features in construction projects. They created a prototype tool using the methodology of activity based costing to help estimators customise early stage construction cost information based on design features. O'Brien and Fisher (2000) applied ABC to calculate the capacity costs in the construction supply chain.

The literature shows that construction is embedded in its own costing practice and that this is challenged for accuracy, but not for efficacy. It keeps on doing the job it has always done because the industry works around the inadequacies. What is needed is a closer study of the thinking behind these construction cost practices so that their success in developing efficacy in decision making can be evaluated. The potential for different approaches to costing needs also to be assessed on this basis.

METHOD AND METHODOLOGY

The research is grounded in the interpretivist tradition. It explores the narrative around actions and decisions in order to know what organisations and individuals do and why they act as they do (Walliam, 2006; Easterby-Smith *et al.*, 2008). The research adopts a position of 'cost as information' then sought to challenge the basis and practicalities of this by treating it as merely a representation of purchasing possibilities and resources. Cost information is made problematic when it is given wider meaning by people and becomes a fixed reference point in construction projects. This research did not therefore start from the hard propositional knowledge of current practices, but rather looked at where cost information is derived from and how it is used, seeking to better understand what cost information means to different people. The research did use some hard propositional knowledge from costing documents and reports but explored this from an experiential and performative perspective. The overall objective was to explain current approaches to costing and explore the potential for making better decisions.

The research involved collaboration with a UK national contractor. This allowed access to data in a case study approach to their costing practices with a view to establishing what was needed for them to apply BIM successfully. This also involved two subcontractors, a mechanical and electrical subcontractor and a suspended ceiling, partitions and dry-lining subcontractor, who entered into the research willingly, as they saw opportunities for better payment. The conflicts of interest and ethical decisions that the study involves have been managed with care so as to be sensitive to their position and gain full access to the reality of their situation. The study was undertaken using interrupted involvement to follow decisions and their consequences at intervals through projects. The research adopted an inductive approach to provide description, understanding and explanation of the sources and uses of cost information

in estimating and tendering. The study also used documentary evidence of cost processes and written cost reports as well as narratives from semi-structured interviews with key participants from pre-construction and site operation teams to establish how they source and use cost information. In the middle of the study a reflective group discussion took place with key participants from the main contractor. To maintain confidentiality, the study used a different project for each organisation. However each project involved a similarly large, complex, one-off construction in which the contractor did not control the design phase. Interviews established that the same project costing processes and written cost reports were used on all projects. In general what people do is similar on all projects.

COSTING PRACTICE DATA

The empirical research aimed to establish whether the cost information collected by main and subcontractors during estimating and tendering was useful for promoting and accounting for improvements in site operations. The investigation sought to determine the reasoning behind the derivation and use of cost information and, importantly, what information was not created.

Based on the documents and narratives provided by the participants it was seen that, once a contractor or subcontractor had decided to submit a tender, their estimating, planning and buying functions face the task of building up project costs from a number of constituent parts while their commercial function faces the task of synthesising the information into a tender. It was seen that because subcontractors themselves subcontract work, there is no distinction between main contractor (MC) and subcontractor (SC1 and SC2) in terms of their costing process. In order to describe, understand and explain the costing processes and compare this with the literature, the investigation was structured around the same three distinct types of information categories as established in the literature review: estimates of the use of internal resources, quotations for work from subcontractors and overarching strategic tendering decisions.

Estimates of use of resources

An estimator creates 'first principle cost information' to forecast the price to pass on for work that will be carried out using their company's internal resources. They check, and hence improve, information received on quantities and specifications for 'measured items' then customise these for work that is under or over measured, or under or over specified. They create good information on their company's costs for directly employed labour using annually updated company information on salaries that are based on national wage agreements and salary on-costs. They also create good information on their company's costs for materials and plant, using regularly updated schedules of negotiated prices from suppliers. They then forecast the activities, resources and resource productivity rates for measured items. Company standard calculations that are derived from previous project experience are created. However the study found that the 'accuracy' of this information in representing site operations is made opaque by commercial practices.

"There are industry standard resource and productivity rates for activities but we create our own. We reviewed our labour productivity four years ago with our site operatives. We identified efficiencies, but then we didn't change our productivity rates because we were in a rising market and all costs were going up" SC1

“We have a standard productivity rate for our labour-only subcontractor who are required to work to a price. In a market upturn we have to use less productive labour but they take the hit” SC2

Quotations for work from subcontractors

For the main contractor, as much of 80% of the price passed on to the client comes from prices received from subcontractors. For a tier 1 subcontractor in one of the major trades, this can also be as much as 60% to 70%. The estimating and purchasing teams obtain and compare bids on the basis of price and technical issues and select a subcontract price to use in their tender. The selected subcontract price comes with a stipulated level of ‘standard trading discount’ that recognises trade business. The estimator creates a new figure by assuming a level of ‘additional trading discount’ on top of the standard. The risk is taken that the ‘additional trading discount’, or more, will be realised in further negotiations if and when the site operations team later place an order with subcontractor who’s price has been selected at this stage.

“Quite often it's pre-discounted so already the client has had the benefit. The person carrying the risk [that the additional discount will be realised when an order is placed for the subcontract] is us.” MC

“Sub-contractors never give the best price first. We pre-discount our price when we put our price in. So we take a discount off their prices so you add all these subbie costs. We'll pre-discount ours before we sell it.” SC1

Overarching strategic tendering decisions

An analysis of estimated direct costs and subcontract prices is passed from the estimating and purchasing teams to an adjudicating group, who review the information and establish the project mark up. The ‘mark up’ is made up of judgements on (i) anticipated cost of ‘design contingencies’ for uncertainty and level of risk and (ii) a ‘margin’ to recover general, non project specific, overheads and a level of profit expected to be earned from the project.

“We've had some vigorous debates about what the correct level of risk contingency should be on those jobs. We've had similar debates on every single job and it's the most subjective point that you could take.” MC

This establishes information on the total cost and is passed on as the going rate. The going rate is used as a target to budget and control costs within cost envelopes.

“We apply risk costs, OH&P as agreed in settlement meeting with directors and this form becomes the financial record of our tender. If successful this passes to the project delivery team and particularly procurement as a record of decisions made at tender stage to come to our offer” SC1

When the price is presented in a standardised format, such as a bill of quantities or schedule of rates, the contractor decides a gross price to put against each cost item in the model. The gross price is made up from the net price of measured items plus a share of the ‘mark up’. Both the net and gross prices can be manipulated across cost items in the model.

“We like to have overvalue in our orders. So we get paid more than we pay out every month and that generates a surplus for our business.” MC

Interviews established that participants recognised that the cost information that is created and the price information that is passed on throughout the supply chain has

many forces acting on it from operational and strategic decisions made throughout the supply chain. Participants saw project costing as a process that results in firms in the supply chain winning and losing on projects at each other's expense.

"There's two layers. Some people might take a few bob off to win a job but the figure they take that from is a figure which people have already made assumptions on." MC

"Some contractors will make double the margin they expected to make and other contractors that'll make half the margin they expect to make. You can guarantee only one of them is going to bang your door." MC

Participants understood that the project cost information created is obscured by layers of commercial decisions that remove cost information from a good representation of work processes, site activities and the resources that are consumed by those activities. They also recognised that as a buyer, their line of visibility into their subcontractors' cost information is shallow.

DISCUSSION

This research sought to understand the problem of costing in a way that allows the industry to move on and account for improvements in work processes rather than rely on gains obtained through commercial buying practices and opportunism. Discussion on costing in the UK construction industry focuses a lot on reaffirming established methods currently used by practitioners and so, (with exception of Zimina *et al.* (2012) and Ross and Williams (2013)), does not ask important questions of efficacy for assessing work processes across the supply chain. This questioning needs to go beyond the concept of improving productivity (e.g. Sezer and Bröchner, 2013). As participants in this case study revealed, in their explanation of 'working to a price', the concept of productivity has the connotation of how much labour you can get out of someone. This privileges self-interest over improving wider processes.

If a contractor is looking to a subcontractor to undertake improvement for the sake of the supply chain, they need to be able to assess this and reflect it in their payment process (i.e. pass on the reward). Zimina *et al.* (2012) looked at target costing and concluded that UK commercial and cost management practices are a major barrier to rewarding efficiencies through a pain/gain sharing payment process. Ross and Williams (2013) look at supply chain cost management and conclude that lack of transparency is a major barrier to rewarding cost and waste reduction through a payment process that protects each company's margin. This study supports the conclusions of Zimina *et al.* (2012) and Ross and Williams (2013) that it is very difficult for the construction industry to get good cost information that reflects the different work processes across the supply chain. Without such cost information, the industry can only enter into buying decisions on the assumption that what is being brought is already fixed. This does not achieve improvement. In a wider critique of improvement in the construction industry, Green (2011) demonstrates the fallacy of the argument that in a market where costs are driven down, subcontractors will be forced to innovate to survive.

The problem of costing needs to be understood in a different way as current practice does not contain the information needed for achieving improvements. What is required then is for the construction industry to look more carefully at alternative accounting practices. Accounting practices that reflect transactions in supply chains may be useful as these were adopted by other industries through the 1990s in response to increased competition and alongside the emergence of TCE. The most developed of

the four main tools that account for the cost of transactions in supply chains, as compared by LaLonde and Pohlen (1996), was Activity Based Costing (ABC), which assigns accurate costs to products or services based on the resources they consume (Kaplan and Cooper, 1988). Tsai (1998) gave a framework for measuring costs under ABC in a two dimensional model adapted from Tsai (1998) as shown in figure 1.

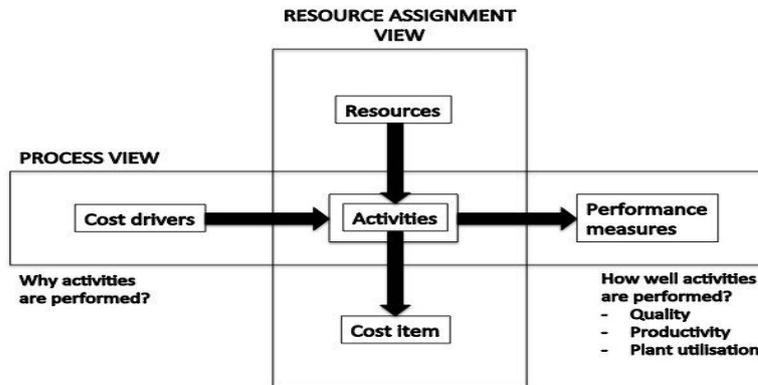


Figure 1: Two-dimensional model of ABC. Source: adapted from Tsai (1998)

The first dimension, the resource assignment view, includes information on labour, plant and materials but does not contain information on work processes (other than in labour which only assumes a measure of productivity). Without information on work processes the resource assignment view does not represent improvement well. However the second dimension, the process view, adds information on method in the form of ‘cost drivers’ that explain why activities are performed and ‘performance measures’ that explain how well activities are performed. Information on cost drivers can quantify improvements in work processes and information on performance measures can be used to fairly reward those improvements.

One barrier to accessing information on cost drivers and performance measures is the shift to larger supply chains in which both main contractors and subcontractors predominantly undertake to buying rather than making. Thus information is lost from the supply chain whenever information created about use of resources is missing as it is passed on as quotations for work. This is illustrated in figure 2.

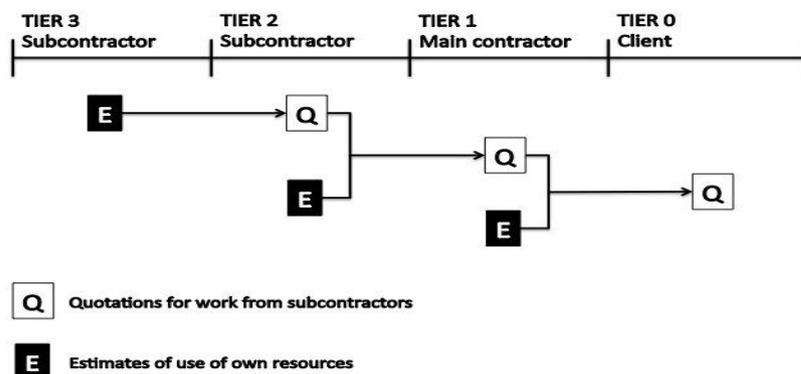


Figure 2: The flow of cost information through the supply chain.

The problem of information loss is exacerbated by different people interpreting the cost information that flows through the supply chain differently. Each of these people

has a different use for the information and this dictates how the costs are interpreted. Most of the cost information in construction has been created for buying, payment and accounting purposes. So when it is used for other purposes it is inadequate. Because of this, getting even more of the current cost information, in no way improves the industry's ability to arrive at decisions that improve processes, or reward better site practice. Even worse, current cost information actually discriminates against improvement by driving perverse incentives and creating unintended consequences following cost information being wrongly used or underused.

BIM offers an immense amount of information that can be extracted from digital models into BIM based costing applications. Currently, digital costing applications are based on either simplistic object quantity take offs or the complexities of current approaches to quantity surveying. This sort of cost information does not adequately represent the reality of site operations; thus, automating this further or exploiting the greater level of detail of information offered by BIM cannot improve site operations as the cost information is at best constrained and at worst provides misleading information. To advance this situation, the construction industry needs to understand its costing processes better and to tie these more clearly to the purpose for which the costs are being used. In particular, the connection between site operations, the purpose for which costs are used, and the method of producing costs needs to be explored in much more detail to devise an alternative to current costing techniques.

CONCLUSIONS

This research has produced unique knowledge about costing by a main contractor and subcontractors. It has established how current costing practices lose information about site operations and methods, as it is transferred during a tendering situation. At each transfer, participants want different information from the costs; however, the ability to do this is limited by the original purpose of the cost. Current cost information is produced for buying, payment and accounting purposes. Thus, using the current costing methods in BIM is not helpful for use for a different purpose, such as evaluating and rewarding improved site practices and supply chain operation. It could, in fact, make things worse by producing more convoluted details that appear accurate but are not linked to what people do. If the industry needs BIM to deliver information that is useful for improving site operations, then this requires understanding cost information better and using costing methods that are tied to that aim. It is only this that will provide real benefits from BIM in relation to cost and improvement.

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CONSTRUCTION PROJECT CHANGE: INVESTIGATING COST AND BENEFITS

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Cost overrun of projects is common in the construction industry. Changes to the original design and to the scope of works during the design development and construction phases contribute significantly to overall cost overrun of construction projects. However, scholars argue that change is inevitable, and some changes add value to the project. Therefore, it can be argued that the overrun of the initial construction cost through the changes made to the project may be insignificant compared to the reductions in life-cycle cost and whole life value of resultant built environments. Early research is presented here of a wider project seeking to evaluate the costs and value of proactive changes made during the construction phase with the intention to add value to the whole life of the project. Change control accounts and other related documentary evidence of two construction projects were investigated to identify changes made to the projects during the construction phase, and cost of those changes. Semi-structured interviews with quantity surveyors and project managers involved in those projects were conducted to enrich this documentary data. Analysis explored the contribution of proactive changes made with the intention to increase whole-life value to the overall cost overrun of construction projects, and clients' understanding and willingness to pay for such changes. The next phase of this research will investigate the whole life value gained by the clients from these changes. Ultimately, this research aims to increase both clients and project managers understanding of cost and value of changes during the construction phase, with due consideration of the whole life cycle of construction projects.

Keywords: project change, cost, cost overrun, value, whole-life-value.

INTRODUCTION

Change in construction projects is often considered inevitable (Cox *et al.* 1999; Sun and Meng 2009) and construction projects simply prone to a high degree of change (Sun and Meng 2009). This can involve alterations to design, construction method, project program or other project aspects caused by modifications to pre-existing conditions, assumptions or requirements (Sun and Meng 2009; Motawa *et al.* 2007). Change can occur from different sources (Motawa *et al.* 2007) and by various causes related to external, organisational and project environments (Sun and Meng 2009). Previous scholars have acknowledged that construction project change can cause serious disruptions (Stasis *et al.*, 2013) and in particular can impact on capital cost of construction (Zou and Lee 2008; Sun and Meng 2009), construction project duration (Sun *et al.*, 2006; Arain and Pheng 2005; Hanna *et al.*, 2004) and other aspects such as labour productivity (Ibbs *et al.* 2007; Hanna *et al.* 1999), health and safety (Williams, 2000), and working relationships (Sun and Meng, 2009). Investigating construction

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project change, and its impacts, therefore remains a continuing concern within construction management literature.

In contrast, relatively few scholars have suggested that changes can be beneficial (for instance, Motawa *et al.* 2006; Sun and Meng 2009; Chang 2002) or explored the importance of encouraging beneficial changes (Ibbs *et al.* 2001). Instead, research tends to focus on the negative impacts of construction project change; for example based on a systematic review of previous completed researches into effects of construction project changes, Sun and Meng (2009) identified that construction rework due to project changes can increase construction cost 10- 15% and can also cause reactive impacts including extra work, time loss, design revision, and indirect impacts such as impact on labour productivity, loss of rhythm, impact on resource planning and cash flow etc. When considered from such perspectives, it is therefore unsurprising that the focus of much management research is on the prediction of change, the minimisation of any reactive impact of project changes, and ideally the avoidance of unnecessary change. However, it is argued here that change can actually be a good thing, and this paper seeks to contribute to this thinking by exploring and quantifying beneficial change within construction projects.

LITERATURE REVIEW

Beneficial construction project changes

As previously noted, few scholars have suggested that changes can be beneficial. Motawa *et al.* (2006) categorised construction project changes into beneficial, neutral or disruptive changes. Sun and Meng (2009) stated that some projects may benefit from proactive changes. Ibbs *et al.* (2001) categorised changes into beneficial changes and detrimental changes, and stated the importance of encouraging beneficial changes and discouraging detrimental changes. Exploring beneficial changes further, Ibbs *et al.* (2001) claimed that beneficial changes resulting from value engineering exercises and can help to reduce cost, schedule, or degree of difficulty, are welcomed by the management team, since these changes benefit the project. These beneficial changes not only give an immediate and proactive impact, but they also can provide the platform and environment for managers to seek further beneficial change. Sun *et al.* (2006) categorised changes as 'necessary' and 'unnecessary' changes and acknowledged that improved project quality as a change effect. Chang (2002) has categorised changes as 'compensable causes', 'non-excusable causes' and 'excusable causes'.

However, none of these studies reveals further details of their beneficial changes, or their long term impact to the building or the businesses operated within those buildings. Furthermore, to date there has been no agreement on the definition of what embodies a beneficial project change. It could be argued that any project change is beneficial in some way, since they intend to improve the performance of the project.

In some cases, change could be introduced to the project with the intention of improving the performance of the project beyond initially expected performance levels; in this situation, such changes can be termed 'proactive changes' and are made to improve performance of the project beyond initially expected performance targets, their causes consequentially categorised as 'proactive change causes'. In contrast 'reactive changes' are those made as a result of reaction to 'reactive change causes', such as change the design to rectify the flaws in the development process. However, it must also be acknowledged that proactive changes still have reactive impact on

initial capital cost, project duration and other parameters identified above. Yet, they have a long term positive impact on the life cycle of the project, through reductions in life-cycle cost and improvements in whole-life value.

Proactive change causes and their impact

Several scholars have acknowledged the existence of client related changes (c.f. Chan and Kumaraswamy 1997; Wu *et al.* 2004; Chang 2002). It can be argued that clients could introduce proactive changes with the intention of improving the performance of the finished building. Yet, most studies in the area have only focused on reactive and necessary changes initiated for client related causes. For example, Chan and Kumaraswamy (1997) identified that inadequate contract durations imposed by clients can be categorised as a client related cause for variation. Citing from previous studies Sun and Meng (2007) reported variations in clients' expectations, budget reduction, demand for accelerated completion, inexperience of client and inappropriate interferences as key client related causes for change. As a result of this focus, there is much less information about effects of the proactive changes initiated by clients. Chang (2002) has categorised client changes as compensable causes, non-excusable causes and excusable causes, and stated that compensable causes are related to requirement changes by clients and other defaults by clients. Undertaking case studies of four engineering design projects enabled Chang to quantify reactive effects (increase in cost and time) of client requested changes. Clearly, it could also be beneficial if this study had extended to the analysis of proactive changes, based on the client requests.

Design changes have also been identified as a root cause for variation by several researches (c.f. Hsieh *et al.* 2004; Sun and Meng 2007), and this could be a cause for proactive change. Yet, similar to research of client change, reasons for design change has not been explored in sufficient detail to enable distinction between reactive and proactive design changes to be made, which could allow identification of beneficial variations. Much more attention has been paid to reactive and necessary design changes. In Sun and Meng (2007)'s systematic review, they identified design errors and omission as the main causes for design changes, and poor briefing practices and changes in client requirement as indirect reasons for design change.

Change due to site safety considerations and security considerations (Hsieh *et al.*, 2004), requirement changes (Wu *et al.* 2004), technology factors such as new materials and new construction methods (Chan and Kumaraswamy 1997; Sun and Meng 2007; Wu *et al.* 2004) have also been identified as causes for change. Even though it is obvious that some of these causes could be related to proactive changes, further details cannot be found within the literature.

As discussed above, the literature reveals existence of proactive changes and proactive change causes. However, research then fails to explore the impacts of such proactive change, which remain unidentified. Based on 101 previous published researches Sun and Meng (2006) summarised change effects into five categories: time related, cost related, productivity related, risk related and other effects. Surprisingly, all the change effects identified by Sun and Meng (2006) are reactive.

The aim of this research is to explore and quantify proactive and reactive changes within construction projects. This resulted in the need to establish the existence of proactive changes and examine how they are introduced to the construction projects, alongside a comparison of the frequency of occurring proactive and reactive changes. Furthermore, comparison of the contribution of proactive and reactive changes to

overall construction cost overruns will enable an enhanced understanding of construction project change within this specific context.

RESEARCH METHODS

Research of construction cost overruns often uses surveys and case studies to explore causes of cost overrun and their frequency, however this can lead to a level of superficiality within the data collected and therefore the potential from its analysis. Furthermore, research has often focused on the negative impacts of change, and the benefits change can deliver is often neglected. . In contrast, this study utilised in-depth case studies as the main research method, in order to collect rich data including the details behind causes of construction project change, alongside any proactive and reactive change causes' contribution to the overall cost overrun of the construction project. Two small scale refurbishment projects were selected as case studies based on the availability of access to relevant information.

Case study A: Case study A was an office refurbishment project located in London. The initial contract sum of the project was £489,654 in the third quarter of 2013 and the project was finally completed at a sum of £ £604,654 in the first quarter of 2014. The scope of work comprised refurbishment to the interior and exterior of an outer London office, including refurbishment of the basement, ground and first floors as well as the repair of existing render and renovation works to window frames.

Case study B: Case study B was the refurbishment of an existing gymnasium in central London, bringing it to DDA compliance. The initial contract sum of the project was £426,718 in the third quarter of 2013 and the project was finally completed at a sum of £622,333 in the second quarter of 2014. Scope of works included refurbishment to the space include new finishes, a new sauna, reconfiguration of showers, WC's. The scope of the mechanical works includes the reconfiguration of existing services and installation of new services to suit the new layouts.

Change control accounts and other related documentary evidence of two construction projects were analysed to identify changes made to the projects during the construction phase, cost and further detail of those changes. Semi-structured interviews with quantity surveyors and project managers involved in the projects were conducted to supplement the documentary data, related to the reasons for changes. Data from these interviews were primarily used to categorise change causes into proactive and reactive. Due to lack of previous research related to proactive and reactive construction project changes, categorisation of proactive and reactive change causes was challenging and involved subjective judgement of the researchers and interviewees. Simple statistical methods were used to compare the frequency of occurring proactive and reactive change cases. Agreed monetary values of the proactive and reactive changes were extracted from variation accounts of the project. As both case study projects are refurbishment works, the generalisability of these results is limited, however the findings of this study does provide insights around project change and cost, as well as confirm the application of this approach to a wider sample in future.

FINDINGS

Case Study A had a total cost overrun of £94,500 and Case Study B had a total cost overrun of £195,616, caused by variations to the projects. The first ten and nine (for Case Study A and B respectively) cost significant items (contributing to 80% of total cost overrun) were selected for analysis. Further details were collected through

interviews and document observations to identify further details of these cost overrun items to establish the precise value of the cost overrun, details of change causes in order to categorise them into proactive and reactive change causes. Table 1 and 2 below summarise the details of cost significant changes in Case Study A and B.

Table 1: Details of cost significant changes in Case Study A

No	Description of the change	value in £	Reason for change	Additional comments (data from semi-structured interviews)	Type of change
1	Boiler changed to a more efficient variety	3,000	Additional works		Proactive
2	Additional kitchen worktop	1,000	Additional works, design error, poor project management, poor cost management	It is being mistakenly assumed that some of existing kitchen worktop was to be retained, as stated on architect's drawing. Later it was recognised that all the worktops to be replaced.	Reactive
3	Carpet tiles specification change	2,000	Additional works, design change		Reactive
4	New window and improved glazing to the fabric of the building.	27,000	Additional works, design change	Initially it was decided that the original glazing was adequate and had no requirement to be changed. Yet these were later changed to improve performance. Cost also includes renovation works to exterior of existing window to be removed	Proactive
5	Painting of exterior masonry and woodwork	-	Adverse weather condition	Delays due to bad weather	Reactive
6	Replace Lighting and sockets to clients requirements	12,000	Client spec not met, design error, poor project management,	Lighting and sockets needed to be improved to client's requirements at an additional cost. Client requirements were not clearly captured and stated in the specifications and the contractor had installed these to a standard appropriate to the work, which client did not liked. Changing these came at an additional cost to the client	Reactive
7	Render to block work	2,500	weather conditions, mistakes on site	in hot weather caused cracks due to drying out too quickly, had to strip off and re apply	Reactive
8	Repair timber floor	-	Mistakes on site	Water damaged caused by the contractor to the parkey timber flooring which required sanding down and polishing out	Reactive
9	Additional rain water harvesting tank	25,000	Additional works	A requirement identified and added later to improve the project	Proactive
10	Water proofing basement	22,000	inadequate site investigation, technical challenges, additional works	It was later identified that the basement need water proofing measures.	Reactive

Table 2: Details of cost significant changes in Case Study B

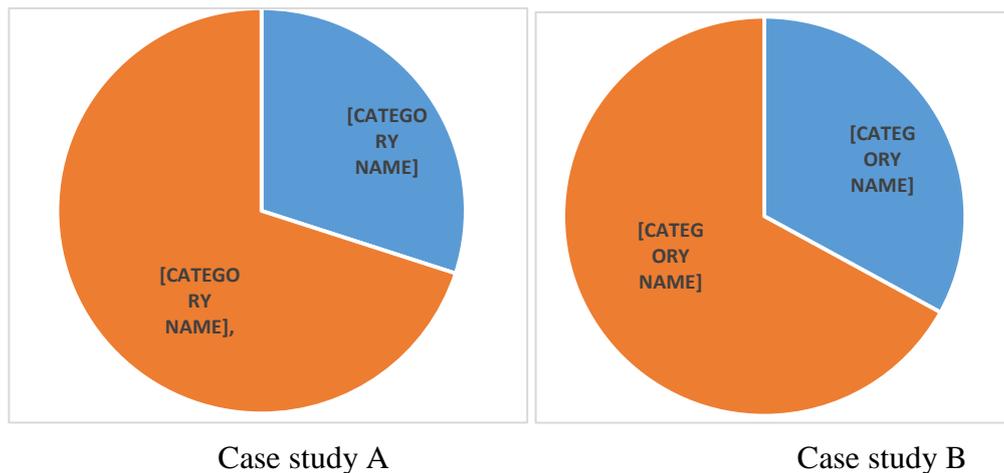
No	Description	value	Reasons for change	Additional comments (data from semi-structured interviews)	Type of change
1	Revised M&E details	60,000	Additional works Design change Design error	Proposed routes in design were not achievable once opening up work had been completed	Reactive
2	Installation of sprinkler system	77,896	Additional works Technical challenge	Future proof area for integration of proposed fire safety works (expected 2016) to limit requirement for opening up once works complete, sprinkler system is now ready for its connection to new system.	Proactive
3	Additional FCU's	17,160	Design change Additional works	Post contract - Client changes to layout required adjustments to ventilation levels and eventually additional FCE's (Fan Coil Units) were required	Reactive
4	Adjustment to New Ramp	5,500	Design error, statutory requirements, additional works	Original design did not meet statutory requirement. Ramp installed as per design was not approved by building control. Adjustments required to make the design compliance with regulations.	Reactive
5	Provide temporary A/C units	7,500	Poor project management, Additional works	Works were phased whilst parts of the gym remain open. It became apparent later that temporary cooling would be required to the gym area in use and this was funded by the project	Reactive
6	Revision to ventilation system	3,500	Design change	Had to be extended	Reactive
7	Remedial works to improving damping in female changing room	4,500	Additional works	Adjustments to fall in shower area to reduce the risk of water pooling and causing damp	Proactive
8	Repair damage to existing partition by sub-contractor	-	Mistakes on site	limited to contractors cost	Reactive
9	New fire alarm loop - Cabling and containment for future void detection and future allowance for install CBS	19,560	Additional works	Future proofing of the space	Proactive

ANALYSIS AND DISCUSSION

Changes due to proactive and reactive causes

Simple statistical analysis was used to analyse the case study data to identify percentage values for the frequency of occurring changes due to proactive and reactive causes (Figure 1). In both Case studies changes were more frequently resulted from reactive change causes (67-70% of times) than from proactive change causes (30-33% of times).

Figure 1: Frequency of changes due to reactive and proactive causes



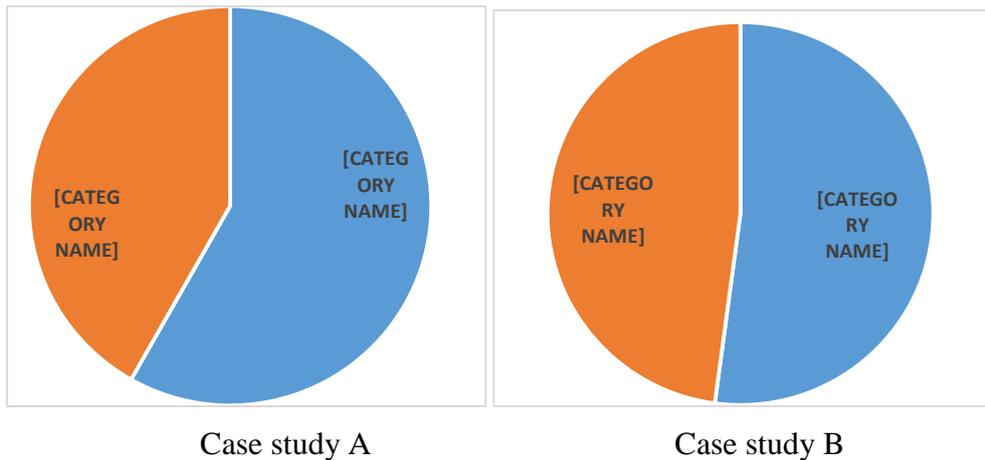
In the analysis of causes for change, it was clear that the changes due to reactive causes were often the result by flaws in the briefing, design development and construction phases (see Table 1 and 2). These include additional works and design changes to ensure the compliance to client requirements and other standards, and re-work to rectify errors. Changes in this category were inevitable to complete the projects to the expected standard of quality. Similar to the findings of (Ibbs *et al.* 2007) some of the changes had ripple effects into construction cost causing additional works in other related elements and thus escalating the cost overrun. For instance, in Case study B, change to the building layout has resulted adjustments to ventilation levels and installation of additional fan coil units.

Proactive change causes were always associated with additional works and design changes to improve the standard of quality of the completed building for operational efficiency (Case Study A), sustainability (Case Study A) and improved user satisfaction (Case Study B) and future proofing (Case Study B) purposes.

Monetary value of changes due to reactive and proactive causes:

Results were further analysed to compare the monetary value of proactive and reactive changes (Figure 2). Agreed monetary values for each changes were extracted from the projects' variation accounts. Surprisingly, total monetary value of proactive changes was higher than the value of the changes, due to reactive change causes in both case studies. These results (including the intentions of proactive change causes discussed above) partly support the idea of beneficial change, suggesting that the overrun of the initial construction cost due to the changes made to the project could result reductions in life-cycle cost and whole life value of resultant built environments. Changes made to Case Study A aimed at operational savings would reduce the life cycle cost of the Case Study A, while some of the changes aimed at improving user satisfaction and sustainability could also improve whole life value. Furthermore, it could be argued that proactive changes aimed at future proofing of the building (as seen in Case Study B) in relation to emerging concerns will eventually contribute to the improvement in whole life value. Surprisingly, the contribution of these type of changes was found to be significant in both cases studied within this research. A clear consequence of these changes is the considerable reduction in life-cycle cost and improvements in whole life value, yet further research is required to estimate or quantify the actual benefits.

Figure2: Value of changes due to reactive and proactive causes



It is interesting to note that for both cases, proactive changes were often initiated by the client, except for the changes aimed at future proofing in Case study B. Involvement of other stakeholders in initiating changes was hardly evident within the data. According to literature, designers remain the primary contributor to the design, although many other sources may also contribute (Emmitt 2007). Evidence of new construction related products and processes emergent to the industry and accessed through the key supply chain organisations involved in the design process is a key source of evidence to the design process, next to the knowledge and experience of the people involved in the design process (Wanigarathna 2014). Furthermore, material and component producers carry out the majority of construction-related research with the aim of improving the performance of buildings (Gann *et al.* 1998). This suggests the existence of un-used opportunities that could have been brought in to the project by other project participants. In general, therefore, it could be argued that construction projects could benefit from changes to adopt new evidence brought in by all key supply chain partners involved in the project. Lack of changes initiated by participants other than the client during the construction phase may be explained by the fact that incorporating changes to a construction project during the construction phase is expensive. Contract mechanisms and conditions of contracts used for the construction projects do not favour late changes into the projects (Bower 2000) and these are often seen as opportunities for the contractors to increase their profit margin (Bijari *et al.* 2006). Further work is required to explore the impact of collaborative working on introducing changes later into the construction projects.

It must also be noted that beneficial changes can have negative impacts on projects with relation to capital construction cost and construction duration, and therefore this should be controlled and managed. Existing change control literature can be employed to supplement the findings of this research, in managing proactive beneficial changes to minimise negative impacts. Yet, attention must be paid to the identification and evaluation of the benefits of proactive change, processes which should be integrated into the existing construction change management procedures.

Results of this research should be interpreted with caution; this analysis is based on the data from just two case studies into small scale construction projects. Both projects are refurbishment projects and therefore, the generalisability of this analysis is limited.

CONCLUSIONS

This paper has made a new contribution to understandings of change, through the identification and exploration of both proactive and reactive change causes, as well as the potential for positive outcomes from proactive changes made during the construction phase of a project. This research extends our knowledge on characteristics of beneficial changes by analysing reactive and proactive changes and change causes. Reactive changes place construction projects at initially expected performance levels, whilst proactive changes intend to improve the performance of projects above the initially set targets. Based on the results from case studies into two construction refurbishment projects, this research found that a significant contribution to the construction cost overrun is related to proactive changes, yet these also have the potential to bring reductions in life-cycle cost and improvements in whole life value of resultant built environments. Further research is required to assess and quantify the extent to which clients realise benefits of these changes over the life cycle of the building. Change is often inevitable in construction projects, and the monetary value of both reactive and proactive changes contribute considerably to the capital cost. This research supports previous research, emphasising the importance of controlling and managing construction project changes (both reactive and proactive) to reduce impacts on construction cost, time and quality. In addition, this study has provided some insights to improve the way of scholars engage in research related to construction cost overrun. There is a lack of literature related to proactive changes within construction projects. Based on the results of this research it could be argued that construction projects could benefit from promoting and facilitating proactive change during the construction phase, and it is recommended that further studies be carried out to validate these findings to different types of construction projects.

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DEVELOPING AN ARTIFICIAL NEURAL NETWORK MODEL FOR LIFE CYCLE COSTING IN BUILDINGS

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Life-cycle costing is an economic assessment which considers all the significant initial, operating, maintenance and disposal costs of ownership over the economic life of a building. Particularly, the maintenance and operating costs associated with these buildings are diverse and reflect the effect buildings have on their owners, users and the environment. An Artificial Neural Networks (ANN) model is presented to estimate operating and maintenance costs of existing buildings. Historical data were gathered from an Office Block, Penllergaer Business Park. The resulting ANN model reasonably predicted the total cost of the building with favourable training and testing phase outcomes. The study can be used to improve the confidence in life cycle costing (LCC) modelling.

Keywords: artificial neural networks, life cycle costing, modelling.

INTRODUCTION

Life cycle costing is defined as the costs associated with acquiring, using, caring for and disposing of physical assets. This encompasses feasibility studies, research and development, design, production, maintenance, replacement and disposal of an asset. It also covers training and operations costs generated by the acquisition, use, maintenance, and replacement of permanent physical assets (British Standards Institute, 1998).

One can draw from this definition that LCC quantifies and forecasts choices which can be used to determine the ideal choice of assets. It allows the life cycle cost and the trade-off between cost elements, throughout the asset life stages to be understood.

Yet, there are immense doubts about the accuracy of LCC estimates as they are deemed to be imprecise, inexact, uncertain and vague (Kirkham *et al.* 2004). The above submission unmistakably shows a variance in prevailing cost estimation techniques and underlines the necessity for re-assessment and potential re-evaluation of LCC methodologies (Doloi, 2011).

Consequently, the challenge among practitioners is to develop a framework for LCC that is not only universal, but more importantly dynamic as clients now want buildings that demonstrate value for money over the long term, and are not interested simply in the design solution which is the least expensive.

These changes have led to and highlighted the importance of LCC approaches to the design, construction and operation of buildings (HMSO, 2000). The purpose of this

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work is to explore the ANN technique and predict the operating and maintenance cost of the building.

ARTIFICIAL NEURAL NETWORKS

Artificial neural networks (ANN) are non-linear mapping structures based on the function of the human brain. They are powerful tools for modelling especially when the underlying data relationship is unknown. The primary advantages of ANNs include their ability to learn by examples and are ideally suited for complex and non-linear data (Gallant, 1993) and to generalise solutions for forthcoming applications (Nikola, 1998).

ANNs do not require a prerequisite establishment of rules and reasoning which govern relationships between a desired output and its significant effective variables (Hornik, 1991). Neural network based modelling process which according to Ogunlana *et al.* (2001) involves five main aspects namely;

- 1) Data acquisition (variable selection) and analysis
- 2) Problem representation at architecture determination
- 3) Learning process determination
- 4) Training of the network
- 5) Testing of the trained network for generalisation evaluation.

A neural network is constructed by arranging several processing units in a number of layers. The output of a single layer provides the input to the subsequent layer and the strength of the output is determined by the connection weights between the processing units of two adjacent layers. A back-propagation neural network is utilised in this study to develop the cost estimation models.

The back-propagation algorithm is the most popular ANN paradigm used for adjusting the weights of a multi-layer neural network that is because of its simplicity and good generalization capability (Rumelhart *et al.*, 1986). It is based on a gradient descent approach to minimize the output error with respect to the connection weights in the network. A summary of the process of a standard back propagation algorithm can be illustrated as follows:

- A set of input factors are presented to the ANN as well as their desired outputs.
- A training stage starts by arbitrary selecting a set of connection weights for each layer. Each neuron calculates its summation function value and accordingly computes its transfer function value, which represents its output. This process is held in a feed-forward manner.
- A set of computed outputs is delivered in the output layer. For each processing element in the output layer an error is calculated, each represents a deviation of the computed output from the desired output.
- Using a learning rule (generalized-delta rule and extended delta-bar-delta rule) the errors are back propagated through the hidden layer(s) and the connection weights is adjusted and updated accordingly.
- A feed-forward process starts all over again. New output values are computed and the above cycle continues until a desired set of requirements are achieved.

Several researchers in the construction industry have addressed potential applications of ANN. De Silva *et al.*, (2013) discussed the use of ANNs in complex risk analysis applications. Ahiaga-Dagbui and Smith (2014) used ANN for estimating final cost of water infrastructure projects while Lin and Mohan (2011) used ANN for the mass

appraisal of the real estate by the municipalities in the USA. Although a substantial amount of research presently exists in ANN forecasting, none explicitly emphasise on commercial offices despite the fact that the costs of running and maintaining these buildings make up a significant portion of their entire outlay (Barlow and Fiala, 2007).

DATA COLLECTION

In order to develop an ANN cost model, historical cost data was gathered from the BCIS for a sustainable commercial office building case study. Data from the building cost information services (BCIS) was chosen because they give early cost advice to budget and benchmark projects and to prepare life cycle cost plans.

Similarly, BCIS data are used by consultants, clients and contractors to produce specific estimates for option appraisals, early cost advice, cost planning, reinstatement costs, benchmarking, whole life costing, facilities and maintenance budgeting.

The BCIS case study is a two storey office Block, Penllergaer Business Park built in November, 2004. It is a new build; steel framed with a floor area of 2,681m. It has a building cost of £3,007,373 and has an excellent BREEAM rating. The forecasted period was put at ten years.

The following four steps discussed below are used in this paper to develop ANN conceptual framework.

- i. Identification of project objectives, and project constraints
- ii. Determine the length of the study period
- iii. Cost breakdown structure
- iv. Forecasting using ANN (Variable selection, Training and Validation)

i.) Identification of project objectives and project constraints.

The LCC analysis is used in this paper to provide an accepted methodology by facilitating a more accurate, consistent application of LCC estimations thereby creating a more effective and standardised basis for life cycle cost analysis.

ii.) Determine the length of the study period.

The study period commenced at time zero which was previously defined.

iii.) Cost breakdown structure

For each LCC project, cost centre was identified and information gathered from historic data and building surveys of the BCIS and subsequently a cost breakdown structure (CBS) is developed for the building.

The cost breakdown structure helps to organise the different costs so it can be distinctly defined and estimated. The BCIS standard form of cost analysis was adopted in this research because it is more elements oriented (see table 1).

Table 1: Historical cost breakdown structure of the operating and maintenance costs of office block, Penllergaer Business Park, Swansea, West Glamorgan

Costs (in £)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Fuel	21094	23098	27490	29874	31983	37894	41094	43098	47652	49847
Cleaning	12764	15097	17645	19836	20739	21735	23984	25408	27498	30763
Admin costs	6590	6945	7630	7953	8506	8943	9583	10984	11473	11847

iv.) Forecasting using ANN

The historical maintenance and operational cost data were forecasted using the Neural Networks fitting toolbox in MATLAB R2015a. ANNs are constructed with layers of units, and thus are termed multilayer ANNs. First layer of a multilayer ANN consists of input units known as independent variables, as well as output units known as dependent or response variables.

All other units are called hidden units. A multilayer perceptron (MLP) learned by back propagation algorithm is used for forecasting because it is a powerful system capable of modelling complex relationships between variables. It also allows prediction of an output object for a given input object and uses sigmoid and linear activation function for hidden and output layers and are universal approximates.

ANALYSIS AND DISCUSSION OF RESULTS

A training set of 30 values, a testing set of 20 target time steps while validation and testing target time steps of 5 values each were used for the ten year forecasting period (data acquisition). Training was set at 70% while cross validation was at 15% and testing was also at 15%.

The objective of the training is to establish weights that minimise errors as the output neurons first give a set of values that differ greatly from the correct results while the objective of cross validation and testing is to learn from examples and capture subtle functional relationships among the data even if the underlying relationships are unknown or hard to learn.

During training, both the inputs (representing problem parameters) and outputs (representing the solutions) are presented to the network normally for thousands of cycles. At the end of each cycle, or iteration, the network was used to evaluate the error between the desired output and actual output. This error was used to modify the connection weights according to the training algorithms used.

The determination of the number of hidden layers and nodes are crucial since if there are too many hidden layers the neural network will not learn the underlying pattern, while with too few the neural network will not pick up the full details of the underlying patterns in the data.

The training set was used to train the network in order to choose its parameters (weights) while the cross validation set was used for generalization that is to produce better output for unseen examples.

The best ANN model to estimate the operating and maintenance cost of buildings was determined by defining the number of neurons (nodes) in the input and output layers,

number of hidden layers and the number of neurons in each hidden layer. The model generated utilizes six input variables (factors affecting operating and maintenance costs) namely engineering services, building materials, budget and finance, skilled labour, building user behaviour, management and administration.

There is no specific rule in determining the number of hidden layers and the number of neurons in each hidden layer (Shtub and Versanob, 1999). For simplicity of the current problem, one hidden layer was used and the following rules were employed to determine the optimum number of neurons for a network (Oreta 2012):

- A network with n-input and m-output units requires a hidden layer with at most $2n+1$ units (Hecht-Nielson, 1998) is (13 neurons)
- Should be between the average and the sum of nodes on the input and output layers is (4-7 neurons)
- Seventy-five percent (75%) of the input nodes is (5 neurons)

After several trials, ANN Structure 6-7-1 (6- input variables, 7-nodes in the hidden layer, 1- output) was found to be the best model to estimate the total operating and maintenance costs of the building (see figure one).

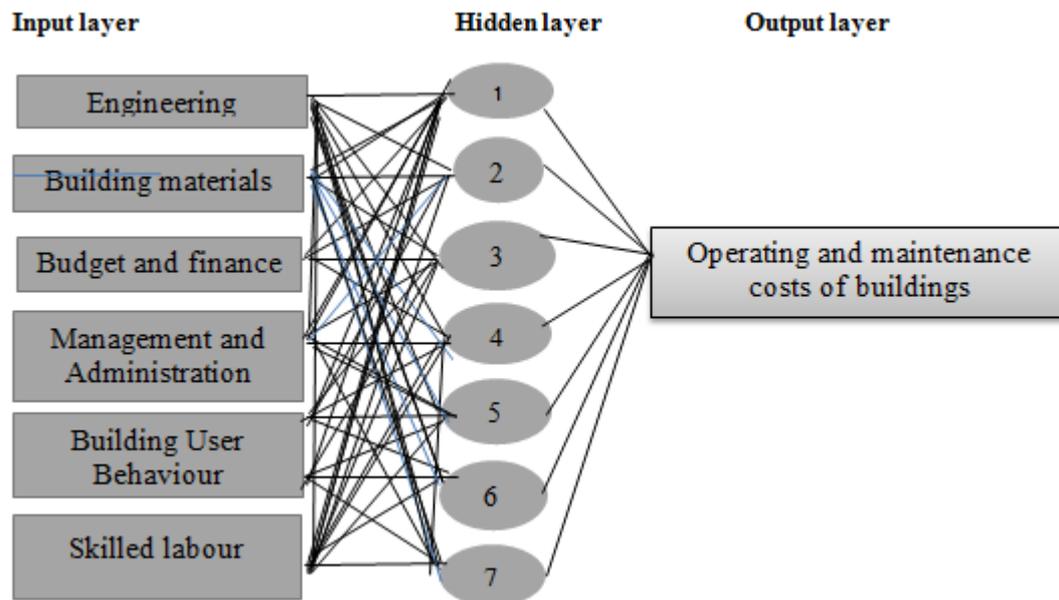


Figure one. 1. ANN Structure 6-7-1

The resulting coefficients and parameters are given in Table two along with the R squared value which indicates how close the relationship is between the dependent and independent variables. The backpropagation algorithm gradually reduces the error between the model output and the target output by minimizing the mean square error (MSE) over a set of training set (Gunaydin and Dogan 2004).

The MSE is a good overall measure of the success of the training process (Al-Tabtaba, et.al., 1999). The weights and bias values were updated according to the Levenberg-Marquardt network training function. This is often the fastest backpropagation algorithm and highly recommended, though it requires more memory than other algorithms (Neural Network Toolbox).

The Table two results show a strong linear relationship between the variables. The accuracy of the costs is favourable but it is important to take cognisance of the fact that a larger amount of data will produce better forecasted values.

Table 2: Regression and Mean Squared Error Analysis

	Regression	Mean Squared Error
Training	0.99985	2.41633
Training	0.99264	1.29839
Validation	0.99259	1.83725
Testing	0.99224	1.49321

Regression values measure the correlation between outputs and targets. An R value of 1 implies that there is a close relationship, 0 means there is a random relationship. The smaller the value of the regression is, the smaller the difference between the predicted time series and the actual one. The mean squared error on the other hand is the average squared difference between outputs and targets. Lower values are better while zero means no error. The values were close to zero thus exhibiting better performance results

For the case study, the training data indicated a good fit. The validation and test results also show R values that greater than 0.99. The next step in validating the network is to create a regression plot, which shows the relationship between the outputs of the network and the targets (see figure two). If the training was perfect, the network outputs and the targets would be exactly equal, but the relationship is rarely perfect in practice.

The following regression plots display the network outputs with respect to targets for training, validation, and test sets. For a perfect fit, the data should fall along a 45 degree line, where the network outputs are equal to the targets. For this problem, the fit is reasonably good for all data sets, with R values in each case of 0.993 or above.

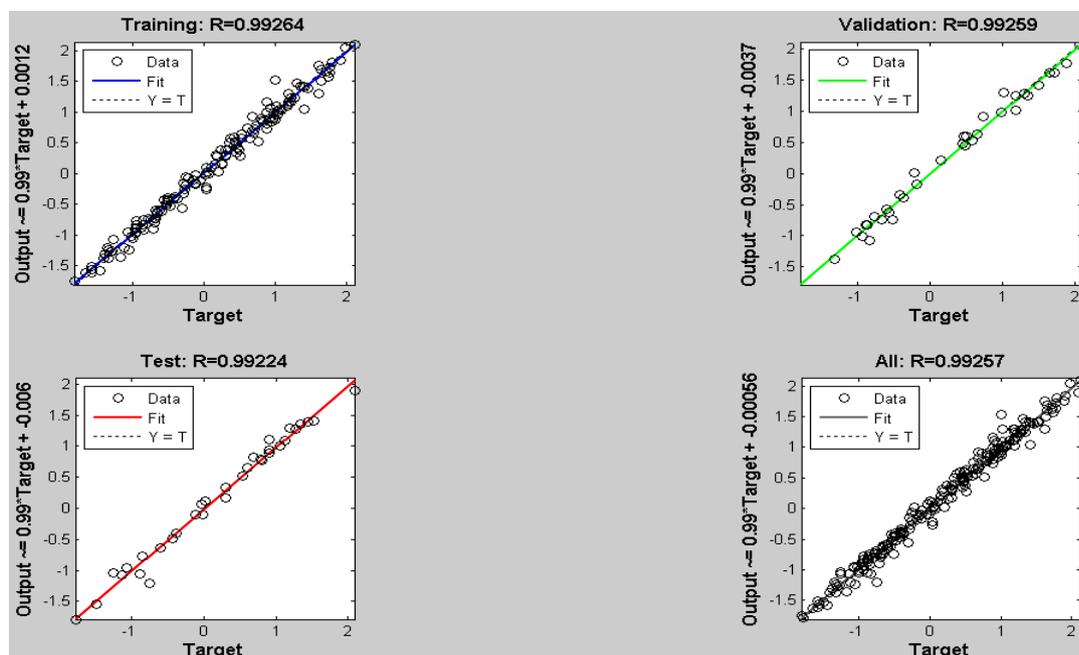


Figure two: Regression result

ERROR AUTOCORRELATION TEST

The following plot (see figure three) shows the error autocorrelation function. It defines how the forecast errors are interrelated in time. For a faultless prediction

model, there must only be one non-zero value of the autocorrelation function, and it ought to occur at zero lag.

This implies that the forecast errors were entirely uncorrelated with each other. If there was substantial relationship in the forecast errors, then it would improve the forecast possibly by increasing the number of delays in the tapped delay lines. For the case study, the correlations, but for the one at zero lag, fall roughly within the 95% confidence limits about zero, so the model is satisfactory.

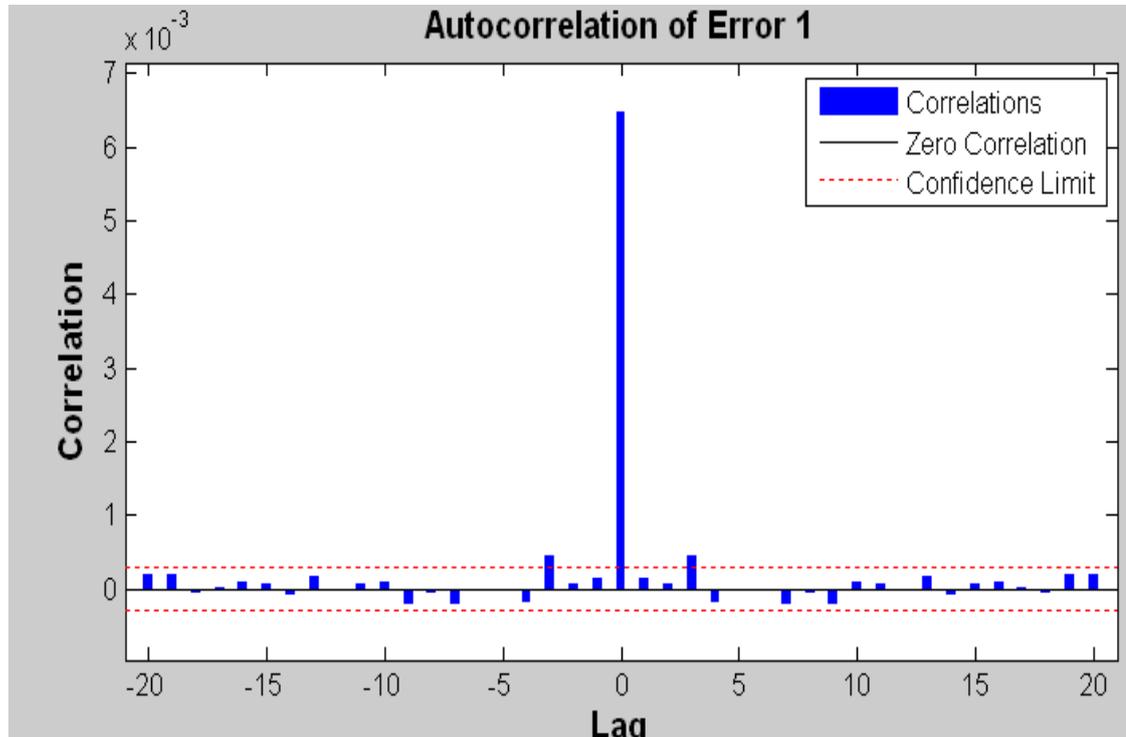


Figure three: Autocorrelation result

PERFORMANCE TEST

When the training was completed, the network performance was checked to determine if any changes needed to be made to the training process, the network architecture, or the data sets. First, the training record, *tr*, returned from the training function.

Then the cost *tr.best epoch* indicated the iteration at which the validation performance reached a minimum. The training for case study one continued for 6 more iterations before the training stopped. This result did not indicate any major problems with the training as seen in figure four.

Similarly, the validation and test curves are very similar. If the test curve had increased significantly before the validation curve increased, then it is possible that some over fitting might have occurred. This is however not the case in this model.

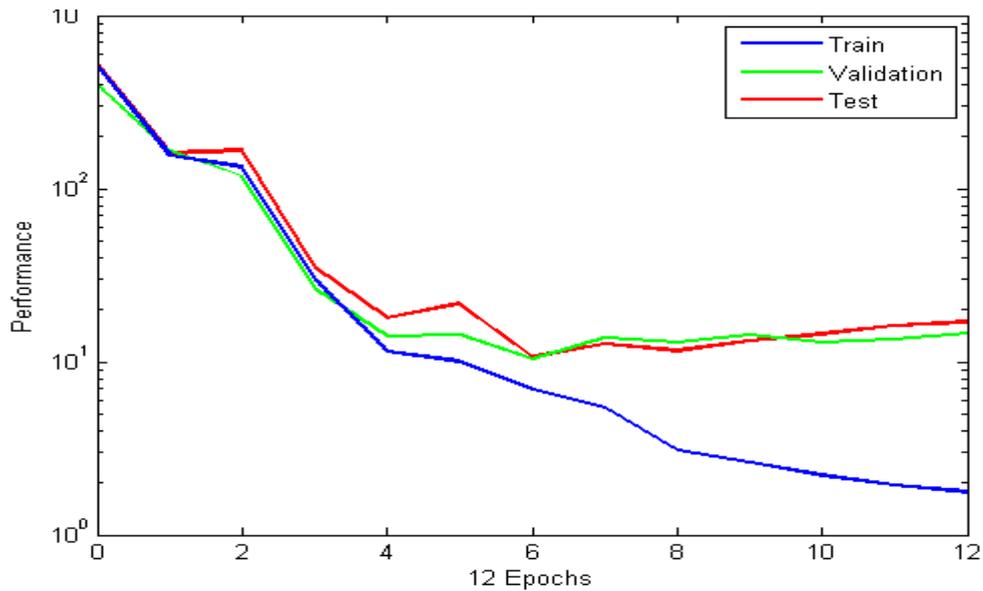


Figure four: Performance test.

Finally, a sensitivity analysis was carried out to study the influence of each input parameter on the performance of the ANN model to predict the cost of buildings (see figure five). The performed sensitivity analysis showed that the engineering services, building materials, budget and finance in the buildings are the most effective parameters influencing the cost estimates of buildings.

The remaining parameters had small effect on the estimated value but it is believed that their existence could be important to enhance the ability of the model to learn and generalize the results.

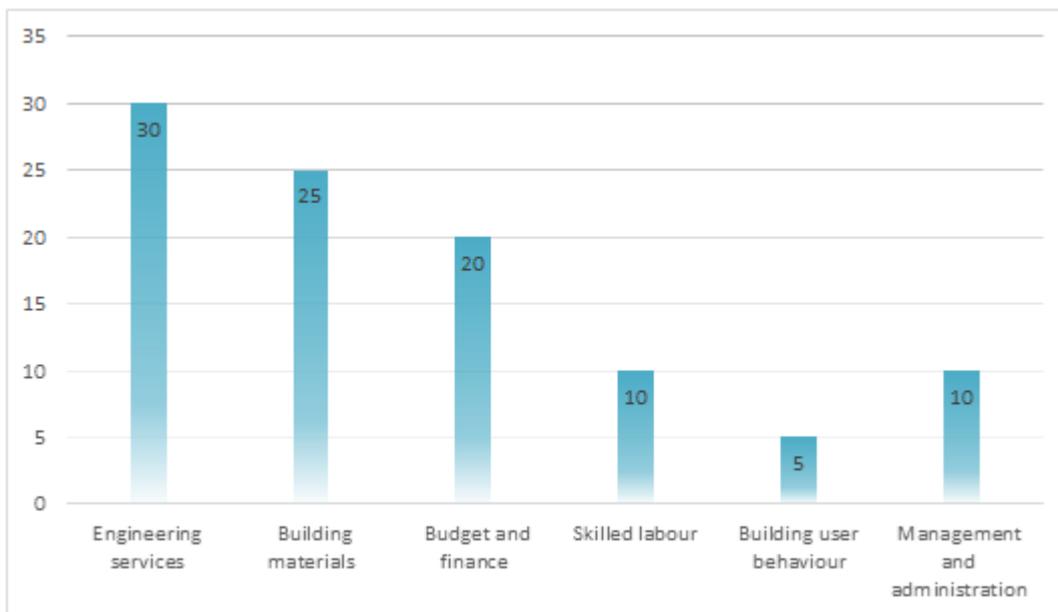


Figure five: Sensitivity measures of the input parameters on the output of the NN model

CONCLUSION

The value of LCC is its ability to provide more comprehensive and accurate cost predictions as there is an increasing realisation of the importance of considering operation and maintenance costs as opposed to capital costs throughout the life of an

asset. In addition, new initiatives such as Public Private Partnership (PPP) schemes are becoming more popular.

It is therefore vital to embed life cycle forecasting of a building during conceptual design assessment stage. The use of modelling in predicting costs should be used not only in the context described here but also as a tool for reducing future costs accumulation in buildings.

Occupants and facilities managers need to be made aware of how their actions can in the long term have a significant impact on operating and future costs. The results obtained from this exercise provide the researcher with a great deal of information about forecasting costs when modelling inputs into life cycle costing exercises.

The conceptual framework is generic and can thus be applied to any sustainable building, at any level from sub-elemental to the whole cost scenario. This study is different from previous ones in terms of the input parameters used and a different case study.

This paper further demonstrates that the development of a cost estimation model using ANN methodology is feasible. There is however the need to evaluate ANN with more projects for future developments

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NON-PARAMETRIC BILL-OF-QUANTITIES ESTIMATION OF CONCRETE ROAD BRIDGES' SUPERSTRUCTURE: AN ARTIFICIAL NEURAL NETWORKS APPROACH

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Bridge construction responds to the need for environmentally friendly design of motorways and facilitates the passage through sensitive natural areas and the bypassing of urban areas. However, according to numerous research studies, bridge construction presents substantial budget overruns. Therefore, it is necessary early in the planning process for the decision makers to have reliable estimates of the final cost based on previously constructed projects. At the same time, the current European financial crisis reduces the available capital for investments and financial institutions are even less willing to finance transportation infrastructure. Consequently, it is even more necessary today to estimate the budget of high-cost construction projects -such as road bridges- with reasonable accuracy, in order for the state funds to be invested with lower risk and the projects to be designed with the highest possible efficiency. In this paper, a Bill-of-Quantities (BoQ) estimation tool for road bridges is developed in order to support the decisions made at the preliminary planning and design stages of highways. Specifically, a Feed-Forward Artificial Neural Network (ANN) with a hidden layer of 10 neurons is trained to predict the superstructure material quantities (concrete, pre-stressed steel and reinforcing steel) using the width of the deck, the adjusted length of span or cantilever and the type of the bridge as input variables. The training dataset includes actual data from 68 recently constructed concrete motorway bridges in Greece. According to the relevant metrics, the developed model captures very well the complex interrelations in the dataset and demonstrates strong generalisation capability. Furthermore, it outperforms the linear regression models developed for the same dataset. Therefore, the proposed cost estimation model stands as a useful and reliable tool for the construction industry as it enables planners to reach informed decisions for technical and economic planning of concrete bridge projects from their early implementation stages.

Keywords: artificial neural networks, bill of quantities, concrete bridge, cost.

INTRODUCTION

Bridge construction increases through time as a response to the soaring urban and inter-urban traffic needs; in addition, developing social concern for traffic impact on the environment further contributes to the construction of new bridges. However,

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according to research studies such as Flyvbjerg *et al.* (2004), Odeck (2004), Flyvbjerg (2007) and Azhar *et al.* (2008), bridge construction presents substantial budget overruns. In this context and given the significant cost of a bridge, the decision makers need to have reliable estimates of the final cost, early in the planning process. This need is rendered even more imperative as due to the contemporary financial crisis, the available public funds for construction projects are decreasing. Furthermore, financial institutions are less willing to finance transportation infrastructure, due to their decreased liquidity in conjunction with the increased traffic risk (e.g. rise of oil price, reduction of users' available budget for tolls). Consequently, in these times, it is even more necessary to estimate the budget of high-cost construction projects -such as road bridges- with adequate accuracy in order for the State funds to be invested with lower risk and the projects to be designed with the highest possible efficiency.

Attending to the above need, this research paper introduces an ANN-based model which, utilising actual project data, achieves reliable estimation of the bridge superstructure material quantities and thus renders possible more accurate estimation of the bridge superstructure cost. The latter is achieved by multiplying the quantities predicted by the model with the unit prices specified by the user. The use of material quantities as a means to extract the cost instead of directly predicting the cost enhances the applicability of the estimation as material quantities are mostly based on the applied design codes representing international standards with wide acceptance and use across countries (e.g. DIN, Eurocodes, AASHTO). On the contrary, cost values are heavily influenced by country-dependent factors (e.g. tendering system, inflation rate) and require proper adjustment to be suitable for use outside a national context.

LITERATURE REVIEW

The management of the construction cost of concrete bridges has been the aim for numerous previous research. A review of publications on cost optimisation of concrete bridge components and systems has been presented by Sarma and Adeli (1998) and Hassanain and Loov (2003). Cost optimization models for bridges have also been developed by Lounis and Cohn (1993), Cohn and Lounis, (1994), Sirca and Adeli (2005). Furthermore, Aparicio *et al.* (1996) proposed a computer-aided design and cost estimating system addressing all elements of concrete highway bridges. Geographically limited bridge cost estimation guidelines have also been developed by the Departments of Transportation (DoT) of California (2011) and New York (2012).

Regarding the cost of different bridge sections, Menn (1990) highlighted the significant impact of the superstructure concluding that it contributes on average 54% of the total bridge cost while Fragkakis and Lambropoulos (2004) found that the superstructure accounts for 34 to 50% of the total bridge construction cost, depending on the design system and construction method used.

As far as the ANNs are concerned, their powerful capabilities for capturing and modelling complex interrelations in real-world datasets have been widely identified in the literature (Marinelli *et al.* 2014, Dimitriou and Hassan 2013, Karlaftis and Vlahogianni 2010, Lee *et al.* 2008, Moselhi *et al.* 1992) and their suitability for cost estimation of various construction projects like buildings (Kim *et al.* 2004), tunnels (Petroutsatou *et al.* 2012), highway projects (Hegazy and Ayed 1998) and drainage projects (Alex *et al.* 2010) has also been highlighted. In the area of bridges, Creese and Li (1995) applied ANNs to estimate the cost of timber bridges based on data collected from 12 projects. The volume of webs, the volume of the bridge decks and

the weight of steel were used as input variables for the prediction of the output variable namely the actual bridge cost. Similarly, Ugwu and Kumaraswamy (2004) developed an ANNs model trained with data from 74 highway bridges in Hong Kong with the aim to predict their construction cost. The input variables were the structure's location, the pavement material and the project configuration. Furthermore, Morcoux *et al.* (2001) developed an ANNs model with a back-propagation algorithm to estimate the concrete volume and pre-stressed steel weight of bridge superstructures. A set of 22 pre-stressed concrete bridges constructed in Egypt was used in training and testing the network. The fairly limited literature on the use of ANNs for bridge cost estimation can be attributed to the lack of suitable data i.e. large, reliable and homogeneous databases with actual data from constructed road bridges; the availability of such data is drastically restrained by the use of different design codes as well as the reluctance of public clients to supply financial information regarding constructed projects.

ANNs MODEL FOR BRIDGE BOQS ESTIMATION

Data collection

The data used for the development of the model were collected from the final BoQs of 68 bridges of a major motorway project constructed in northern Greece between 1996 and 2008. The designs were all carried out by Greek and international structural design firms following international competitions and were in compliance with the German DIN standards and Greek regulations for earthquake loading. A thorough three-stage review process was applied to all designs before construction.

In order to collect and record the characteristics of each construction project, a list of questions was prepared requesting general information (e.g. location, highway section and design office), the bridge's fundamental design parameters (e.g. number of spans, construction method used, length of each span, width) and the quantities of concrete, reinforcing steel and pre-stressed steel for each span. The questions were initially answered by the construction managers/supervisors responsible for each project and the contractor's civil engineers. After scrutinising the replies, the authors visited several construction sites, in order to check and confirm the validity and accuracy of the data provided.

The final database covers a wide range of bridge characteristics including various landscape profiles (mountainous, flat terrains, significant slopes, etc) and different construction methods. Specifically, three different construction methods leading to a different type of bridge are represented in the sample as per Table 1.

Table 1. Characteristics of the structures included in the database

Construction Method	Type of Bridge	Number of bridges	Number of spans
1	precast pre-stressed beams with composite slab	31	47
2	cast-in-situ deck	22	47
3	cantilever construction	15	33

Apart from the construction method/type of the bridge, the database also includes the material quantities of concrete (Vc), reinforcing steel (Bs), pre-stressed steel (Bp) as well as basic design parameters such as the length of the span or cantilever (l) and the

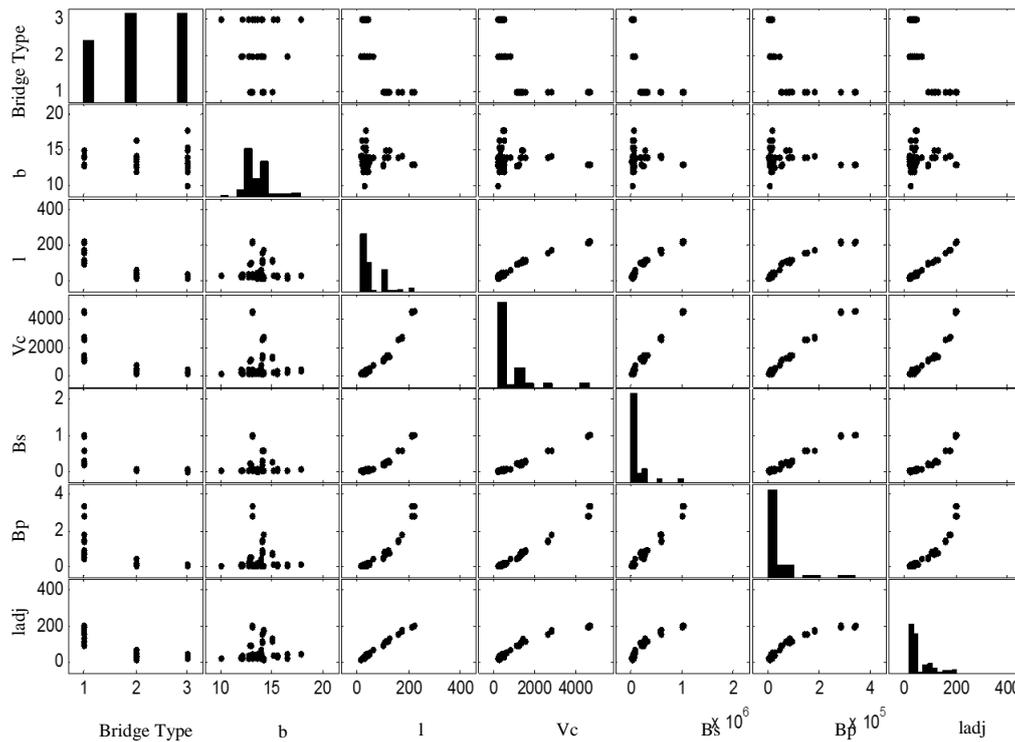
deck width (b). In order to take into account the difference of deck width among the bridges of the data sample, an adjusted length of the span or cantilever was also defined (l_{adj}) as a function of the median value of the deck width for each construction method in the sample (b_{med}) as per eq.1. This value equals 13.10 m for superstructures with precast beams, 13.50 m for superstructure with cast-in-situ box girders and 14.00 m for cantilever construction.

$$l_{adj} = l * \frac{b}{b_{med}} \tag{1}$$

Data multivariate analysis

A multivariate analysis was undertaken to offer a better understanding of the complexity of the interrelations between the aforementioned variables of the dataset bridge type, b, l, Vc, Bs, Bp, l_{adj}. The matrix of the correlation diagrams provided in Fig. 1 provides a better picture of how the variables co-relate e.g. the plot of the down left corner shows how the variable l_{adj} varies within each one of the three bridge types available. The various correlations presented in Fig. 1 reveal that there are pairs with an obvious (mostly nonlinear) trend and others with no obvious correlation, though an underlying pattern in the dataset can be initially assumed.

Fig 1. Correlation diagram matrix of the sample bridge variables.



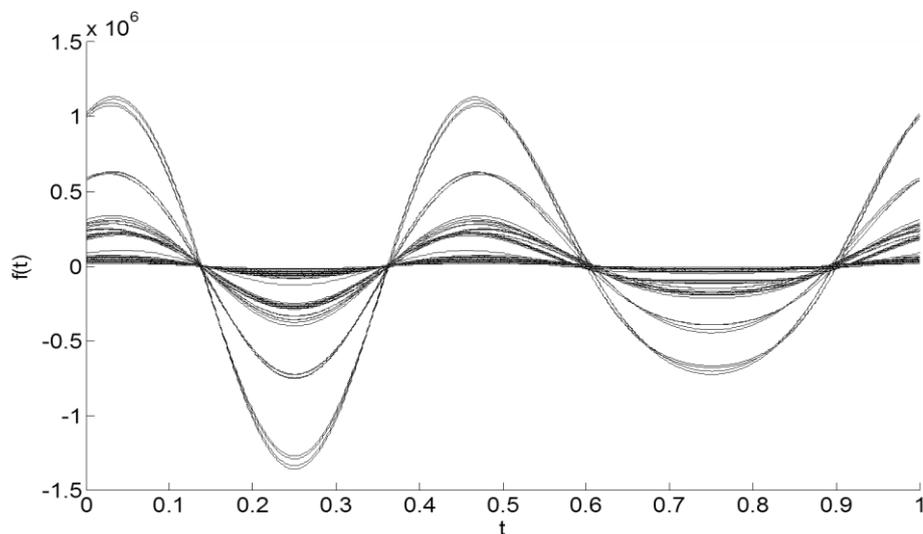
For further investigation of the correlations in the available dataset, the multivariate analysis based on Andrews plots (Andrews 1972) was conducted (Fig. 2). Andrews plots provide a statistically sound way to depict multivariate datasets and get insights on possible correlations (Khattree and Naik 2002) but does not provide the exact nature of these correlations. Further information about Andrews plot can be found in Garcia-Osorio and Fyfe (2006). In the specific form of the Andrews plot used in the present study, each observation i, is represented by a function f(t) of a continuous

dummy variable t over the interval $[0,1]$. Function $f(t)$ is defined for the i -th observation in the dataset X as follows:

$$f(t) = X(i,1)/\sqrt{2} + X(i,2)/\sin(2\pi t) + X(i,3)\cos(2\pi t) + \dots \quad (2)$$

The projection of all observations in a comprehensive way facilitates the identification of patterns (similarities among multivariate data) as well as outliers in the dataset. Specifically, in varying the value of t in eq.2, we are moving along the curve; data points which are similar will behave similarly in that the locus of their movement will be similar. As depicted in Fig. 2, the Andrews plot analysis, identifies at least four clusters in the dataset, offering evidence on correlations which could be further investigated by means of non-linear regression models. Therefore, the above presented identification of some pattern among the data provides incentives for developing a nonlinear model for bridge BoQ estimation and testing its performance on real-world dataset. As already mentioned, the modelling approach will be based on ANNs and is presented in the following section.

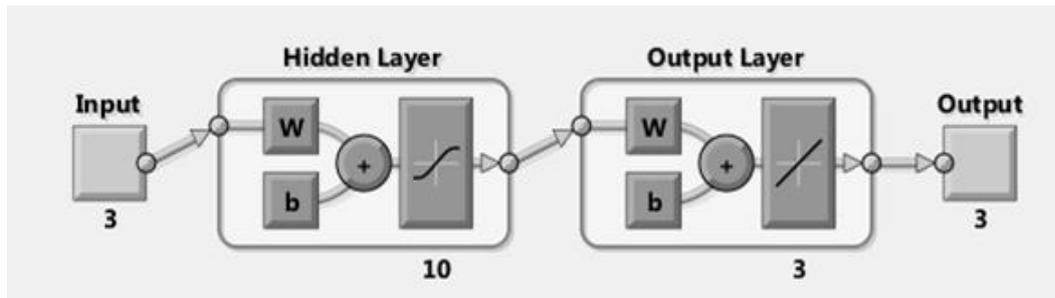
Fig 2. Andrews plot for the complete bridges dataset.



Application of the Feed-Forward Artificial Neural Network on the Dataset

The available dataset was used for the training of an ANN based on a Feed-Forward setup (FFANN). The structure of the FFANN is presented in Fig. 3, where the deck width in meters (b), the adjusted length of span or cantilever in meters (l_{adj}) and the categorical variable representing the bridge type (Type) are fed as inputs to a hidden layer of 10 nonlinear neurons each of which has a log-sigmoid transfer function. Three linear functions for estimating the volume of concrete in m^3 (V_c), the weight of reinforcing steel in kg (B_s) and the weight of pre-stressed steel in kg (B_p) form the output layer of the ANN.

Fig. 3. A standard depiction of the selected ANNs structure.



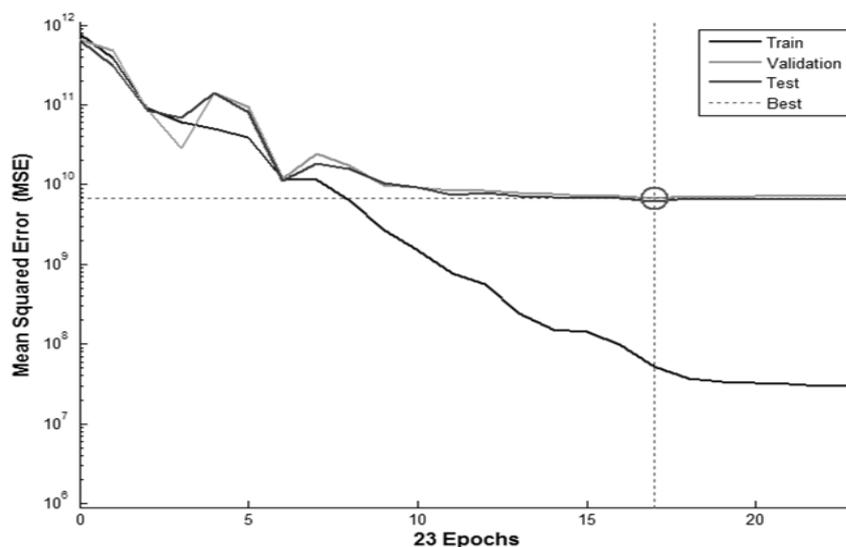
Several FFANN structures with differing size and transfer functions were tested, but the one selected exhibited better characteristics concerning the over-fitting and generalisation abilities trade-off. This type of FFANN has several advantages including being straightforward, powerful in mapping nonlinear interrelations within datasets, able to treat both continuous and categorical (integer) data and easy for coding and testing.

The training process of the selected FFANN was based on the Levenberg-Marquardt routine of nonlinear optimisation. In particular, the dataset was divided in three parts, namely, for training, validating and testing into typical proportions of 70%, 15% and 15% respectively. The training set was used by the optimisation routine to update the weights of the connections between the layers with the aim to minimise the Mean Squared Error (MSE) between observations and predictions.

Then, the validation set was used to test the trained model against over-fitting /memorisation. Specifically, if a model performs satisfactorily during the training process but the error increases in validation, this indicates that the model ‘memorises’ instead of capturing the underlying correlations among variables.

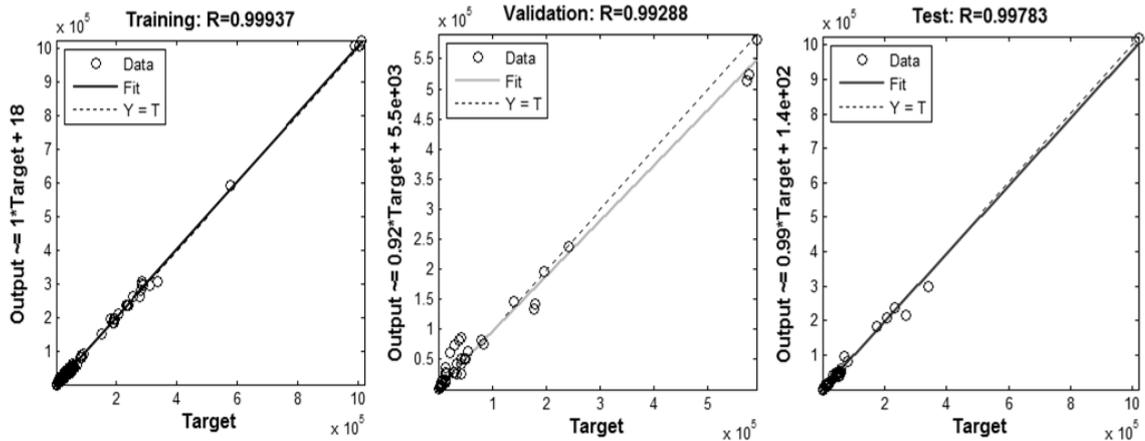
Finally, the test set was used for unbiased evaluation of the model’s performance. In Fig. 4, the convergence diagram of the calibration process for the complete dataset is presented, exhibiting the capability of the calibrated (starting from a random state) FFANN to model the interrelations among the dataset variables with a small error component ($<10^8$), as measured by the MSE metric.

Fig 4. Convergence diagrams of the selected ANNs training process.



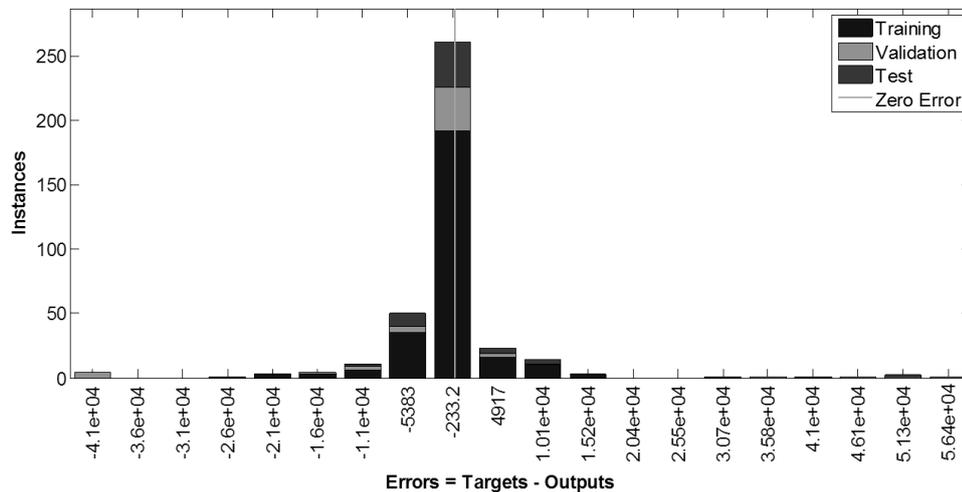
The performance of the proposed FFANN can be further exposed by the correlation diagrams for the three sets (training, validating and testing), presented in Fig 5. It can be observed that the selected model setup and its calibration are liable to estimate bridge superstructure BoQ with notable accuracy, since the correlation of predictions and observations is very high ($R \sim 0.99$) for all sets. This is a clear indication of the model's value for practical purposes.

Fig 5. Performance analysis of the selected ANNs.



Moreover, the almost normal distribution of the errors for the three sets (training, validation and test sets) presented in Fig. 6, further supports the reliability of the calibration process as this type of error distribution suggests unbiased estimation capabilities of the model.

Fig 6. Distribution of errors for the database used (distinguished in training, validation and test sets).



Comparative statistics

In order to check the performance of the proposed model, apart from the goodness-of-fit tests already presented, comparative statistics with standard regression models were also performed. In particular, the proposed ANN model was compared against the parametric linear regression models developed in Fragkakis *et al.* (2010) for the same dataset and for each construction method. The comparison process concerned the same test subset i.e. the 15% of bridges from each of the three construction methods.

Two metrics of goodness-of-fit were used, the adjusted coefficient of determination (R²), which typically provides a measure of the variability explained by the models, and an error metric, the Mean Absolute Percentage Error (MAPE). This combination of metrics provides a clear picture of the accuracy of the alternative tests. As observed in Table 2, the ANNs model outperforms all the three linear regression models in both metrics. Similar performance superiority of the ANNs over linear regression has also been reported by Creese and Li (1995) for their timber bridge cost prediction model.

Table 2. Comparative statistics for the alternative regression methods for each construction method.

	Precast Beams		Cast-in-Situ		Cantilever	
	R ²	MAPE (%)	R ²	MAPE (%)	R ²	MAPE (%)
Linear Regression	0.967	12.29	0.952	16.82	0.956	16.36
ANNs	0.979	11.48	0.995	13.94	0.981	16.12

CONCLUSIONS

The development of large-scale road transport projects in the current financial circumstances requires reliable cost estimates in the preliminary design phases where the most influential cost-wise decisions are taken. Aiming to support these preliminary decisions, the current paper presented a contemporary, robust and reliable model for bridges superstructure cost estimation. The estimation is achieved by multiplying the properly selected unit prices per material with the superstructure material quantities (concrete, pre-stressed steel and reinforcing steel) which the ANN predicts following proper calibration with data from 68 recently constructed concrete bridges. Input variables for the ANNs model are the deck width, the adjusted length of span or cantilever and the type of the bridge (with precast beams, with cast in situ deck or cantilever construction). As demonstrated, the developed model captures very well the complex interrelations in the dataset providing reliable estimations of the final quantities for bridges and demonstrating strong generalisation capability. The performance of the proposed ANNs model was further compared against the performance of linear regression and it was clear that the ANNs led to improved results in terms of accuracy. Therefore, the proposed cost estimation model stands for a useful and reliable tool for the construction industry as it enables planners to reach informed decisions for technical and economic planning of concrete bridge projects from their early implementation stages. Furthermore, the proposed model provides evidence of the potential usefulness of ANNs in cases of civil infrastructure planning and design as similar databases and cost estimation models could be developed for the remaining bridge sections (piers and foundations) and other road infrastructure elements (e.g. culverts). Moreover, this particular artificial intelligence computational paradigm is suitable for integration in the currently available design and management infrastructure software and thus, this research also makes a valuable contribution to the construction software industry.

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SPOTLIGHT ON CONSTRUCTION COST OVERRUN RESEARCH: SUPERFICIAL, REPLICATIVE AND STAGNATED

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Construction projects routinely overrun their cost estimates. A plethora of studies have thus been dedicated to investigating the root causes, sizes, distribution and nature of overruns. The causes range from a poor understanding of the impact of systemicity and complexity projects, unrealistic cost targets and misguided trade-offs between project scope, time and cost to suspicions of foul play and even corruption. In spite of the vast attention dedicated to the problem of cost overrun, there has been limited evidence to support the claim that the size or occurrence of cost overruns is reducing in practice. A review of the literature reveals that it may not be an exaggeration to claim that the bulk of our current cost overrun research may be largely inadequate and deficient to deal with the complexity posed by construction projects. This paper provides a critique of current cost overrun research and suggests that the adoption of systems thinking is required to better understand the nature of cost overruns. We explore some of the embedded methodological weaknesses in the approaches adopted in a majority of cost overrun research, particularly the lack of systems thinking and demonstrable causality. We reach the following conclusion - cost overrun research has largely stagnated in the refinement and advancement of the knowledge area. It has largely been superficial and replicative. A significant paradigm and methodological shift may be required to address this perennial and complex problem faced in construction project delivery.

Keywords: causality, cost overrun, cost control, project performance, replication, research method, systems thinking.

INTRODUCTION

Cost estimates prepared in the early stages of a project allow a client to evaluate most economical tenders, secure funding or perform a cost-benefit analysis. These estimates also often become the basis for cost control during project delivery. Where the project is a commercial asset, the initial capital investment to deliver the project must be balanced with the cost of maintenance and operations over the life-time of the project to ensure it remains profitable and that planned returns on investment are achievable. Thus, decisions made during the formative stages of a project carry far-reaching economic consequences and can seal the financial fate of a project. Effective cost

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planning, therefore, relates design of buildings to their cost, so that while taking full account of quality, risks, likely scope changes, utility and appearance, the cost of a project is planned to be within the economic limit of expenditure.

Unfortunately, construction projects regularly still make the news headlines, not for being remarkable engineering accomplishments that will support and stimulate economic growth and social integration of communities, but rather for being poorly managed and often over budget. A significant number of construction projects routinely overrun their cost estimates. According to the works of Flyvbjerg *et al.* (2002), infrastructure projects are reported to have an 86% probability of outrunning their set cost targets. The average size of these overruns can be as high as 45% for rail projects, 34% for bridges and 20% for road projects. Love *et al.* (2012) and Odeck (2004) on the other hand found that overruns could be as high as 70% and 183% more than the initial estimate respectively. The global audit and professional services firm, Ernst and Young, reviewed the performance of 365 infrastructure projects delivered in the oil and gas industry and found that at least 64% of the projects were faced cost overruns to varying degrees. The projects recorded an average cost overrun of 59%, representing an incremental cost of US\$500 billion in real terms (Ernst and Young 2014). Merror (2012) also found that up to 78% of oil and gas projects face significant cost overruns at an average of 33%.

Cost overrun has been attributed to several sources including scope creep and rework (Love *et al.* 2005), unrealistic cost targets and misguided trade-offs between project scope, time and cost (Ahiaga-Dagbui and Smith 2014b), a poor understanding of the systemic and dynamic nature of projects (Eden *et al.* 2005), unidentified or improperly managed risk and uncertainty (Okmen and Öztas 2010) to suspicions of foul-play and corruption (Wachs 1990).

A review of the construction management literature, however, reveals that a plethora of studies have been dedicated to understanding the problem of cost overruns (Morris 1990, Flyvbjerg *et al.* 2004, Odeck 2004, Ahiaga-Dagbui and Smith 2013, 2014a, Love *et al.* 2015). Most of these studies usually identify several purported causes of overruns and often make recommendations for mitigating and containing the phenomenon. However, there seems to be no evidence of alleviating the problem or improving the reliability of cost estimates for construction projects. The industry may have earned itself the unenviable repute of delivering projects late and over budget, again and again, leaving clients dissatisfied and the tax-payer often out of pocket.

So, why are cost overruns so prevalent in the construction industry irrespective of the attention it gets both in academia and practices? Why has there not been much improvement in the *reliability* of initial cost estimates over the years? Surely the industry has become a lot better at managing projects. Procurement systems have greatly evolved from traditional adversarial design-bid-build to different forms of collaborative and relationship contracts. There are more measures now for accountability and cost control for project procurement. Information technology for construction has also improved significantly with the advent of Computer Aided Designs (CAD) and Building Information Modelling (BIM). There are now online collaborative platforms for effective communication, design, visualisation, simulation, control and coordination of the entire construction process. There appears to be growing take-up of digital 3D design and even 4D models that integrate the spatial and temporal aspects of a project to understand, predict, evaluate and manage even the most complex projects. Most of these IT systems support project cost estimation as

well as allow for the use of estimation software and advanced costing methods like feature-based estimation, genetic algorithms or fuzzy logic.

It is against this backdrop, this paper provides a critique of current cost overrun research and a nudge towards adoption of systems thinking in dealing with construction cost overruns. The paper will explore some of the embedded methodological weaknesses in the approaches adopted in a majority of cost overrun research, particularly the lack of systems thinking and demonstrable causality as well as the over-simplification of the cost overrun problem and replication. The paper concludes with some recommendations regarding the future direction of cost overrun research and mitigation.

COST OVERRUN RESEARCH: SIMPLISTIC, SUPERFICIAL AND REPLICATIVE

As already alluded to, there is no shortage of research dedicated to understanding the problem of cost overruns or making recommendations on how to alleviate this perennial problem in the construction industry. On the whole, this is commendable and should be further encouraged. However, there seems to be no evidence of real improvements in the reliability of initial cost estimates or the predictability of final cost, even with the use of new technologies available to construction experts. A critical review of the literature however quickly reveals that it may not be an exaggeration to claim that the bulk of our current research may be largely inadequate and deficient to deal with the complexity of construction cost overruns. Worryingly, it would seem that most studies are rather simplistic and superficial, replicative and not been cumulative enough to be effective in addressing the problem. On close scrutiny also, there would seem to be stagnation in the rigour and thoroughness of cost overrun research.

Memon *et al* (2012) undertook an investigation into the 'causes' of cost overrun in large construction projects in Malaysia. Using the extant literature, they first identified 35 different factors that could lead to cost overrun and then required of *clients, consultants and contractors* to rank these factors on a five-point Likert scale from 'not significant' to 'extremely significant'. These factors include 'poor project management', 'lack of coordination between parties', 'mistakes during construction' and 'slow information flow between parties'. A relative importance index, defined in equation 1, was then used to weight these factors. The strength of correlation between the various factors was also measured using the Spearman's rank correlation, ρ , to add some statistical rigour to the study.

$$\text{Relative Importance Index} = \frac{\sum_1^5 w.x}{A.N} \quad \text{----- Equation 1}$$

Where

w = weighting given to each factor by respondents

x = frequency of response given for each cause

A = highest weight (i.e. 5 in this case)

N = total number of participants

Out of the 150 questionnaires distributed, 103 were returned with 97 valid. Fluctuation in prices of materials, contractor cashflow problems and client payment delay were

the top three 'causes' of overrun. Respondents were also required to recall the approximate extent of cost overrun (cost beyond contract sum) for the projects they were involved with within the past ten years. A majority (61%) of the respondents reported a range of 5% to 10% of contract sum. About 20% recalled overruns beyond 20% of contract sum.

This approach to cost overrun research is not untypical at all- Kaming *et al* (1997), Ameh *et al.* (2010), Mansfield *et al.* (1994), Jackson (2002), Enshassi *et al.* (2010), Durdyev *et al.* (2012), Rosenfeld (2014) and many others have all conducted almost identical studies. A careful scrutiny of most of the studies aforementioned, reveal some common pathologies in much of cost overrun research:

1-Lack of systems thinking

This is perhaps the most common shortcoming in the methodological approach adopted in cost overrun research. Most studies identify single points in a causal chain where an intervention may have reasonably been implemented to change performance and prevent an undesirable outcome. This includes past research by some of the authors of this current paper (AandB) as well as studies by Odeck (2004), Durdyev *et al* (2012), Flyvbjerg *et al* (2004) and Mansfield *et al.* (1994). The identification of singular causes, which in most cases only describe the proximal causes, is counterproductive, as overrun causation can only be understood by looking at the whole project system in which it occurs and how variables dynamically interact with one another. Problems very seldom occur as stand-alone issues. Even though they may superficially appear to be different, sources of poor performance on construction projects are very much interrelated, sometimes in rather complex ways. The crucial skill in understanding cost overrun is not the ability to list or rank factors but the capacity to see connections and the dynamics between the various sources. Hamilton (1997) outlines two important properties of systems thinking that would be useful in cost overrun research - every part of a system has properties that it loses when separated from the system and every system has some essential properties that none of its parts do. Thus, when a system is taken apart, it loses its essential properties (Von Bertalanffy 1956).

Singular cause identification approach is perhaps based on a faulty understanding of the nature of construction projects in general. As suggested by Rodrigues and Bowers (1996), traditional approaches to investigating project management related problems usually assume that if each element of the project can be understood, then the whole project may be controlled and delivered effectively. Of course, this approach has yet to help project managers deliver their projects on budget and agreed timescales. It is important to therefore to adopt a systemic, or causal loop approaches when investigating complex problems like cost overruns particularly in large public projects. Boateng *et al* (2013) and Ackermann *et al* (2007) have both applied this systemic approach for identification and modelling risk in project delivery.

2-Illusion of causality - correlation does not mean causality

A significant number of cost overrun research set out to identify the so-called 'root causes' of the problem but invariably only end up scratching the surface of this complicated problem. Finding strong correlations between factors does not mean the factors are *causes* of the phenomenon under study. For example, the fact that high 'graffiti' (Skogan 1990) and 'broken window' neighbourhoods (Wilson and Kellig

1982) correlate rather strongly with high crime levels does not mean that graffiti or broken windows *cause* the crimes. The next example borders on the absurd, but aptly sustains the argument being developed. Since 1883, eight Pontiffs have died, five in Grand Slam years of the Six Nations rugby tournament. This led to the conclusion that “*every time Wales win the rugby grand slam, a Pope dies, except for 1978 when Wales were really good, and two Popes died*” (Payne *et al.* 2008). [Note: the authors of the Pope study did not intend the findings to be taken seriously, but it supports point nonetheless. There was no Papal death the last time Wales won in 2008 anyway].

Just because two things strongly correlate does not necessarily mean that one *causes* the other. This would seem readily obvious, but can be easily overlooked. A correlation provides circumstantial evidence implying a causal link, but the weight of the evidence depends greatly on the particular circumstances involved. Ubani *et al.* (2013) set out to investigate factors that cause cost and schedule overruns in Nigeria. They developed a questionnaire based on “*110 hypothetical cost overrun*” factors identified from the literature. The returned questionnaires from respondents were then analysed by measuring relative importance and correlation coefficients. They found that material related issues, including price fluctuation and shortages were the main causes of overrun. They rejected the hypothesis that contractual relationships, labour and design had any significant influence on cost overrun. They then recommended that clients, contractors and consultants “*should pay more attention to both material and external factors for there to be effective and efficient delivery on construction projects at the right time and cost.*” It is readily obvious the lack of demonstration of causation between the factors identified or the superficiality of their approach and recommendation. The reader is invited to take a closer look at the formulation of the following studies to see if *causation* has been sufficiently demonstrated to warrant their paper titles: “*Significant factors causing cost overruns in telecommunication projects in Nigeria*” (Ameh *et al.* 2010); “*Causes of construction cost and time overruns: The 2010 FIFA World Cup stadia in South Africa*” (Baloyi and Bekker 2011); “*What causes cost overrun in transport infrastructure projects?*” (Flyvbjerg *et al.* 2004) and “*Causes of delay and cost overruns in Nigerian construction projects*” (Mansfield *et al.* 1994).

3-Ambiguous and Superficial Factors

Poor project management, lack of coordination between parties, mistakes during construction and slow information flow between parties are some of the factors used in the survey by Memon *et al.* (2012). Others like inadequate control procedures, slow decision making, waiting for information or poor documentation used in Frimpong *et al.* (2003) are rather too ambiguous. They could be easily be misinterpreted by the respondents especially if they are all not thinking within the context of a particular project or situation. The reader is invited to pause for a moment here and think through the factors “*poor project management*” and “*poor documentation*”. It is very likely that several interpretations, scenarios or examples came to mind in that exercise. This may be a quick indication that such factors are rather too superficial and therefore must be broken down further if real sources of overrun are to be identified. Questionnaires may be a quick and easy way of sampling the views of respondents but can also be problematical if the researcher’s definition of a factor does not correspond with the respondent’s understanding.

Unless they were perhaps used in a structured case study, for example, it is argued that questionnaires alone may not be suitable for investigating complex and systemic problems like cost overrun on construction projects. Good project management or efficient document management will mean very different things to respondents. The factors are simply too high level to help in getting to the heart of the problem itself. Interviews allowing the surfacing of deep tacit knowledge and also enabling the capture of relationships can provide a much more comprehensive and effective representation of the situation.

4-Cross Perspective

To further complicate matters, respondents are often drawn from different professions in the industry. On first thought, this may seem a prudent approach as it helps to investigate the problem from different perspectives. However, both Durdyev *et al* (2012) and Memon *et al* (2012) for example, surveyed clients, consultants and contractors without controlling for the different perspectives of these professional. It might be agreeable that the perceived sources, sizes or nature of overruns will be significantly vary depending on whether the construction profession works for a client or the contracting firm, or whether they work in the public or private sector. It probably may be best to survey these groups separately than merge all their responses into one. This problem of context and cross-perspectives could at least be partially addressed by using structured case studies as all respondents would be reviewing the same project(s). The findings of this kind of study would usually be more revealing than a generic questionnaire without any context or background.

5-Availability Heuristics

Heuristics are mental shortcuts that help us make decisions and judgments quickly without investing a lot of time analysing information. One such heuristic is termed the *availability heuristic*. According to Gilovich *et al* (2002), availability heuristic is employed when someone estimates the frequency or probability of an event based on the *ease* with which instances or associations could be brought to mind. Even though heuristics can be extremely helpful, they can easily become a hindrance to deep and careful thinking. In their seminal work on heuristics, Tversky and Kahneman (1973) posit that availability can often be affected by various factors which are completely unrelated to the actual frequency or probability of the event under review- how busy the respondent is, their interest in the subject under study, level of experience, peculiarities of the most salient examples they can recall, their understanding of the questions in the survey or the time available to complete a questionnaire. Tversky and Kahneman (1973) thus warn that if availability is applied to the analysis of an event, these factors “*will affect the perceived frequency of the classes and the subjective probability of events. Consequently, the use of the availability leads to systematic biases*”.

Without a carefully designed research and established context of projects being evaluated, results of the questionnaires, such as the ones conducted in (Ameh *et al*. 2010, Durdyev *et al*. 2012, Memon *et al*. 2012) become slightly problematic. It is no surprise that the same factors seem to come top of the list most of the time in these surveys - poor estimation, poor project management, inadequate risk management, unexpected ground conditions, scope changes or material price changes. These are the

usual suspects and they come to mind very readily for respondents. It will take more thoughtful research design, perhaps research conducted within the context of a particular project, to be able to partly circumvent these default responses that have yet to help mitigate or contain cost overrun in construction.

6-Replicative

Finally, replication, the performance of another study to statistically substantiate, or challenge, a hypothesis has significant value for research and therefore has been the cornerstone of scientific and social studies. It is based on a simple concept: “*trust, but verify*”. Where a replicative study results in different findings, it may indicate that the original hypotheses may have been incorrect or only partially correct, and that an alternative formulation may be able to reconcile apparent divergent results.

Replication is therefore essential in helping to establish or disprove causal inferences, determination of generalisability of findings and even spur on new research. When carried out in a cumulative manner, it helps to build on previous studies and facilitates a better understanding of a phenomenon.

For cost overrun research, however, replication has largely been a case of reinventing the wheel - doing the same thing over and over. Edge (1995) aptly describes this sort of research as “*the mass production of a standard product*” lacking in “*intellectual expansion*” of the field. However, expansion in depth and detail of cost overrun research must take priority of mere quantity and bulk. Albeit with a slight variation in context, there has been little methodological advancement in the studies by Mansfield *et al.* (1994), Kaming *et al.* (1997), Jackson (2002), Ameh *et al.* (2010), Enshassi *et al.* (2010), Memon *et al.* (2012) and Durdyev *et al.* (2012). They mostly draw-up a tall list of supposed 'causes' of overruns in a questionnaire and require of respondents to rank them using their perceived frequency or importance. It comes at little surprise that Flyvbjerg *et al.* (2002) observed in their seminal studies that that the size of overruns have not reduced over the 70 years that they studied. They also concluded that “*no learning that would improve cost estimate accuracy seems to take place.*” That may well be partly due to the stagnation in rigour and robustness of research dedicated to ameliorate the problem. In some ways, we might just be where we always were, and always will be if there are no significant paradigm and methodological shifts in cost overrun research.

CONCLUSIONS

We have explored some of the methodological deficiencies in the approaches adopted in a majority of cost overrun research. These include a poor understanding of systemicity and embeddedness of the sources of overruns, a lack of demonstrable causality and superficiality of the research design. We find that cost overrun research has largely stagnated in the refinement and advancement of the knowledge area - the bulk of it has largely been replicative. We would particularly like to highlight the lack of systems or holistic thinking in cost overrun studies, which invariably leads to the identification of single points in a causal loop of sources. We argue that this approach is a flawed simplification of the cost overrun problem and rather counterproductive. Overrun causation can only be understood by looking at the whole project system in which it occurs and how several variables dynamically interact with each other. It may be important to reiterate here that the crucial skill in understanding cost overrun is not

the ability to list or rank factors but the capacity to see connections and the dynamics between the various sources. It is suggested that significant paradigm and methodological shift may be required to properly understand the nature and sources of cost overruns. System dynamics or causal loop mapping, used in combination with structured-case studies, may be a better approach to investigating the cost overrun problem.

Finally, it may be worth mentioning that this paper was not meant as an attack on the works of respectable colleagues but an attempt to look intently at our collective efforts and map-out future directions for cost overrun research that effectively combines criticality and robustness. This is particularly important and timely especially against the backdrop of overwhelming evidence that cost overrun is as much a problem today as it has been decades ago. Besides, what is the benefit of doing the same thing over and over again if it is not yielding transformative results anyway?

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DESIGN

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VISUALISATIONS AND CALCULATIONS OF SPACES: NEGOTIATING HOSPITAL DESIGN DURING ON- BOARDING

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There is a complex relationship between the use of visualisations, and the production of both designs and physical spaces. In the case of hospitals, technical, aesthetic and practice-based requirements are incorporated into negotiations around facilities, layout and operation, and a plethora of stakeholders are engaged in the process. This paper describes a case of the ‘on-boarding’ phase in the design of a new hospital in North Zealand, Denmark. It describes the use of various visualisations in the engagement of actors concerned with managing the budget and delivering the building programme as well as the eventual users of the hospital. It reveals how visualisations are mobilised to form different and overlapping types of spaces. These are described as economic spaces, concerned with maintaining the economic budget frame, when the client organization is communicating the project and the design to healthcare practitioners at the hospital; design spaces, which include forms of user involvement, when the design team is developing and testing a methodology for engaging with medical staff; organizational spaces, concerning the connection between new physical spaces and healthcare professionals, when members of the project organization work with the aim of facilitating organizational changes in the way health care is delivered at the hospital. Finally the paper discusses how these spaces are connected, and how they both enable and constrain innovation in design and healthcare.

Keywords: design, hospitals, space, visualisation.

INTRODUCTION

“We have to give the frame to the users. We cannot change it and they have to understand this”

(Member of project organization, process meeting/ user involvement, May 22th, 2014)

The paper is concerned with the development of designs for a new hospital in Denmark. The focus is on the ‘on-boarding’ of the design team, designs and users, an early stage in the building design process where the client representatives, project management, design organizations and users begin to develop working relationships, and processes to deliver the project. The study inquires into the material link between practices of design and types of space and of clinical work in the context of hospital construction projects. Empirically, the study concerns how the project organization, in interaction with members from the client organization and various forms of visualization, design and develop spaces for the New North Zealand Hospital (NHN),

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part of the Danish hospital building programme currently underway. Theoretically, the paper contributes to our understanding of the role of visualizations in design processes, notably; how methods and technologies of visual representations are being used in the hospital project and thus aims to explore the under-theorized workings of the visual in complex organizational settings (Meyer *et al.*, 2013). We develop this to discuss how particular conceptions of space are developed and mobilized in the process of on-boarding, in terms of the physical architecture (area size and number of rooms, functions), but also the notions of design spaces (especially the engagement of users in the design), organizational spaces (work processes) and economic spaces (cost and budget). To understand how the visualizations are mobilized in the on-boarding phase we focus on how these representations are linked to different concerns and aspects of space and practices.

The paper and argument is structured in the following sections: Firstly, the article presents theoretical perspectives on different understandings of how spaces and visualizations are being conceptualized in construction and design. Secondly, we present our research methodology and how the data was collected. Thirdly, we present our case hospital as a part of the current reform of Danish healthcare delivery. The presentation of the case is followed by an analysis of how the hospitals design is being negotiated in the different spaces during on-boarding. Finally, our findings and conclusions shows, that the visualizations of the different yet connected spaces and the development of the hospital design is related to a number of emergent concerns in the processes of designing and constructing the new hospital.

Concepts of spaces

Space is more than physical Cartesian space (Frandsen *et al.*, 2012). We argue that spaces have different meanings and functions, and that these different spaces can be linked to forms of visualizations in the project. Visual representation can constrain and enable different practices, contribute to the broader construction of organizational spaces, and constitute and create economic spaces. For our case, the selected design proposal consists of complex visualizations of the hospital, and the team consists of many different companies with different competences. We focus on the role of visualizations as a part of design work (Ewenstein and Whyte, 2009; Yaneva, 2005, Meyer *et al.*, 2013) and as design space (Kreiner and Tryggestad, 2002) but we are also interested in what complex roles the different forms of visualizations such as 2-D and 3-D (Justesen and Mouritsen, 2009) have as a part of ongoing negotiations of the future spaces and practices of the hospital between the members of the project organization and the client organization that will own and use the new hospital. The project organization has economic obligations in relation to stakeholders, which in turn influence the project economy (Flyvbjerg *et al.*, 2003). The project economy appears in relation to devices, such as budgets (Tryggestad *et al.*, 2010) that visualize aspects of the project in terms of cost items like building design, eventually also with further links to devices such as building information models. How members of the project organization handle multiple matters of concerns related to visualization (Latour, 1986) of different spaces and functions is one important aspect of this study. Various links between spatial settings and management of organizations have been explored in management studies (Kornberger and Clegg, 2004; Van Marrewijk, 2009) and in relation to organizational changes as a part of designing new buildings (Stang Våland and Georg, 2014). We aim to describe and analyze the process when the design proposal, and the concepts and principles it builds on are being reworked and materialize in new forms in the on-boarding phase and how the visualizations have

different meanings and functions in different project contexts, such as on-boarding of the design team and user involvement (Luck, 2003) of clinical staff.

METHODOLOGY AND DATA COLLECTION

The research builds on an ethnographic study in a construction setting (Pink *et al.*, 2010; Kreiner *et al.*, 2011) during the on-boarding phase at NHN that lasted from April 2014 to July 2014. The empirical study of the on-boarding phase began the week after the winner of the project competition was announced. We studied the on-boarding phase and how the design team and the design project was integrated into the project organization at NHN as a part of forming a new project organization. Our study focuses on the project organizations everyday work, collaborations and negotiations during this phase, and how a new project organization is formed and structured in a way that enables the project organization to handle the new tasks that it will meet in the next phases of the construction project.

Data collection is based on direct observation, meetings and document analysis with the main research method being participant observations of meetings. The observed meetings represented tasks and responsibilities related to different levels in the project organization. These participant observations were supplemented by informal interviews after meetings, or in other informal environments (lunch meetings and talking when transporting back from the meetings). We observed 1) *client-meetings* at the strategic level of the project organization where the management of the project organization participated. At the tactical level we observed 2) *process meetings* that represented the link between the strategic levels of the project organization. We also observed work at 3) *user involvement meetings* are the operational level, where project managers from the client organization and project managers from the design team planned the user involvement in the next phase of the project.

As a part of the participant observations, a large number of documents were collected. The collected documents and objects consist of Gantt diagrams, budgets, project manuals, project plans, contracts, drawings of the new hospital and project office etc. Before each meeting, members of the client organization sent the agenda and the documents that were to be discussed at the meeting. During the observed meetings the members of the client organization, as well as members of the design team, presented documents as a part of the collaboration and negotiations between members of the client organization and the design team. After the meetings the client organization sent minutes and other documents that they worked on to the researchers.

The collected documents, plans and visualizations are not analysed as isolated entities, our research interests is to understand how the different forms of visualizations are used during the meetings (Ewenstein and Whyte, 2007, 2009), and how they are a part of the collaboration and negotiations between the client organization and the design team during on-boarding phase when they form a new project organization. The research entails interventions with practice. After the on-boarding phase ended the researchers invited members of the project organization to participate in a seminar where observations and preliminary results were presented and concerns at NHN were discussed. This seminar gave a more nuanced understanding about the client organizations strategic considerations before on-boarding, which the researchers did not know during the observations.

THE CASE OF NEGOTIATING A HOSPITAL DESIGN

Background: Danish healthcare reform

In 2007 “*Kvalitetsfonden*”, the current building and renovation program for the Danish hospitals was established. “*Kvalitetsfonden*”, is the largest investment in public physical infrastructure in Denmark with a total budget of 42 billion Danish krona; 16 construction projects including renovations of existing hospitals, five green field hospitals, and five new “*super hospitals*”. These 42 billion Danish krona are co-financed by the Danish state and the five regions in Denmark. The ambition behind the reform is to create more effective, cheaper and better healthcare delivery in Denmark.

The construction and renovation of the hospital buildings changes how healthcare is delivered to patients in Denmark, and the construction projects bring with them complex challenges of how to manage several institutional concerns, such as; the location of the new hospitals, the design of the hospitals, new technology and treatment capacity, flexibility for future use, the division of labour between medical professions within and between hospitals, regions and municipalities, patient and end-user involvement, public participation and democracy. These national challenges touch in more than one way on the complex and evolving relationships between the hospital’s healthcare practices and the organization of the physical spaces for these future healthcare practices. The design of the new hospitals is regulated by national standards, i.e., the ‘Expert panel’, a committee jointly formed by the Danish Government and the five regions decided that all the new hospitals had to be designed with single bedrooms (Harty and Tryggestad, 2012). Redesigning the Danish healthcare delivery affects patients and health care practitioners in a number of ways. When it was decided to build the new super hospitals, it was not easy to decide where to locate the new hospitals, many people, especially outside the big cities have been concerned because their local hospitals are being closed, as a part of centralizing healthcare delivery in larger and more specialized hospitals.

On-boarding at NHN

The case hospital NHN is a green field hospital and a “*super hospital*”, with a budget on 3.8 billion Danish crowns located south of Hillerød. When the hospital is finished in 2020 the hospital will treat more than 300,000 persons in North Zealand. As a part of the construction of the hospital the infrastructure in the area changes radically: new train stations and roads will be constructed, and a new suburb Favrholm is being planned around the hospital. The resulting ambition of the competition brief was high “*setting new standards*” in the design and delivery of public health care. For the last phase of the project competition for New North Zealand Hospital the client organization, and a panel of judges, advisors and a group of healthcare practitioners negotiated with three remaining teams, before the teams handed in their final design proposals. The teams with competences within areas such as architecture, engineering and hospital planning changed their designs during the competition to meet the critique and feedback they received in these dialogues. The client and project owner was not just interested in receiving analogue drawings and models in the project competition. The teams’ designs of the future building also included 3D visualizations and film animations. The teams also had to produce Building Information Model (BIM) visualizations which integrate spatial aspects of the emerging designs with quantity, cost and scheduling information, due to economic (cost) concerns, but also because BIM visualizations were seen as a method to secure sufficient amount of total

space in the future hospital. Visualizations of the hospital, spaces and healthcare functions are used as tools to involve future patients and healthcare practitioners in the development of the organization of the future hospital, its working spaces and functions. In the on-boarding phase we identify a number of different yet interrelated concerns related to visualization processes and spaces. We therefore develop the idea of the production of spaces when these different concerns to the future functions and practices at the hospital are taken into account.

VISUALIZATION AND CALCULATION OF INTERRELATED SPACES

We now introduce aspects that show different concerns related to space and practices during on-boarding. These concerns are different from each other, but they are also connected, because they all relate to the visualization of spaces and practices in the construction of the new hospital. First, we illustrate how visualization of *economic spaces* (cost budgets) are connected, and how economic concerns are related to work in the on-boarding phase, when the progression of the project has to be measured on a monthly basis. Next, we show how the visualization of spaces is also connected to concerns about the *design spaces* in the form of the involvement of the users in the next phase of the project. This aspect is about design practices and how spaces can be developed. These concerns are connected to the economic space because the design of the hospital cannot be changed if it adds costs beyond the budget frame. The third aspect is user involvement, and it relates to how the project organization can develop *organizational spaces* through the introduction of design principles and concepts to the health care practitioners, when space is being visualized to enable user involvement. Finally, we describe in our observations a concern related to the *connection between the new physical spaces and emerging concerns in other spaces*. This concern entails the connectivity between economic-, design- and organizational spaces, and their impact in the physical space of the hospital.

Table 1: Overview of different spaces, concerns and forms of visualizations

Spaces	Concerns	Forms of visualization
Economic spaces	Budget frame	Cost figures, time lines, BIM
Design spaces	User involvement	Rooms, corridors, drawings, mock-up's, LEGO
Organizational spaces	Principles and concepts of healthcare	2D models (images and text)
Physical spaces	Interrelated concerns	Artifacts from past dwellings (below construction site), images and texts.

Economic spaces

Prior to the on-boarding phase and during the design competition the project organization submits the 3.8 billion DKK budget to a feasibility test. The project management's concern is about the budget sum, that it might not be feasible, given the high design ambition of 'setting a new standard' of hospital healthcare. The design obtained from the competition in the form of a BIM model was used to estimate the costs of the design solution. Project management concluded that the hospital design was feasible in terms of delivering new standards of healthcare, but not within the existing budget frame. This in turn created a new set of concerns; should the design

adapt to the budget or should the budget adapt to the design? It was decided to negotiate for extra funding in order to maintain the high design ambitions, but the proposal for extra funding was rejected by the expert panel and the Ministry of Health as was project management's proposal to secure additional extra funding for the hospital kitchen.

The hospital project has to be monitored by the project organization that has strict obligations to report the progress of the project on monthly basis to the funding bodies represented by the Ministry of Health and the Capital region. As a part of the work in the on-boarding phase the design is being translated into more well defined categories and spaces that can be measured in economic terms. For this to happen, the hospital project had to be divided into subprojects within a work-breakdown structure. During on-boarding we observed tensions when the new delineated design spaces were going to be measured in outputs translated into economic terms:

“We would like traffic lights. It is important with the output from the user workshops. Are we on track?” (Member, project organization)

“We cannot measure every project every month” (Member, design team)

The project organization uses the metaphor of traffic lights in relation to each of the subprojects. Members of the design team argue that the proposed work-breakdown structure does not reflect the actual design processes and overall design task. Therefore, the team is concerned that too many subprojects will collide with their design work.

How many subprojects that will be established is not settled at the beginning of on-boarding, but is subjected to further negotiations between the project organization and the design team. The design team became concerned about the measurement of the project being too “bureaucratic”, while project management with budget responsibility became concerned about how to better measure and control the progression of the project with respect to cost and time.

The budget visualizes aspects of the project in terms of economic quantities such as the cost of an individual design item or work package. The project budget delineates an economic space and affords certain understandings of the physical spaces that are in the process of being designed and constructed, where the value of a design element like a kitchen can be calculated and valued against the budget frame and subjected to further negotiations. In this example, it is the budget frame that is maintained while it is the design ambition of having a kitchen that 'has to pay'. In this process BIM is used to visualize and test the relative feasibility of the budget against various design options. Both project management and the design team develop new concerns about the inflexible ways in which the budget frames the design work during the on-boarding phase.

Design spaces

Engaging with the users of the hospital during on-boarding and design is a requirement for the project organisation. In user workshops the design team have to visualize the spaces of the hospital to demonstrate the design to clinical personnel and to get inputs and feedback from them, related to their own experience and expectations. However, this is not a fully open and negotiable process for the design team and there is, from their perspective, a need to limit the possible requests for adaptations and changes the users and user workshops might produce.

*“How do we explain space in a way that they know what inputs to come with?”
(Member, design team)*

Some important arguments for limiting potential changes in the design are to be found in the economic concerns, with the inflexibility of the budget translating into relative inflexibility of design options. The user involvement is even undertaken by the economic subprojects rather than the design as a whole, showing the connection to the economic spaces. But it is also reflected in the planning of the workshops. During on-boarding the design team and the project organization discuss how to limit where users engage with the design, to reduce the design space in which users can participate. Two aspects are important in relation to this delineation of the design space. The first aspect is how to keep the design intent clear and understandable for the users. There is a challenge to ensure that all aspects of the hospital are being handled and discussed in the workshops and that nothing is neglected. The design team have described their design methods in the proposal for the competition, but in this subsequent on-boarding phase they have to be more concrete. But the second aspect is how to limit the impact on the design, as they want to avoid changes and alternatives. The question is what kind of methods is the design team going to use in the workshops in the next phase of the project to balance these concerns related to both demonstrating the design to the users, but also limiting the design space in which users can affect changes. This is connected not only to the selection of visualisations presented to the users, but also to the decision to make the workshops themed around the hospitals specialities and parallel workshops about particular issues, such as patient security and ‘the secure hospital’ or hygiene, rather than presenting the purely spatial, Cartesian layout of the design.

Organizational spaces

The new design of the hospital has wide implications for the organization of the daily work practices of the future hospital, and the design team is acutely aware of the possible ramifications of this. The design of the hospital is based on a number of principles and concepts. One important aspect of these design principles is that of optimizing the use of space.

“What does ‘right of use’ instead of ownership mean for the staff?” We need many perspectives on this. (Member, project organization)

The quote illustrates a concern about the principle of ‘right of use’, because the project organization during on-boarding recognizes that there is no simple causal relation between a new spatial-organizational design principle for a hospital and the future daily clinical practices in this new hospital. The perspectives and involvement of the clinical staff are thus required in an effort to further translate the design principle into their daily practices. It is not only functions such as offices, research activities and administration that are being transformed into “*shared spaces*” at the new hospital. Also, the patient bedrooms are organized in a flexible “*snake*” structure and the different clinical specialities have to share these patient bedrooms according to the number of patients they have at any one time. The new design implies, or has embedded within it, new organisational spaces and principles. The project organization is aware that the healthcare practitioners may not understand these spatial principles and concepts, or that they may react negatively, because their territories and usual ways of working are being challenged.

The members of the project organization decide that the schemes that visualize how different rooms are organized are too abstract to communicate this and that the design

team need a more concrete method when they are explaining these principles to them. The design team and the project organization eventually agree to initially leave architectural drawings out of the visualization of the principles and concepts. Instead they decide to initiate the user involvement by discussing with them aspects closer to their own clinical practice such as the movements and ways of working within the physical space. In effect, the discussions are moved away from the design drawings to discussions around the new organizational spaces and new ways of working. When the users understand the principles and concepts it is possible to go into more details of the design. As a part of the involvement of the healthcare practitioners the project organization have agreed with the project owner (the hospital) that they will involve a pilot group consisting of people with an interest in improving the working environment and collaboration at the hospital. This group will do a small pilot test of the method before the larger scale involvement at the user workshops. The assumption behind this set-up is that the pilot group will have a strong voice in furthering the user involvement since it represents both hospital management and the clinical staff.

Physical spaces linking present spaces and concerns to the past

The physical cannot be ignored, and materialization of physical space and place is pushing back, as the project organization initiated work to prepare the construction site. It was part of the plan to drill and investigate the soil and the first holes and samples from the examination only confirmed what was expected. Later, when digging and drilling wider and further into the ground, the crew discovered that the soil was much softer in particular places, with “*pockets*” of very soft material. This unexpected discovery added an unexpected cost of 100 million Danish krona to the project in terms of extra ground work and construction design below ground. In addition, the assumption about a “*green field*” construction project became challenged as further geological and archaeological examinations revealed the construction site to also be culturally very rich, including over 3000 year old dwelling places. These two events; the subsequent materialization of physical spaces and cultural spaces below ground, illustrate the unexpected and negotiated links between them. In summary:

Economic spaces: The project budget as an economic space that visualizes the project in economic (cost) terms. It affords project management with a control device in relation to the design team. The budget frame must be maintained. Additional visualizations such as the timeline and work break down structures helps to detail the control of the design team. We identified tensions between control and innovation in design and healthcare practices.

Design spaces: Control of what users can contribute, and a tension between an economic concern with the project budget and design innovation based on user involvement. The design team becomes a spokesperson of the design, but is also expected to maintain control of the design space so that the project can stay within the budget - one form of visualisation. Thus the design team becomes spokesperson of several concerns, including an economic concern and is in turn monitored on its progress within another visualisation device - the break down structure of subprojects.

Organizational spaces: Materialization of organizational principles and concepts about healthcare in architectural design. The project organization has to integrate concerns about physical spaces for healthcare and facilitate organizational changes in healthcare practices through novel architectural visualisations as a part of their work. The clinical staff cannot understand the physical spaces of the new architectural design without

relating it to their existing practices. Yet, it is these existing practices that are about to change as an integral part of the hospital construction project.

Physical spaces: Work below ground can challenge contemporary assumptions, visualizations and spaces related to building and construction design, budget and time schedules for the project. The construction of a physical space for the building foundation opens up a link to hidden past spaces and places and forges new unexpected links to present spaces. These emerging uncertainties cannot be fully known in advance, but are revealed as the work of preparing the physical space for the foundation materializes in the ground.

Table 2: *Interrelated spaces and emerging concerns*

Illustration of spaces	Illustration of tension	Visualizations in use
Negotiations between economic spaces and design spaces	Kitchen is taken out of the hospital design due to economic concerns about the budget	Budget calculations and design drawings
Negotiations between design spaces and organizational spaces	Without the kitchen the healthcare concern related to nutrition becomes stronger	2D models of organizational principles and design drawings with kitchen
Negotiations between economic spaces, design spaces and organizational spaces	Due to concerns related to the budget and the organizational concerns (principles and concepts) the user involvement have to be limited	Budget calculations and organizational design principles
Negotiations between physical spaces and the other spaces	Artifacts from dwellings and geological surprise increases budget costs related to site development and construction design	New budget calculation (100 mill DKR budget increase) and re-design/downsizing physical spaces

CONCLUSION

The contribution of this paper is the identification of four aspects of space in this on-boarding process and the ways that heterogeneous visualisations are produced and mobilised to support or problematize them. In doing so, we tentatively analyse and discuss how these spaces are connected, and how they both enable and constrain innovation in design and with what practical implications for hospital construction projects and healthcare. These spaces and visualisations are much more than the product of visualizing rooms, corridors and offices, much more than Cartesian representations of physical spaces (existing or to be). This is not the first attempt to develop a more striated or multi-layered appreciation of space. For instance scholars such as Tissen and Deprez (2008), building on Lefevre and Foucault, propose a ‘trialectics’ of space, consisting of representations of space (such as the emerging hospital design), representational space (the ordering of space across, in this case new hospital practices) and spatial practice (the eventual lived space of production and reproduction, or even the social space of design work). Whilst these do not directly map onto our conceptions, a strand of future work will be to explore the connections and possible alignments between the project spaces and visualisations in our analysis with these concepts. Another avenue for further work is the connectivity and interdependencies between these types of space, and the exploration of other possible spaces, such as ‘digital space’ within these representations. Similarly, subsequent

empirical work will provide more detail on the ways that users are able to influence or incorporate their understandings, practices and experiences into the design process.

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INTEGRATION OF LEAN CONSTRUCTION CONSIDERATIONS INTO DESIGN PROCESS OF CONSTRUCTION PROJECTS

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The design phase in the life cycle of a construction project contributes significantly to the performance of a project. The poor outcomes from the design phase in the construction project development process are considered as the major contributors to project delay, poor performance, and budget overrun. All of these affect the overall project performance. It is the aim of this study to innovate a design process model to improve the performance of design process where conventional design processes would not be effectively or efficiently applied. The adaptation of lean principles with the identification of wastes in design process and identification of enablers in design process are evaluated. The innovative design process model presented in this paper is developed based on the core enabler that can be used to eliminate the identified waste. There are 15 wastes identified and the set-based concurrent engineering (SBCE) is considered in the core enabler of the design process model.

Keywords: design process, enablers, lean consideration, project life cycle.

INTRODUCTION

The design phase in the construction project life cycle is considered as a significant contributor to the project performance. Many researchers have considered this phenomenon as being dependent on the project success which comprises of quality, cost, time and sustainability. Nowadays, most of the construction projects must be delivered through the fast track, therefore it is difficult to co-ordinate between the specialists and personnel as there is no accepted platform of good practice in managing the design process (Bibby, 2003). Although some technologies have been developed and applied in construction projects, the performance of the construction industry is still considered low (Sacks and Goldin, 2007). Aziz and Hafez (2013) argue that the current technologies can only improve the management of the construction process, but, however, in improving quality of the projects effectively, it does not reduce cost and time of design and construction. This is referred to as the traditional method that is still in place and currently being practiced in the industry.

The objective of this study is to develop the innovative design process in building construction projects where 'lean thinking (LT)' is being considered for design process improvements. The proposed design process model integrates LT into the traditional design process with activities which are able to eliminate wastes in the design process. The model is based on the set-based concurrent engineering (SBCE) concept that has been identified in the literature review of this study.

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METHODOLOGY

A comprehensive literature review has been carried out to establish the definition of wastes in the design process for building designs, which forms a part of the LT principle where wastes are required to be eliminated in a process. As such, identification of waste is established. After establishments of the definition and identification of wastes, the lean enablers have been studied and identified, which the available tools and methods of lean implementation are considered. Evaluation of the core enablers is the main focus in this study as these core enablers are used to drive the process and to support the innovation of the design process. Subsequently, a design process framework model which adopts LT is proposed which includes waste identification, lean enablers, waste elimination and recommended design process activities.

LITERATURE REVIEW

Design Process

The construction process can be usually divided into three phases, i.e., project conception, project design, and project construction (Chan and Kumaraswamy, 1997). This can be described as a linear project delivery as modelled by Emmitt (2002). Project conception which involves clients and designers is identified as the inception phase where feasibility of the ideas and intention are being analysed. The project design involves two phases of project conception and design where designers and detailers work together to produce a concept design and convert it to a detailed design. Subsequently, the project construction is identified in the third phase as assembly where builders materialise the client's requirements. This construction process is also referred to as the design and production process which have been practiced in different countries such as USA, the UK, Australia and Canada. Lam *et al* (2012) elaborate the design process as being a process where an architect often prepares study drawings, documents, or other media that illustrate the concept of design for client's review during the schematic design.

The guideline set above was made easily to follow and understand. However, in reality and on its practical point of view, it is very complicated as referred by Freire and Alarcón (2000) who state that the architectural design process itself possesses complicated management problems. They explained that the problems in design involve thousands of decisions which may take over a period of years to be resolved. However, all of the guidelines for the process above are still valid and practiced regardless of the problems encountered by the practitioners.

Although the construction process have been established in these countries, there is a lack in details on how these phases should be carried out (Orihuela *et al.*, 2011). It has been suggested by the institutions that this is only a guideline for the practitioners, but it still however lacks details in activities which need to take place. Therefore, it is necessary to develop a design process framework in which shows details of activities that need to be considered. At the same time, such a design process framework is required to eliminate wastes and enhance building project performance.

Waste in Design Process

The design factors that affects quality of building projects studied by Oyedele *et al.* (2001), do not create value. This is related to the definition made by (Huovila *et al.*, 1997; Koskela, 1997; Mossman, 2009), which states those factors that do not

contribute to the task completion and value generation can be considered as waste. Subsequently Koskela *et al* (2013) state that there are different definitions and perspectives when addressing the wastes in design such as iterations which can be a waste to the client but generates value to the project design, latency will lead to delay in a project but will provide time for solution development in design, and reciprocal interdependencies which can be a waste in the process but not in design that relies on the maturity of the design solution. The differences in waste perspectives that lead to the logic seven sources of wastes from the production perspectives as stated by Ohno (1978), may not be directly applied. Instead, it should act as a guideline to understand the waste in the design process.

It would be worthwhile to understand the knowledge gained by manufacturing industries in order to understand the meaning of waste beyond the surplus of materials. Taiichi Ohno's book (Ohno, 1988) lists seven wastes that can be identified in the production of cars. Such wastes are then cited in Koskela *et al.* (2013) which include overproduction, time on hand, transportation, processing itself, stock on hand, movement, and making defective products (listed in that order). The perspective of waste describes that waste can be divided into two categories, i.e., process and operation. Process is the conversion of input such as raw materials into the desired product while operation can be described as an activity that performs the conversion. Based on the identified wastes and definition of waste in manufacturing industry, they can be understood as the seven wastes that can be categorized in one of the two categories (Koskela *et al.*, 2013). Waste as cited by Ohno (1988) is applicable to other industries such as service, health care, construction industry etc. However some of evidences suggest that several wastes in Ohno's list can be omitted as they are either not applicable or have little contribution in certain industries (Abila, 2010; Bicheno and Holweg, 2009). It is clear that the factors affecting the design performance does not contribute towards the tasks completion and value generation. Therefore, in this study, it is decided to consider factors that affect the quality of building projects in the design phase are in actual fact, and to identify the wastes in design process of construction projects.

Waste in construction projects can be defined as minimizing what is unnecessary for task completion and value generation (Koskela and Huovila, 1997). Similarly, Formoso *et al* (2002) consider the waste as the loss of any resources including materials, time and capital, which can be generated by activities either direct or indirectly caused and that do not add value to the final product for the client. Whereas, Pinch (2005) identified seven types of waste in construction projects: (1) waste from defects, (2) waste from delays, (3) waste from over-production, (4) waste from over-processing, (5) waste from maintaining excess inventory, (6) waste from unnecessary transport, and (7) waste from unnecessary movement of people and equipment. This is mostly relevant to the activities during the construction phase, but not at the planning and design phases. It is the intention of this study to elaborate on the waste that is related to the design activities. It is believed that the factors that affect the performance of the project have contributed to the waste within the design process (Alarcon and Ashley, 1996). According to Oyedele (2001), there are limitations in terms of literature with regard to the design factors that affects the quality of construction projects. If so, then it is a waste to the construction project to have these factors within the design activities. These factors are believed to be non-adding value to the client as well as the project itself. Most of the wastes in design can be associated with the contributing factors of low performance of the construction project. There is

no consensus and general agreement as to the set and categories of waste in the design process. On the basis of existing literatures, fifteen wastes in the design process of the construction projects can be identified as shown in Table 1, which can be eliminated by using the proposed design process. These identified wastes are the outcomes of the literature review carried out by the researchers where key words have been used to filter the research papers.

Table 1: An example of setting out a table with column headings

Phase	Activity	Type of Waste														
		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Stage 0 Define Value	0.1 Classify projects	√		√												
	0.2 Explore client value	√		√										√		
	0.3 Align project with company strategy			√											√	
	0.4 Translate value to designers	√		√	√									√		
	0.5 Internal review		√					√			√		√		√	
Stage 1 Map Design Scope	1.1 Identify sub-design solution targets				√											
	1.2 Decide on level of innovation to sub-design solution				√											
	1.3 Define feasible regions of design scope				√				√	√						
	1.4 Internal review		√					√			√		√		√	
Stage 2 Concept Design Development	2.1 Extract design concepts							√								√
	2.2 Create concept design for sub-design solution							√								
	2.3 Explore the concept design for sub-design solution							√			√					
	2.4 Capture knowledge and evaluate					√	√	√								
	2.5 Communicate concept designs to others		√				√	√								
	2.6 Internal review		√					√			√		√		√	
Stage 3 Concept Integration	3.1 Determine concept design intersections						√	√								
	3.2 Explore possible designs						√	√								
	3.3 Seek conceptual robustness						√	√								√
	3.4 Evaluate concept design for lean construction							√								
	3.5 Begin process planning for construction						√	√			√					
	3.6 Integrate the final concept design of sub design solution							√			√	√				
	3.7 Internal review		√					√			√		√		√	
Stage 4 Detailed Design	4.1 Release final specification						√	√								
	4.2 Define construction tolerances						√	√			√					
	4.3 Full project definition						√	√								
	4.4 Internal review		√				√	√			√		√		√	
Total		3	6	4	4	1	8	18	1	1	7	4	5	2	7	1
Key:		W1=Poor client briefing W2=Inadequate pre-design project meetings W3=Lack of project definition W4=Design defects W5=Inadequate technical knowledge W6=Poor specification W7=Design changes W8=Insufficient and unrealistic constraints of project cost W9= Insufficient and unrealistic constraints of project time W10=Inadequate involvement of other professionals and teamwork during the design stage W11= Lack of constructability review of design W12=Poor communication among design team W13=Making design decisions on cost and not value of work W14=Poor level of commitment to quality improvement among design professionals W15=Effect of design code and standards on quality														

Lean Enabler

Lean enablers act to create value and eliminate wastes in the architectural design process. Subsequently, the method of identifying the lean enablers is based on the review of literatures purposely chosen from the International Group for Lean Construction (IGLC). The reason is because this organisation actively conducts conferences related to the development of new principles and methods for design and construction management, which is exclusive to the construction industry with reference to the lean principles that are developed in manufacturing industries (Etges *et al.*, 2012).

On the basis of the collection of research papers presented in the IGLC’s publications, there have been 85 research papers published which are relevant to the design process. However, 40 papers are concerned design processes referred to different design processes of structural, mechanical, and infrastructure engineering which are not of an architectural design in nature. 45 papers which are relevant to building projects with a focus on architectural design phase are being considered. There are six approaches that appeared in this review which are Concurrent Engineering, Target Value, Simulation, Collaboration, Coordination and Set-Based. Apart from these,

The lean enablers in other industries such as car manufacturing, electronics production, domestic appliances, and car accessories have been explored in this study. This research adopts the enablers studied by Khan (2012) for comparison and to find

enablers in construction project design. Khan (2012) states that the ‘changeless core’ was initially found as a main factor in the product development success of Toyota Motor Co. The cores of, such as value, knowledge, and improvement, are believed to be the foundation of product development that is later known as SBCE (Khan *et al.*, 2011). Some of researchers state that SBCE is considered as the main enabler for lean production development (Ward, 2007). This enabler is a system of the design process which comprises other enablers and is supported by other enablers (Sobek *et al.*, 1999). Therefore, in this research, the principle of SBCE is used to develop a construction design process framework so that it can be aligned with the conventional design process in building construction processes.

A Review of Set-based Concurrent Engineering

In the manufacturing industry, there are sufficient evidences for the use of scientific product development approaches (Ward *et al.* 1995). The study on the use of ‘set-based design’ in the Toyota production development provides the procedures on how the Toyota designers produce sets of design alternatives and gradually narrow the set until they come to a final solution. However, in some perspectives, this system of product development process is an inefficient system. Apparently Ward *et al* (1995) does not present a detailed process or methodology for the system, which just states the three central elements that the Toyota focuses on, namely: value, knowledge (or learning) and improvement. With this phenomena, researchers turn to study the system in detail. According to Khan *et al* (2011), the elements presented above enabled Toyota to achieve customer needs through the optimal designs, minimise design rework, and achieve high profit levels and named the process as SBCE.

In the construction industry, SBCE approaches have been applied to the construction phase such as site layout, construction engineering, engineering design and construction technology. There is limited literature that addresses the adaptation of SBCE in the construction project design process. Therefore, some of the procedures cannot be adopted entirely into the construction project design process. Nonetheless, the lesson learned can be considered as guidance where communication is very important in order to evaluate the set of design effectively.

A comparison between the traditional design method and the proposed design method in the process of design is conducted in this study. The traditional method can be called as point-based method, while the proposed method can be called as set-based method. Point-based method evolves the development of one problem solution which is further developed into the conceptual design as early as possible. This causes the iteration of design due to the knowledge gained throughout the process. Furthermore, this may also cause costly rework and some resources may not be available at the rework stage. The set-based method of SBCE provides various sets of design and the selection of the design is delayed as the design set is gradually narrowed based on the knowledge available to support decision making, and finally, the final design is then committed which will reduce or eliminate the re-work. The advantage of using set-based method is that the waste in the design process is eliminated by every activity embedded in the design phases. Therefore, by eliminating waste the value can be maximized.

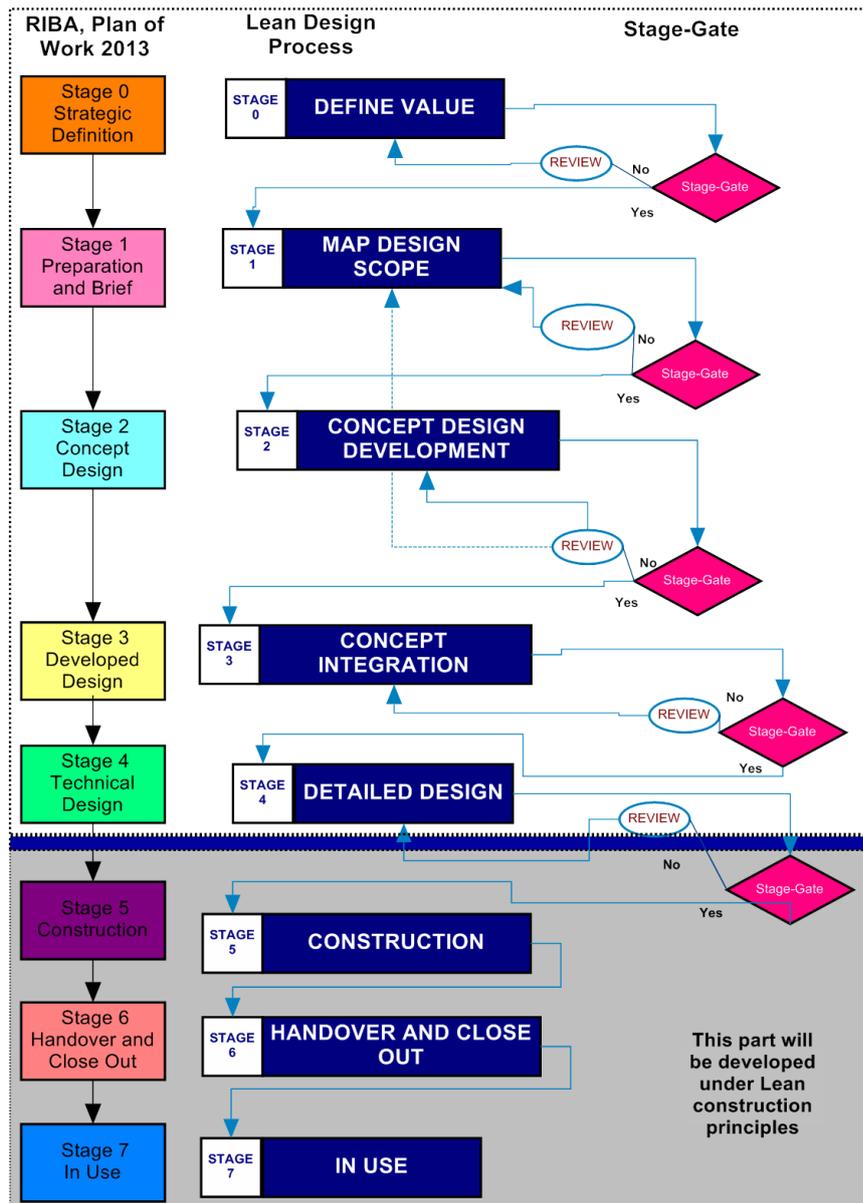


Figure 1: Design flow with embodied 'Lean Principles'

CONCEPTUAL DESIGN PROCESS MODEL

The design process improvement is initiated by implementing lean design based on the SBCE concept. The followings are the descriptions of each stage and activities with the elaborations of method to accomplish them. The stages in this model as shown in Figure 1 are aligned with the project stages presented by RIBA, Plan of Work 2013.

Stage 0: Define Value - the initial concept definition is developed based on strategic goals, client requirements, and any other factors that need to be considered.

0-1 Classify project: Each project should be classified in order to forecast the time and cost commitment. The expected level of innovation at both the project and sub-project level should be clarified in addition to other relevant parameters. The intended market should also be clarified in the case that it impacts subsequent engineering activities. This is relevant in the context of sustainability development, when a refurbishment or

extension, or indeed a rationalised space plan, may be more appropriate than a new project.

0-2 Explore client value: Client needs and desires should be thoroughly understood in order to determine design targets and ensure the necessary provision of client value; The extent of this activity will depend on the level of innovation; design criteria will be determined based on client value amongst other factors, to support the evaluation of alternatives of product designs.

0-3 Align with company strategy: Each project should be aligned with the company design strategy, in order to take strategic advantages from projects. This will prevent value (/benefits) gained through projects from being wasted and ensure the enhancement of the design process.

0-4 Translate value to designers: The information developed in this phase should be compiled in a document referred to as the building concept definition: both the strategic objectives and the understanding of client value will be translated to the designers that are involved in the project via this document.

0-5 Internal review: the internal review should be made after all the methods have been completed. This is acting as the gate stage to avoid any rework at the later stage. Reference should be made available to all the parties involved in the design and any confidentiality should be treated accordingly.

Stage 1: Map Design Scope - designers define the scope of the design work required as well as feasible design options/regions.

1-1 Identify sub-design solution targets: Each sub design solution team should decide based on the project concept definition which components to improve and to what level of innovation; this will help to prevent over-design while encouraging the necessary innovation and enhancements.

1-2 Decide on level of innovation to the sub-design solution: Each sub design solution or component team will analyse their design and identify their own lower-level targets (lower level requirements) based on the project design concept definition.

1-3 Define feasible regions of design scope: Appropriate design possibilities should be defined based on knowledge and past experience, while considering the views/constraints of different functional groups.

1-4 Internal review: the internal review should be made after all the methods have been completed. This is acting as the gate stage to avoid any rework at the later stage. Reference should be made available to all the parties involved in the design and any confidentiality should be treated accordingly.

Stage 2: Develop Concept Design - each designer develops and tests a set of possible conceptual design solutions. This will enable designers to eliminate weak alternatives based on the knowledge produced in this phase.

2-1 Extract design concepts: Concepts should be drawn from previous projects, R&D departments, and competitor products (benchmarking).

2-2 Create concept design for sub-design solution: This time is scheduled specifically for design teams to brainstorm and innovate so that a set of possible design solutions is proposed; The set for a particular sub-project may be only 2 options, while a component that is not being changed would not require a set; Alternatives within a set may comprise of differences in fundamental concepts, components, arrangements, properties or geometry.

2-3 Explore the concept design for sub-design solution: alternative solutions shall be simulated, prototyped, and tested for lifecycle cost, quality, and performance.

2-4 Capture knowledge and evaluate: Knowledge that has been created will be captured either quantitative or qualitative in order to evaluate the sets.

2-5 Communicate concept designs to others: Each sub-project or component team will present their set to the other teams at an event (e.g. meeting) in order to get feedback and understand constraints.

2-6 Internal review: the internal review should be made after all the methods have been completed. This is acting as the gate stage to avoid any rework at the later stage. Reference should be made available to all the parties involved in the design and any confidentiality should be treated accordingly.

Stage 3: Integrate Concept - sub-design intersections are explored and integrated designs are tested; based on the knowledge produced in this phase the weak design alternatives will be removed allowing a final optimum product design solution to progress into Stage 4.

3-1 Determine concept design intersections: sub design solution that progress into phase 5 can be considered for project integration. The intersection of feasible sets will be reviewed, considering compatibility and interdependencies between sub design solution and components.

3-2 Explore possible designs: Potential systems can be simulated/prototyped (parametric and physical), and tested for cost, quality, and performance.

3-3 Seek conceptual robustness: Conceptual robustness will be sought against physical, market, and design variation in order to reduce risk and improve quality.

3-4 Evaluate concept design for lean construction: Once the potential sets have been explored, they will be evaluated for lean construction to assess the costs, efficiency, and problems etc.

3-5 Begin process planning for construction: Once the potential sets have been evaluated, construction planning will be considered. The effects on cost, time, quality, efficiency, potential problems etc. will also be considered.

3-6 Integrate the final concept design of sub design solution: Based on the evaluations and knowledge captured, sub-optimal project designs will be eliminated and the proven optimal design from the project alternatives will be finalized.

3-7 Internal review: the internal review should be made after all the methods have been completed. This is acting as the gate stage to avoid any rework at the later stage. Reference should be made available to all the parties involved in the design and any confidentiality should be treated accordingly.

The lean design model provides a process for conceptual design up until design freeze and the initiation of detailed design. There are some activities that have however been included as recommendations for detailed design that will be described briefly below.

Stage 4: Produce Detailed Design- the final specification is released, Architects, Engineers and Consultants provide tolerances and the process continues with detailed design activities.

4-1 Release final specification: The final specifications will be released once the final project concept is concluded; this is important because by communicating that the

specification will be released after all of the activities in phases 1 to 4, it will be more likely that the specification and commitment will be delayed.

4-2 Define construction tolerances: Construction will negotiate part tolerances with design teams; this is another aspect of delaying commitment in design.

4-3 Full project definition: Further detailed design work will follow; it is assumed that companies may continue with their detailed design processes for assurance and qualification of design solutions which is normally industry and product-specific.

4-4 Internal review: the internal review should be made after all the methods have been completed. This is acting as the gate stage to avoid any rework at the later stage. Reference should be made available to all the parties involved in the design and any confidentiality should be treated accordingly.

CONCLUSIONS AND RECOMMENDATIONS

The design process framework presented in this paper provides an overview of implementation of LT in the design process of construction projects. The dominance tool of set-based concurrent engineering has been developed and acts as an enabler to adopt LT as well as lean construction. The framework focuses on the performance improvement in the design process in order to eliminate waste in the project design process. The proposed design framework by adopting LT will be able to achieve optimal designs, minimize design rework, and ease constructability. The presented design framework also addresses the challenges identified such as rework, sub-optimal design, knowledge crisis, lack of innovation, and high unit costs. The stages defined in the proposed model can be embodied into state-of-the-art design development of civil works while maintaining the traditional design process with the implementation of LT. Further research work will be conducted by case study to validate the framework in order to get an empirical result of the study.

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PARETO ANALYSIS ON THE QUALITY SECTIONS/FACTORS PREVALENCE OF NIGERIAN DESIGN FIRMS

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Design Organisations bear greater responsibility in ensuring quality as they define the requirements of owners into drawings and specifications to contractors. The aim of this research is to establish the prevalence of Nigerian Design Firms in meeting requirements of identified quality management section/factors as well as identifying the vital quality sections/factors which have greater influence on their adherence to quality management provisions based on identified 20 quality sections/factors. Questionnaire survey was used to generate data for the study. Average Percentage Prevalence and Pareto Analysis approaches were adopted for analysis. The study established 73.22% overall average percentage quality section prevalence among the Nigerian Design Firms. This result placed the firms in the category that 'Require Serious Improvement.' Pareto Analysis identified Employee Training and Education (59.49% Overall Average Percentage Prevalence), External Design Review (62.01%), Design Contract Review (65.21%) and Performance Quality Audit (69.12%) as the major (vital) factors among the 20 that had influence on the design firms. It is recommended that adequate attention and action be paid by the Nigerian Design Firms in meeting the requirements of the identified quality section/factors for improved performance.

Keywords: design firms, pareto analysis, percentage prevalence, quality management.

INTRODUCTION

Construction is the fundamental foundation upon which humanity exists, develops and survives. This is because the industry provides the facilities and infrastructure that make people function (Windapo and Omeife, 2012). Design is one of the processes employed by the industry in the evolution of new building projects; normally assembled from selected products designed to suit certain requirements (Tunstall 2000). According to Hutley (1987), "*good design embraces such things as getting a proper brief, ensuring the design matches the client's requirements, prescribing the best material for the job and making sure that what is linked on the drawing board can be built*". Design quality involves the degree to which features of facility conform to the client's need and it is the quality determined by the consultants on behalf of the client. It is also the quality standards required by the contract and described in the appropriate production information issued by the designers to the production team (Bamisile 2002)."

Building designs are generally guided by client's requirements and standards. Similarly, design and construction quality require appropriate systems, procedures, communication and documentation. Such system is obtainable in various standards

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that establish minimum quality frameworks and requirements. Variation of standards is attributed to among many reasons, differences in local requirements and specific industry requirements. Hendrickson and Au (1989) mentioned that about 8,000 localities are having their own building codes. Bubshait *et al* (1999) discovered that International Standard Organisation - ISO9000 series, Malcolm Baldrige (MB) and BS 5750 standards provide framework covering 13, 14 and 10 quality sections relevant to design, respectively. Ducan *et al*, 1990 and Bamisile (2004) identified designer qualifications, design contract review, documents preparation, circulation and approval, external design review, design buildability, design maintainability and computer usage as other aspects of design. Moreover, other relevant aspects such as design contract review documents preparation, circulation and approval were also highlighted by Stebbing (1987).

Requirements of Quality Management System (QMS) and other standards paved way for the development of quality management practices. This is in attempt to provide theoretical foundation to scientifically connect traditional Quality Management philosophies with practical activities (Kim *et al* 2012). In such an attempt, Bubshait *et al* (1999) conducted an exploratory survey among local design organisations of the Eastern Province of Saudia Arabia. The survey was aimed at evaluating the prevalence of the quality practices among the design firms. Seventy quality practices were identified, which were grouped under fifteen quality sections. The survey identified a significant need for improvement in 'working relationship', employer training and education', and 'performance audit' among the other sections.

In Nigerian, the issue of quality and standard has been the subject of concern in the country's construction industry due to incessant collapse of building structures around the nation (Abiodun and Afangadem, 2007). Despite the existence of standards in the country, yet shortcomings still persist in the construction industry. A large part of the blame has been attributed to design. Bamisile (2004) remarked that "*one could say that the design team has not yet adopted any quality culture in their contribution to production of buildings in Nigeria*". Therefore, the aim of this research is identify the prevalence of the practices of the Nigerian design firms using the approach of Bubshait *et al* (1999) and to identify the vital factors which influence their adherence to the requirements of quality management practices using Pareto analysis. As a result of additional factors (quality sections) identified, this research worked with twenty quality sections. The choice of Bubshait *et al* (1999) approach was informed by its applicability to Nigerian set-up. Pareto analysis was identified to be useful due to its simplicity and focus on identifying vital factors out of a total whole.

DESIGN ORGNISATIONS AND PARETO ANALYSIS

Role of Design Organisations in Quality Management

Quality Management is a major management function within construction companies (Harris and McCaffer 2005). Design stage is a vital component of construction QMS. Quality of design involves the degree to which the features of a facility conform to the client's need. Any deviation in defining owner's requirements at design stage can lead to increased costs of project. Oladokun and Adalakun (2008) identified factors that affect quality of building projects. These are; nature of project; design; labour; equipment; subcontractors; systems (computer software and application); process of execution; financial issues; owner, and environment. Similarly, a survey conducted on 159 construction professionals and academics in Egypt to establish relative

importance of factors needed to improve construction by Abdel-Razek (1998) revealed that improving design and pre-construction planning was ranked first.

Design quality is many-faceted; there are a host of factors and considerations that influence design quality (Barret 2000). Proper co-ordination could be difficult but necessary in order to prevent occurrence of defects.

Bubshait *et al* (1999) opined that design organisations bear the greater burden in ensuring quality. They need to provide a high quality of service to ensure that their client's project achieves the best possible standards of cost, time and quality. To achieve quality in design, organisations are required to be innovative in developing quality management practices guided by standards. Quality management practices are critical activities that lead directly or indirectly, to improved quality performance and competitive advantage (Kim *et al* 2012).

Application of Pareto Analysis in the Construction Management

Reh (2014) mentioned that *“in 1906, Italian economist Vilfredo Pareto created a mathematical formula to describe the unequal distribution of wealth in his country.”* This was as a result of his observation that 20% of his people owned 80% of country's wealth. Pareto principle states that majority of errors come from only handful of causes. In ratio terms 80% of the problems are linked to 20% of the causes. Eventually, Pareto analysis was employed as a problem-solving tool in many sectors, including construction industry. The Constructor (2015) asserted that *“problem solving for quality management in construction can be achieved by tools like combination of brainstorming sessions, Fishbone diagrams and Pareto analysis”*. Similarly, Faucheux (2013) identified Pareto Principle as one of the *“top”* Total Quality Management (TQM) tools available. 'Six sigma' was also identified among the tools of TQM (EPA 2015). It consists of a set of methods for systematically analysing process to reduce process variation. Sigma quality level serves as an indicator of how often defects are likely to occur in a process. However, according to Harris and McCaffer (2005) Pareto Analysis is a simple technique that helps separates the major causes of problems from the minor ones. It is identified as an effective means of visually representing major causes of a problem. It is useful in helping focusing attention on relevant issues.

Durdyev and Ismail (2012) used Pareto analysis with an aim to identify nature of improvement measures for 20% of factors causing 80% of the on-site productivity problems in the New Zealand construction industry. The study identified project management, project finance, and workforce and project characteristics (out of seven factors) accountable for bulk on-site productivity problems.

RESEARCH METHODS

Sample frame and Sample Sizing

Nigerian building design firms were the target population for the study. To obtain sample size, a list of registered design firms was obtained from Corporate Affairs Commission (CAC), Abuja. 6,990 Architectural and Engineering Consultancy firms registered with the body. By using the approaches outlined by Krejcie and Morgan, (1970), Cochran (1977) and Bartlett *et al* (2001), a sample size of 237 was calculated at 95% confidence level.

Data Collection

Primary data was obtained using survey questionnaire based established quality sections/factors. 100 quality practices were identified under 20 quality sections/factors. The quality sections correlate with the major design quality sections in the ISO 9000 family series, Malcolm Baldrige Standards, BS 5750 and other sources (Stebbing 1987, Ducan et al, 1990, Bubshait et al, 1999, Sebastian et al, 2003 and Bamisile, 2004). The specific quality sections (coded QS for the purpose of the research) are; Organisational Quality Policy (QS1); Designer Qualifications (QS2); Employee Training and Education (QS3); Design Contact Review (QS4); Design Planning (QS5); Design Inputs (QS6); Design Process (QS7); Documentation Preparation, Circulation and Approval (QS8); Interface Control (QS9); Design Review (internal) (QS10); Design Changes (QS11); External Design Review (QS12); Subcontractor Control (QS13); Documents Control (QS14); Design Maintainability (QS15); Design Buildability (QS16); Computer Usage (QS17); Working Relationship (solely with client) (QS18); Working Relationship (jointly with client and contractor) (QS19); and Performance Quality Audit (QS20).

Respondents were asked to rate their quality practices, namely; 'Always – 100%'; 'Mostly – 75%'; 'Sometimes – 50%'; 'Rarely – 25%' and 'Never – 0%'. 100% rating of a particular quality practice means all requirements are met or available. Responses obtained were used for conducting analysis and values obtained were used to draw inferences. Targeted respondents were the Executive/Senior Management of the design firms since management quality management system is normally their responsibility.

Both stratified random and cluster sampling methods were adopted to ensure groups and geopolitical zone representations, respectively. This is in line with assertion by Fellows and Liu (2003) "*stratified sampling is appropriate where the population occurs in 'distinct' groups or strata.*" Similarly, Keller and Warrack (2003) pointed out that cluster sampling is useful whenever the population elements are widely dispersed geographically.

Data Analysis Techniques

Average Percentage Prevalence

This part of the analysis was based on the criteria used by Bubshait *et al* (1999). Average percentage prevalence for each quality practice was calculated using equation 1.

$$\text{Average Percentage Prevalence} = \frac{\sum(aixi)}{\sum(xi)} \text{-----} (1)$$

Where ai takes the value (rating) 100, 75, 50, 25 and 0; and xi (x1, x2, x3, x4 and, x5) represent the number of corresponding respondents answering always, mostly, sometimes, rarely and never, respectively. Average values were also calculated under each quality section to establish average quality section's prevalence. Averages across the groups were also computed.

Generally, based on the results obtained, observations and inferences on groups' performance in relation to a particular quality sections/factor were drawn using four categories of performance as identified in the work of Bubshait *et al* (1999). They are;

‘Commendable (90-100%)’; ‘Satisfactory (81-89%)’; ‘Require slight improvement (75-80%)’ and ‘Require serious improvement (less than 75%)’

Average Percentage Prevalence Approach

Haughey (2014) outlined eight steps involved in Pareto Analysis that lead to indentifying 'vital few' from 'trivial many.'

- 1 Create a vertical bar chart; causes on the x-axis and count on the y-axis.
- 2 Arrange the bars in descending order of cause importance.
- 3 Calculate the cumulative count for each cause in descending order.
- 4 Calculate the cumulative count percentage for each cause in descending order
- 5 Create a second y-axis with percentages descending in increments 10; (100% to 0%).
- 6 Plot the cumulative count percentage of each cause on the x-axis.
- 7 Join the points to form a curve.
- 8 Draw a line at 80% on the y-axis running parallel to the x-axis. Then drop the line at the point of intersection with the curve on the x-axis (parallel to y-axis). This point on the x-axis separates the important causes on the left (vital few - 20%) from the less important causes on the right (trivial many – 80%).

RESULTS

Response Rate

The response of the administered questionnaires revealed a response rate of 44.7% (106 questionnaire were returned out of the 237 copies administered). Out of this figure, 96 questionnaires (40.5%) were identified to be usable for analysis. Based on the assertion of Moser and Kalton (1971), result of a survey could be considered as unbiased and significant if return rate falls between 30 to 40%. In that premise, the percentage of usable questionnaires was also adequate for analysis.

It was discovered that Multi-disciplinary firms formed the largest group with 44.8%. This suggests that most of the design firms engage or coordinate more than one design activity. Architectural firms followed with 28.1%, then Structural design firms (16.7%) and lastly, Mechanical and Electrical design firms had 10.4%. Therefore, all the groups of firms identified were represented.

Average Percentage Prevalence

Table 1 presents the average percentage prevalence calculated for the groups of firms with respect to each quality section/factor. Individually, the prevalent practices among the Architectural firms relate to Computer Usage - Q17 (86.11%) and Design Buildability - Q16 (80.56%). Both were satisfactory. However, the remaining quality section/factors require either slight or serious improvement.

The only commendable practices recorded by the Structural firms in relations to Q16 (90.63%). Similarly, the group recorded satisfactory performance in Design Planning - Q5 (87.26), Design Review - Q10 (80.60), Design Changes - Q11 (82.69%), Documents Control - Q14 (82.74%), Design Maintainability - Q15 (83.58%) and Q17 (84.67%). This placed the group above others despite its overall average of 77.4% which generally suggests need for slight improvement.

Standing as the last group with overall average percentage prevalence value of 67.94%, is the Mechanical/Electrical firms which recorded neither commendable nor

satisfactory statuses. The prevalent practices for the groups relates only to Subcontractor Control - Q13 (80.00%), Working Relationship Jointly with Client and Contractor -Q19 (77.50%) and Q10 (75.00%) which all require slight improvement.

Table 1: Quality Sections' Average Percentage Prevalence for Groups of Firms

Quality Section (Code)	AR (%)	ST (%)	M&E (%)	MD (%)	AVR (%)
QS1	72.37	77.97	70.83	74.01	73.80
QS2	69.91	80.32	73.75	71.43	73.85
QS3	52.00	69.79	53.33	62.83	59.49
QS4	65.08	69.85	56.67	69.24	65.21
QS5	78.70	87.26	72.08	84.14	80.55
QS6	70.84	74.22	71.25	71.73	72.01
QS7	73.79	77.78	71.12	75.49	74.55
QS8	69.67	75.47	65.06	70.47	70.17
QS9	67.12	80.04	68.89	74.54	72.65
QS10	76.49	80.60	75.00	81.78	78.47
QS11	72.10	82.69	72.50	78.85	76.54
QS12	65.23	62.13	56.25	64.41	62.01
QS13	78.50	68.39	80.00	75.63	75.63
QS14	74.25	82.74	70.34	82.60	77.48
QS15	76.39	83.58	63.75	83.25	76.74
QS16	80.56	90.63	62.50	86.25	79.99
QS17	86.11	84.67	68.75	87.82	81.84
QS18	71.19	72.32	77.50	77.02	72.32
QS19	68.76	69.77	60.40	71.25	71.90
QS20	67.81	78.35	67.94	69.92	69.12
AVR	71.84	77.40	70.83	75.63	73.22

AR = Architectural, ST = Structural, M&E = Mechanical/Electrical and MD = Multi-disciplinary.

Multi-disciplinary firms recorded six quality sections/factors with satisfactory practices. These are Q5 (84.14%), Q10 (81.78%), Q14 (82.60%), Q15 (83.25), Q16 (86.25) and Q17 (87.82%). With overall average of 75.63% the group's status generally fall close to that of the Structural firms'.

However, the overall average percentage prevalence of 73.22% calculated for all the groups of firms implied that serious improvement is required in their practices with regards to the quality section/factors. As can be depicted from the general performance, certain quality sections/factors had more influence than others. While Q5 and Q17 appeared to be the most prevalent (both require slight improvement), their influence was outweighed by the influence of the values recorded in the remaining eighteen quality sections/factors. Thus Pareto analysis would be employed to identify those quality sections/factors which if given adequate focus would result in the improvement of the firms' performance instead of all the eighteen.

Result of Pareto Analysis

In order to carry out the Pareto Analysis, the overall average percentage prevalence values of the firms in the last column of table 1 were used. Maximum average percentage prevalence for each quality practice is 100%. Therefore the negative impact of each quality section/factor depends on the shortfalls recorded by each quality section/factor. Table 2 was constructed based on the steps outlined by Haughey (2014). Note that the cumulative value of 100 in the last column corresponds with the quality section/factor having highest shortfall (QS3).

Table 2: Quality Sections' Cumulative Count Percentages

Quality Section / Factor (Code)	SF (%)	CC	PC (%)	CPC (%)
QS3	40.51	535.68	7.56	100.00
QS12	37.99	495.17	7.09	92.44
QS4	34.79	457.18	6.49	85.35
QS20	30.88	422.39	5.76	78.86
QS8	29.83	391.51	5.57	73.10
QS19	28.10	361.68	5.25	67.53
QS6	27.99	333.58	5.23	62.28
QS18	27.68	305.59	5.17	57.05
QS9	27.35	277.91	5.11	51.88
QS1	26.20	250.56	4.89	46.77
QS2	26.15	224.36	4.88	41.88
QS7	25.45	198.21	4.75	37.00
QS13	24.37	172.76	4.55	32.25
QS11	23.46	148.39	4.38	27.70
QS15	23.26	124.93	4.34	23.32
QS14	22.52	101.67	4.20	18.98
QS10	21.53	79.15	4.02	14.78
QS16	20.01	57.62	3.74	10.76
QS15	19.45	37.61	3.36	7.02
QS17	18.16	18.16	3.39	3.39

SF = Short fall, CC = Cumulative Count, PC = Percentage Count and CPC = Percentage Cumulative Count.

Figure 1 shows a curve plotted using the cumulative count percentage. The broken line separates the vital causes (factors) – top 20% (left side) from the trivial many – lower 80% (right side). It can be depicted that four quality sections/factors fall under the vital few. These are QS3 (Employee Training and Education), QS12 (External Design Review), QS4 (Design Contract Review) and QS20 (Performance Quality Audit). From the average percentage prevalence analysis the four quality sections/factors recorded 59.49%, 62.01%, 65.21% and 69.12%, respectively. All the figures fall below 75% which suggests serious improvement.

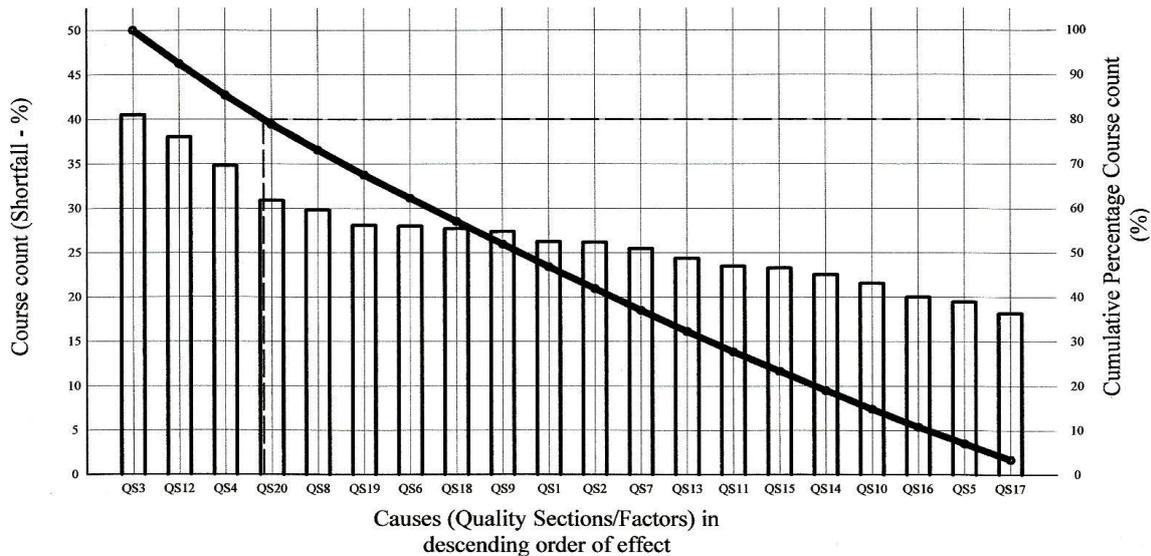


Figure 1, Pareto diagram separating vital from trivial factors

CONCLUSIONS AND RECOMMENDATIONS

The study established that the overall average percentage prevalence recorded by the Nigerian design firms registered by the Corporate Affairs Commission was 73.22% (based on quality section/factors studied). This indicates that the Nigerian design firms generally fall in the category of 'Require serious Improvement'.

The result of the Pareto analysis conducted identified four major (vital) quality section/factors which largely influence the performance of the Nigerian design firms. The sections/factors were; Employee Training and Education (QS3), External Design Review (QS12), Design Contract Review (QS4) and Performance Quality Audit (QS20). It is therefore imperative that quality management provisions relating to these quality sections are adhered to by the design firms. Hancock (1992) argued that *"many of the problems and conflicts within the construction industry are as a result of misunderstanding and a lack of perception founded in our education of construction industry professionals."* Similarly, Stebbing (1987) noted that design contract review is the *"most important activity, but insufficient emphasis is given to it in most QA standards."* Actions required to be performed on the specific practices relating to the identified quality sections/factors according Bubshait *et al* (1999) are follows.

Employee Training and Education (QS3)

In this respect it required that all the practices under the quality section need to be properly addressed. On-the-job training must be provided to employees; short courses and seminars need to be arranged; and organisations must provide library facilities to their employees.

External Design Review (QS12)

Firms must ensure that external design review are performed by client or contractors to verify design adequacy; verifying that consideration is always given to all contract clauses; ensuring that considerations are always given to results of field survey conducted by others; and in case of one man discipline, review of design from outside the organisation is always arranged.

Design Contract Review (QS4)

This requires that; a review team is always constituted comprising of project manager, discipline lead engineers and quality assurance representative to review new design project; the team should always consider the scope of works and ensure it is understood; the team must always ensure that quality assurance plan identifies the true scope of work involved; the team identifies all parties and exact nature of statutory requirements; and that the team should always identify all considerations relating to environmental issues.

Performance Quality Audit

With regards to this quality section/factor, it is regrettable to mention that Standard Organisation of Nigeria (SON) is yet to commence performance quality audit among the Nigerian design firms (Bamisile, 2004). Therefore, personal effort is required from among the firms in preventing, identifying and taking proper actions regarding non-conformance to quality provisions.

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FACTORS IN BUILDING DESIGN THAT IMPROVE BUILDING MAINTAINABILITY IN MALAYSIA

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A building designed with good maintainability considerations not only functions as intended, but is also adaptable to current and future use. The purposes of incorporating good maintainability considerations into the design of a building are to achieve high building performance, ease day-to-day housekeeping tasks, make the building adaptable for future needs and maintain a stable usage cost throughout the building's design life. This study identifies factors that improve building maintainability in building design by applying structural equation modelling with partial least square estimation (PLS-SEM) technique. Data collection method in this study includes an expert panel interview using prepared semi-structured interview questions and a questionnaire survey to identify the influencing factors to improve the maintenance-related needs of the building. Based on hypotheses derived from the expert panel interview, a structural model is developed using systematic procedures in the application of PLS-SEM technique. The population of interest is defined as building designers, including architects, civil, mechanical and electrical engineers, quantity surveyors, and client's technical and maintenance engineers. This study identifies five significant factors or variables that can enhance building designs, and in turn improve building maintainability in Malaysia. The most significant variable is developing efficient design tools that utilise information and analysis focusing on the user's usage behaviour.

Keywords: building maintainability consideration, building performance, design management, structural equation modelling, partial least square.

INTRODUCTION

A building designed with good maintainability considerations, not only functions as intended but is also adaptable to current and future use. The purposes of incorporating good maintainability considerations into building designs are to achieve high building performance, ease day-to-day housekeeping tasks, make the building adaptable to future needs and maintain a stable usage cost throughout the building's design life. Lack of attention to maintainability considerations at the design stage may lead to difficult and costly operation to users; hence users' expectation may not be achieved (Nicolella 2014; Wood 2012; Williamson *et al.* 2010; Ikpo 2009). As a result of fragmented work processes coupled with building designers' focus on meeting statutory and safety requirements; maintainability needs are considered as a trade-off and deemed less important (Neza and Mohamad 2014).

Current building designs rely on the designers' experiences and lessons learned from previous projects (Omigbodun 2001; Kartam 1996; Stewart 1994). To improve designs, a structured approach that focuses on meeting users' expectation in terms of

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maintenance-related considerations is highlighted. Many studies on construction industry's productivity concluded that improving the maintainability of buildings will yield significant impacts in long-term use of the buildings (Egan 1998, 2010; Fairclough 2002; Construction 21 Report 1999; Latham 1994). In Singapore, for example, the Construction 21 Report (1999) identified improving maintainability as the core strategic method in situations where resources are limited. The report outlined eight potential factors that improve building maintainability. The factors are life-cycle cost (LCC), rating individual devices for maintainability, longer defect liability period, designers' and suppliers' role in providing information on construction methods and materials, use of Design and Build (D&B) procurement system, the availability of LCC data, developing guidelines, and improving training programmes. The eight factors fall into three main areas, which are: Competencies Development, Method and Database Development and Procurement Strategy.

A study by Silva (2004) using the same factors or variables reflected the importance of ensuring designer's competency through basic knowledge, continuous training and formulating a holistic method that focuses on building performance while in use rather than focusing on satisfying the current code of practice and client's needs. Arditi and Nawakorawit (1999) also stressed the importance of designer's competency along with efficient and effective methods; to enable informed decisions during the design stage. The approach in building design must be efficient in using project information and, effective in analysis that focuses on high engineered quality and good product performance. Procurement strategy must take into account the need to include a reliable design team from the beginning until operation stage, to ensure high maintainability building. The above discussion and interview with experts lead to the following hypotheses:

H1, a collaborative team approach in building design has a direct positive effect in improving designer's competency development.

H2, a collaborative team approach in building design has a direct positive effect in producing designs with improved building maintainability.

H3, a collaborative team approach in building design has a direct positive effect in the efficient use of information and effective design method.

H4, designer's competency development has a direct positive effect in improving building maintainability at the design stage.

H5, efficient use of information and effective analysis in building design has a direct positive effect in producing designs with improved building maintainability at the design stage.

H6, an integrated procurement system has a direct and positive impact on improving building maintainability.

H7, product performance evaluation has a direct and positive impact on improving building maintainability.

The above relationships given in the hypotheses are presented in a structural model in Figure 1. The items in rectangular boxes represent observed variables or the item's measurements according to the answers from the questionnaire (see Table 1). The latent variable (LV) "*Collaborative Design Team (CDesign)*" is measured by a three-item measurement (i.e., the rectangular box), "*Designer Competency Development (DComp)*" is measured by a four-item measurement, "*Information and Method of Use (InfoMethod)*", "*Integrated Acquisition System (Integrated)*" and "*Product Performance (PP)*" are measured by a two-item measurement; and "*Improve Building Maintainability (HMB)*" is measured by a five-item measurement.

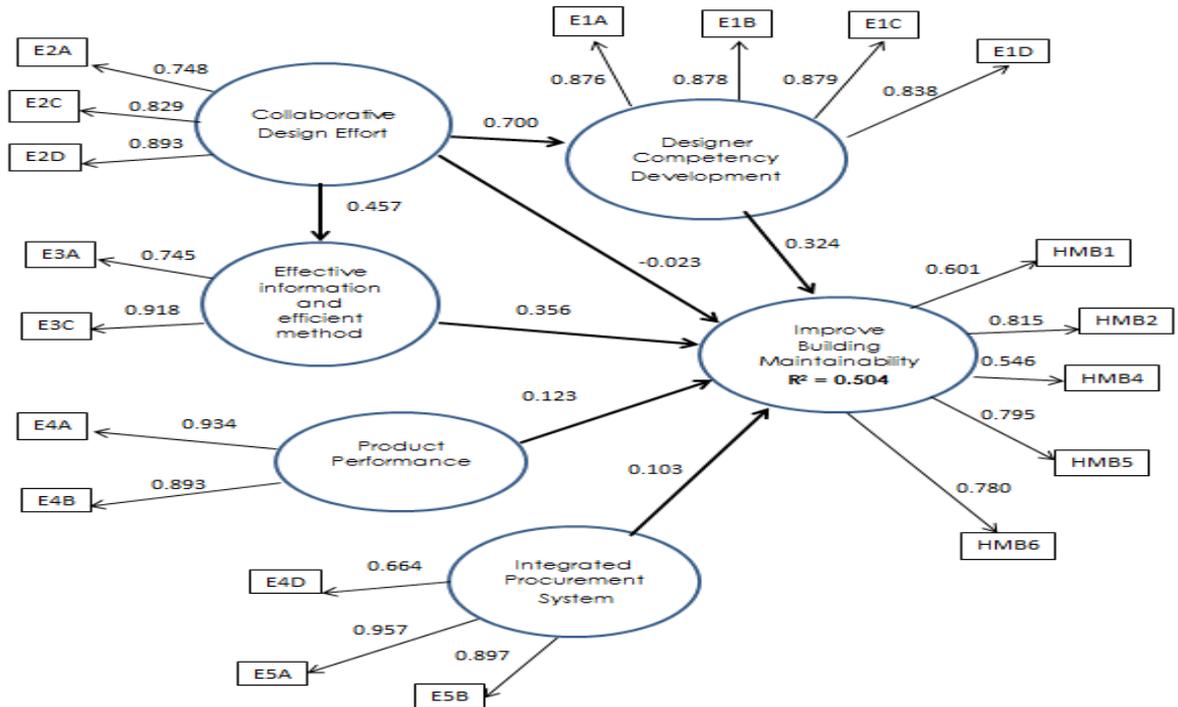


Figure 1: Structural model of the factors to improve building maintainability in the design stage

RESEARCH METHOD

Structure Equation Modelling Partial Least Square (PLS-SEM)

PLS-SEM is a second generation multivariate technique (Fornell and Cha 1994) which can simultaneously evaluate a measurement model (the relationships between constructs and their corresponding indicators), and a structural model with the aim of minimising error variance (Chin 1998). PLS-SEM was developed by Joreskog and Wold (1982), and Wold (1980). It has the capability of working with unobservable LVs and can account for measurement error in the development of LVs (Chin 1998). The estimation procedures in PLS-SEM use the ordinary least - square regression-based method, which estimates the path relationships with the objective of minimising the error term while maximising the R square value to achieve the predicted objectives (Hair *et al.* 2014). PLS-SEM works efficiently with small sample size and complex model while making practically no assumption about the underlying data in terms of data distribution. PLS-SEM makes use of resampling methods to determine the confidence interval of the model parameters by using a random subset of data such as bootstrapping. Bootstrapping is a robust alternative to statistical inference based on parametric assumptions such as normality when the assumptions are in doubt (Mooney and Duval 1993). When the research has an interactive character as in the case of incremental study, which is based on new measures and structural path, PLS-SEM is deemed more appropriate. In this respect, these statements are confirmed by Reinartz *et al.* (2009) that, PLS-SEM is the preferable approach when researchers focus on prediction and theory development.

Data Collection

The systematic procedures for applying the PLS-SEM are shown in Figure 2. The data collection method in this research includes an expert panel interview using a prepared

semi-structured interview questions and questionnaire survey to identify the current design focus, the main problems during building operations and the key variables to improving the maintenance-related needs of a building. The population of interest is defined as building designers, including architects, civil, mechanical and electrical engineers, quantity surveyors, and client's technical and maintenance engineers. Data collection was conducted from early April 2013 to the end of May 2013. The questionnaires were handed out to the design engineers and collected immediately after they were completed. Of the 250 questionnaires sent, 111 questionnaires were returned representing an overall rate of 44.4%. The responses were checked for completeness and coded for data analysis. The public sector represented 54.1% of responses while the private sector represented 45.9% of responses. All respondents are involved in design tasks with 67% of respondents rated themselves as being competent in building maintenance.

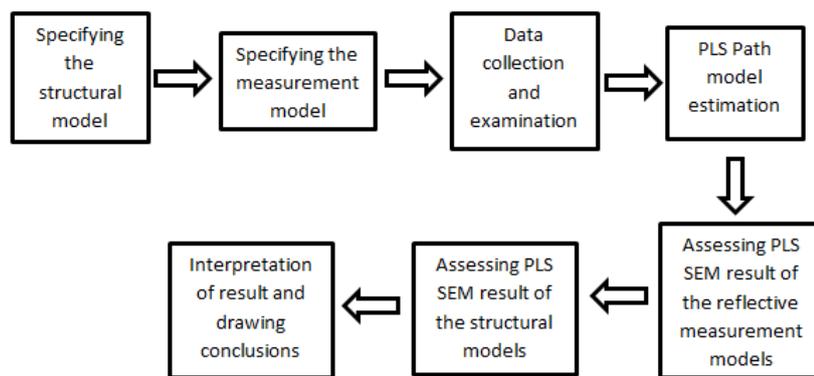


Figure 2. A Systematic Procedure for applying PLS-SEM (Adapted from Hair *et al.* 2014)

MODEL TESTING AND RESULTS

Measurement model testing

Smart PLS M2, Version 2.0 (Ringle *et al.* 2005) software was used to analyse the data. The two main criteria used for testing the goodness of measures are validity and reliability. Reliability is a test of how consistently an instrument measures a concept while validity is a test of how well an instrument measures the particular concept it is intended to measure (Sekaran and Bougie 2010). The adequacy of the model was evaluated using individual item reliability analysis, convergent validity and discriminant validity. The first criterion to be evaluated is typically the internal consistency reliability (Hair *et al.* 2014). Composite reliability (CR) values of 0.6 to 0.7 are acceptable in exploratory research, while in a more advanced stage of research; values between 0.7 and 0.9 would be regarded as satisfactory (Nunnally and Bernstein 1994). Table 2 shows that the composite reliability has a value of between 0.821 and 0.924, which is acceptable. The value for a loading of 0.5 is considered significant (Hair *et al.* 2010). All loadings are shown to be higher than 0.5, which can thus be regarded as satisfactory. Construct validity describes how well the result obtained from the measurement fits the theories around which the test is designed (Sekaran and Bougie 2010). This can be assessed through convergent and discriminant validity. A loading of 0.5 is considered significant (Hair *et al.* 2010) and individual reliability of the item can be assessed by observing the loading. All items measuring a particular construct were highly loaded on that construct and loaded less on the other constructs, thus confirming the construct validity.

Table 1. Operationalisation of independent latent variables

Latent Variable (LV)	Item Code	Description of measurement item (indicator)
Collaborative Design Effort	E2A	Design team consists of multidisciplinary members and future building maintenance team assembled at the planning stage to help develop the project brief.
	E2C	Translating of needs statement of clients into design information with which the building maintenance team will produce a clearly defined project needs statement in terms of building maintainability needs.
	E2D	The multidisciplinary design team must include a building manager in the design stage to identify building maintainability needs.
Designer Competency Development	E1A	Provide training and development programmes on building maintainability needs for building designers.
	E1B	Provide building maintenance curriculum at universities and for all technical institutions.
	E1C	The construction industry to promote an accredited professional design review on maintainability of the building.
	E1D	Building designers must evaluate the performance of the buildings they designed.
Improve Building Maintainability	HMB1	Low unplanned maintenance.
	HMB2	Minimum downtime of equipment.
	HMB4	Minimum downtime of building system and subsystem.
	HMB5	Ease of procurement of spare parts and components.
	HMB6	Predictable maintenance cost.
	Effective information and efficient method	E3A
E3C		The design team identifies important information to carry out products that meet users' needs at once.
Integrated Procurement System	E4D	Extend the defects liability period of buildings or beyond the current period.
	E5A	The client chooses a successful tender based on whole life cycle cost rather than just initial cost.
	E5B	Value analysis and Life Cycle Cost analysis for material and equipment selection.
Product Performance	E4A	The design team focuses on products which are minimally sensitive by selecting material, equipment and integration.
	E4B	Many design arrangements tried or tested under a few users' conditions to reduce rework, defect and unplanned maintenance instance.

Note : All Response options 1-5: 1=Least Important to 5= Extremely Important

Convergent validity is the degree to which multiple items that measure the same concept are in agreement. As suggested by Hair *et al.* (2010), the factor loadings, composite reliability and the average variance extracted were used to assess convergent validity. The loadings for all items exceeded the recommended value of 0.5 (Hair *et al.* 2010). Composite reliability (CR) (see Table 2) that depicts the degree to which the construct indicators indicates the latent construct, ranged from 0.821 to

0.924, which exceeded the recommended value of 0.7 (Hair *et al.* 2010). The average variance extracted (AVE) measures the variance captured by the indicators relative to the measurement error and should be greater than 0.5 to justify using a construct (Barclay *et al.* 1995). The average variance shown is in the range of 0.513 to 0.835. The results in Table 2 demonstrate convergent validity and good internal consistency within the measurement model.

Table 2. Result of the measurement model

Construct	Item	Loading	AVE	CR
Designer's Competency	E1A	0.876	0.753	0.924
	E1B	0.878		
	E1C	0.879		
	E1D	0.838		
Collaborative Design Effort	E2A	0.748	0.681	0.865
	E2C	0.829		
	E2D	0.893		
Effective information and Efficient Method	E3A	0.745	0.699	0.821
	E3C	0.918		
Integrated Procurement System	E4D	0.664	0.720	0.883
	E5A	0.957		
	E5B	0.897		
Product Performance	E4A	0.934	0.835	0.910
	E4B	0.893		
Improved Building Maintainability	HMB1	0.601	0.513	0.837
	HMB2	0.815		
	HMB4	0.546		
	HMB5	0.795		
	HMB6	0.780		

a Composite reliability (CR) = (Square of the summation of the factor loadings) / {(square of the summation of the factors loadings) + (square of the summation of the error variances)}

b Average variance extracted (AVE) = (summation of the square of the factor loadings) / {(summation of the square of the factor loadings) + (summation of the error variances)}

After confirming the convergent validity, the discriminant validity was assessed using Fornell and Larcker (1981) method. Discriminant validity is the degree to which items differentiate between constructs or measure distinct concepts. The items should load stronger on their own construct in the model and the average variance shared between each construct and its measures should be greater than the variance shared between the construct and other constructs (Compeau *et al.* 1999). The square root of the AVE of each LV should be larger than the correlation between the two variables. As shown in Table 3, square root of the AVE, which is shown on the diagonals, is greater than

the values in the row and columns on that particular construct, then it can be concluded that the measures are discriminant. From Table 3, it is shown that the values in the diagonals are greater than the values in their respective row and column, thus indicating the measures used in this study are distinct.

Table 3. Discriminant validity of constructs

	CDesign	DComp	HMB	Info/ Method	Integrated	PP
Cdesign	0.825					
Dcomp	0.700	0.868				
HMB	0.435	0.625	0.716			
Info/ Method	0.457	0.655	0.647	0.836		
Integrated	0.166	0.387	0.274	0.172	0.849	
PP	0.416	0.362	0.428	0.582	0.095	0.914

Note: Diagonals value represents the square root of the AVE and the off-diagonals value represents the correlations

Structural model testing

Figure 1 shows the path coefficients and R square, The value of R square of the Improving Building Maintainability construct was 0.504, suggesting that 50.4% of the variance can be explained by the five predictors, namely Collaborative Design Effort (CDesign), Designer Competency Development (DComp), Effective Information and Efficient Method (InfoMethod), Integrated Procurement System (Integrated) and Product Performance (PP).

Table 4. Result of structural model

Hypothesis	Relationship	Std Beta	SE	t value	Decision
H1	CDesign --> DComp	0.700	0.039	19.254	Supported
H2	CDesign --> HMB	-0.023	0.129	0.170	Not Supported
H3	CDesign --> InfoMethod	0.457	0.064	6.923	Supported
H4	DComp --> HMB	0.324	0.130	2.308	Supported
H5	InfoMethod --> HMB	0.356	0.105	3.228	Supported
H6	Integrated --> HMB	0.103	0.090	1.312	Supported
H7	PP --> HMB	0.123	0.088	1.290	Supported

Cutoff value for significant level $p < 0.10$, one tail = 1.28

Using a bootstrapping technique with a re-sampling of 500, the path estimates and t-statistics were calculated for the hypothesised relationships. Hypothesis testing was achieved by comparing the path coefficients (β) between each LV: the higher the path coefficient, the stronger the effect of the predictor LV on the dependent variable. A summary of the hypothesis testing is shown in Table 4. The hypothesis is considered upheld based on the conventional significance level of 0.10. Table 4 shows that only H2 path is not significant while the others are shown to be significant.

FINDINGS AND CONCLUSION

The findings of this study present some useful insights for improving building maintainability during the building design stage. First, the fragmented nature of the building design process is clearly illustrated in the analysis, for respondents do not believe that a collaborative design team will enhance building maintainability. Current design activities are executed independently by each discipline and the coordination is usually made during several technical meetings. This typically leads to significant rework of the design to suit each discipline's needs, often leaving maintenance-related needs to be overlooked. Most of the design activities produced workable designs that integrate every discipline's requirements and as a result, the building maintainability element is left to the facility operator to manage and mitigate the setbacks of the design at the operational stage. The focus is on building design for delivery only and typically does not address ease of usage, maintenance-related considerations and building adaptability in the operational stage. The typically fragmented nature of the building design team will significantly improve design results when the design is executed in a collaborative setting, particularly when communication is efficient and experience is shared, improving designer's competency.

Current building designs rely on the experience of the designers and lessons learned from previous projects. Often, there are no specific guidelines and procedures to incorporate the maintenance requirements of a building. Maintainability-related needs are based on the experience of the designers, and it is assumed that all designers have the experience of producing building designs that consider maintenance issues fully. Respondents in this study strongly agreed that a collaborative design team would influence the development of designer's competency and the use of efficient information and methods. Better building designs require designers' interactions at the design stage to facilitate how they use information for their design. For example, a structural engineer may use floor area to calculate the loading (i.e., a structure element), while a mechanical engineer may use the floor area for the computation of heat, ventilation and air conditioning requirement (i.e., user comfort). An electrical engineer may use the area to consider the lighting requirement in his or her design (i.e., another aspect of the user comfort), while the architect is concerned with the form and function of the area (i.e., whether it will create a complication between the structure and ventilation). Therefore, collaborative design will facilitate the translation of client's needs into design information, producing a clearly defined project needs in terms of the maintainability of the building. A design team consists of multidisciplinary members and future building maintenance team assembled at the planning stage; can help develop a project to identify its construction and building maintainability needs.

In the measurement model, "*focus on critical product information*" is shown to have the most influence (0.918) compared to "*use of product performance and cost data*" (0.745). A holistic approach and design tools that focus on product performance are needed to improve building maintainability. The conservative view of building design ensures compliance with the law for safety and meeting the cost agreed with the clients. It also satisfies the basic needs of the building. While pressure to speed up production in terms of design and construction increases, the clients also expect high-quality designs, ease of building maintenance, and stable cost of operations. Therefore, a more efficient design method is needed. A design with low maintenance-related consideration significantly lowers building performance.

The current design approach in construction is seen as inefficient in producing building designs with high operational performance. The building design result also typically lacks performance evaluation, which is typically the ease of building operation and maintenance. In manufacturing, improvement in terms of product design, construction and assembly have been realised by utilising an improved production philosophy. The manufacturing product development approach has gained improvement in terms of product design and has become the main reference to learn from and apply to in the construction industry. A method such as the Robust Engineering (RE) approach in manufacturing has been shown to improve the product's engineered quality and performance. One of the most important considerations in design is ensuring product performance, which is the ability to identify the problems affecting a product while in operation. Adapting this manufacturing approach to building design could espouse the same benefits for the construction industry as it has for the manufacturing industry.

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THE SIGNIFICANCE OF DIVERSE ECONOMIC LOGICS FOR INNOVATION IN THE CONSTRUCTION INDUSTRY

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In the production of the built environment, construction, planning and design are ongoing problem-solving efforts involving fragmented, multi-tier supply chains. The complexity of operations entails multiple actors with disparate responsibilities and diverse operating modes and economic logics. Each actor has only partial involvement in a project, and often operates in several different projects at the same time. Technological improvements and creative, economical solutions to complex problems in design and in construction are rarely commercialised and reused in subsequent projects. Even if ingenious, many solutions are not institutionalised or do not become part of daily routine. Furthermore, innovative technologies often presuppose that one or more actors take on risks that they are ill-equipped to handle, while those who choose to invest in innovative technologies often experience that they are unable to harness any revenue from their new ideas. This contributes to innovation efforts in construction evolving within one particular situation having outcomes not being generalised, not being created in a form that makes it transferrable, and not being learned. Problem-solving and technological change, therefore, may happen without actually leading to innovation. We seek to understand this aspect of innovation in the construction industry by examining the economic logics of different actors in construction projects. The objective is to understand how diverse logics alone and together influence the outcomes of efforts to innovate. By characterising and contrasting logics, it is possible to understand how the attractiveness of various types of innovation will vary systematically between the actors, and how liaising and interactions between them may influence innovation patterns. By discussing specific empirical examples of attempted innovations, we will understand better why it is that resources such as solutions to intricate and novel problems and innovative technologies are not routinely seen as assets and brought forth as successful and consequential innovation in the industry.

Keywords: innovation, economic logics, improvement, technology.

INTRODUCTION

The specific characteristics of any industry influence the innovation processes going on there (Malerba, 2004). The construction industry, which is responsible for planning, designing and physically producing the built environment, encompasses

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complex, multi-tier supply chains, large and heterogeneous sets of firms, whose value-creating activities are organised very differently (Bygballe and Jahre, 2009). These actors are all engaged in on-going problem-solving efforts both on-site and off-site. Temporary organisational structures – construction projects – bind more permanent organisations together for some time, but in constellations that are typically both fragmented and fluid (Dubois and Gadde, 2002). Responsibilities for design, specification, installation, maintenance and operation are generally separated between many different firms (Gann and Salter, 2000). Operations are carried out at different times and under different contractual arrangements. Each company has its own specific, negotiated and contractually recorded responsibility. Contracts are never fully comprehensive, however, and project success depends on commitment from participants not only to do their part, but also to be willing and able to collaborate with other stakeholders (Bresnen, 1990). For most firms, involvement in a specific project can only be partial. First, because responsibilities in the project are divided, and second, because every firm has several contractual obligations and commitments running concurrently in a number of different projects. The complexity of the temporary organization is multi-dimensional; projects are made into a whole by way of complicated legal and economic, as well as informal arrangements that serve to produce a certain level of transparency and predictability in the collaborative set-up. We might argue that there is a certain economic logic of the construction industry, which reflects the economising process within and across projects, in which economic benefits are pursued and distributed among the parties in the construction process, with diverse economic logics (Bygballe, Håkansson and Jahre, 2013).

The way the construction production processes are organised and the diverse economic logics are likely to influence innovation, whether positively or negatively. Projects are arenas for learning and problem-solving since new project objectives trigger search activities that are needed for identifying new solutions (Slaughter, 2000). However, new solutions are risky and introducing change in construction can create unanticipated effects. Since construction projects are inter-organisational, new solutions must be negotiated with one or more actors within the project coalitions (Winch, 1998). As a result, the perception of degree of change and links to other systems can differ among involved parties (Slaughter, 2000). Given the different interests involved, it is likely that some solutions that are good and economically beneficial for one party or a group of the involved firms may not be good for others. Proper incentive systems must therefore be in place, where the benefits from innovations are split between the clients and the actors in the project coalition (Winch, 1998). In other words, innovative solutions are not simply risky; they impact on particular participants in specific ways. The project coalition involves a complex network of contracts, along with rights and liabilities that flow from the contracts.

Research into construction project practices shows that technological innovations and creative, economical solutions to complex problems in design and in construction are difficult to commercialise effectively and to reuse in other projects (Ozorhon, Dikmen and Birgonul, 2005). Creative solutions to challenging problems tend not to be assimilated into routine practices and diffused across the construction sector. This indicates that diffusion of innovation in construction is difficult. There are several reasons for this, among others that the introduction of non-standard methods and construction products also require those involved to cope with increased risk (Slaughter, 2000). Actors may not be equipped to handle this additional risk. Nor may they be interested in facing more risk, even if they know how to. Indeed, the risks and

responsibilities set out in contracts may inhibit the uptake of innovation. Clearly, shrewd business people will only choose innovative solutions over well-tried solutions if there is a good reason to do so, typically a real economic benefit. If those committing to use novel technologies cannot harness additional revenues from innovation, there is one significant reason less to expect wide diffusion of innovations. Furthermore, if incentives are weak, then what may appear to be a viable innovation in one particular situation in one project might still not be diffused.

If it is true that specificities of construction generate incentive structures that explain why problem-solving and technological innovation do not lead to innovation across projects and firms, then it should be urgently important to understand better what these specificities are, and what mechanisms are at work. Previous research has suggested that a key innovation barrier is the construction industry's inability to create long-term connections and network effects (Dubois and Gadde, 2002; Miozzo and Dewick, 2004). The lack of connections hinders the learning loops from the project to the company and industry levels, which are necessary for innovation (Bygballe and Ingemansson, 2014). The economic logics (as well as institutional) of the industry and its key contributors in construction projects have to be better understood, to make it possible to explain why the potential benefits of innovations are not harnessed, and why there is a lack of connection and the implications thereof. We seek to understand this aspect of innovation in the construction industry by examining the economic logics of different actors in construction projects. The objective is to understand how such diverse logics influence the outcomes of efforts to innovate. The aim is to conceptualise patterns of economic logics springing out of the diverse institutional contexts that actors are typically embedded in. By characterising and contrasting logics, it is argued below that it becomes possible to understand how the attractiveness of various types of innovation will vary systematically between the actors, and how liaising and interactions between them influence innovation patterns. By way of a discussion, empirical illustrations of attempted innovations from previous research are provided to demonstrate how it is that resources such as solutions to intricate and novel problems and innovative technologies are not routinely seen as assets and brought forth as successful and consequential innovation in the industry. We seek to understand the economic logics that motivate firms' behaviour and their employees' decision-making in the context of the network of contracts that constitutes the project coalition or temporary organisation. This involves laying bare the key economic incentives that drive or hinder the take-up and diffusion of innovative technologies.

UNDERSTANDING THE ECONOMIC LOGIC(S) OF CONSTRUCTION (ACTORS) AND ITS IMPACT ON INNOVATION

In this paper, we see innovation as sticky change of established value creation practices (Orstavik, Dainty and Abbott, 2015). Value creation is often synonymous with production. However, we use the term value creation, as activities in construction are not only physical creation and assembly, but very often consist in service provisioning of various kinds. The idea that changes are sticky entails that they have an aspect of irreversibility, and that they are sustained in value creation efforts over time. Innovation is not simply the creation of novelty; it entails a lasting change in the established ways of value creation.

Considering innovation in this way as nothing but transformation of established modes of production, encompasses all the different forms of innovation in the

Schumpeterian tradition. That is to say products and processes, as well an organisation, raw materials and markets (Schumpeter, 1934). When considering innovation in construction, what is of interest is all organised value creation efforts going on as part of designing and producing the built environment. Hence, the whole of the complex set of value creation chains is of concern to the analysis. Innovation potentially occurs along these chains, and may affect other parts of a chain, and other related value creation chains. In this respect, we are in line with Roger's (2003) diffusion theory, which concerns positive and negative incentives for adopting innovations and the way diffusion is patterned by way of such factors. Innovation in this perspective is taken as given novelties that rational actors have the choice to adopt, or not to adopt. However, this perspective has been criticised for overlooking the important transformation processes often associated with diffusion. Generally, innovations find their form in a process where creation of the new and the diffusion of novelty is closely intertwined (Hall, 2005; Rosenberg, 1982).

For our purposes, this means the following reasoning: different firms are engaged in various value creation activities. For example, in the building sector, architects develop designs in dialogue with clients and produce documents to communicate this to others in the process; consultant engineers make calculations of loads and specify construction dimensions; technical subcontractors create and assemble systems for electricity, ventilation, plumbing, etc.; main contractors procure and coordinate everything on site and clients fund the work. Each organisation makes decisions of different kinds, in relation to their contractual duties and professional obligations. Clearly, the different actors entertain different kinds of production skills, deal with diverse input materials and tools, create different outputs, are assessed against diverse quality criteria, etc. Furthermore, different actors employ different remuneration principles, have diverse sets of "*significant others*" (different business environments), and they are subject to various legal and contractual frameworks that influence, among other things, the timing and amount of payment they may receive for their work. Even culture is different across firms in projects, as firms have different value orientations, senses of identity, etc. This, essentially, is what we mean by the notion that institutional and economic logics of stakeholders in construction projects are diverse. This diversity is important when trying to understand the nature of innovation in construction and the barriers to successful creation and diffusion of innovation. The diversity is multidimensional, and subjecting it to systematic analysis entails an effort to simplify and to distinguish more important from less important factors. If we take the different actors involved in the construction process, how could we understand their economic logics? Table 1 illustrates a "*simplified*" outline of key features of the economic logics of different parties.

The "*owner/client*" in construction tends to take on many different forms. Sometimes a client is both owner and user of what is being built, but often this is not the case (for example, property developers who develop real estate for sale). Nevertheless, the client plays a vital role with respect to innovation in setting the project objectives and choose the project team. The question is, what incentives are there for clients who build for their own purposes versus clients who build for others, and do public and private clients differ? There are characteristic differences between key groups of participant:

- Architects and consulting engineers could innovate, but the legal aspects of their professional indemnity insurance policies specifically exclude them from employing untried technologies. So, what are the consequences of this risk

avoidance, which is likely to characterise the consulting part of the industry? Is this the key barrier to innovation in the industry?

- Main contractors could innovate, but their contract typically centres on only bringing resources to site, in order to build what has been designed. This is the essence of what is usually known as general contracting, which is not as traditional as some people make out, since it is only something that happened as a result of the industrial revolution (Hughes, Champion and Murdoch, 2015). This also means that contractors often operate as coordinators rather than technology or competence providers. What are the consequences for the type of innovation that this type of actor is interested in pursuing?
- Sub-contractors and suppliers could innovate, but no architect would specify an untried technology. Sub-contractors are paid for installing things, but traditionally not for running them after they are installed. Thus they have no “*skin in the game*” when it comes to innovative buildings helping to improve client processes in a building in use. (These are, essentially, the technology providers as far as a client is concerned, the sub-contractors as far as designers and contractors are concerned). This type of actor is also often involved “*late*” in the process and usually has a delimited role in the project as a whole – how can an actor that is not part of the process nor project as a whole know what needs to be changed/innovated as well as how?

Material suppliers are often not even defined within the construction industry, which is one reason why many of the traditional innovation measurements show that construction scores low on innovation (Winch, 2003). Material suppliers are often highly research-intensive. In many segments, such as concrete, any new solution must be thoroughly tested, as the implications of failure can be fatal. Material suppliers are therefore often large, multinational companies, since being in the forefront is highly resource-demanding. Given that much of the innovation in the construction industry comes from this part of the value chain, what are their innovation logics? In other words, what is it that enables these to be so innovative?

Table 1: A “simplified” and generalised outline of the economic logics of construction industry actors

	Clients/Owners	Architects	Consulting engineers	Building contractors	Technical sub-contractors/specialist	Materials suppliers
Role	A decision-maker in the overall process.	Design – concept/design process.	Calculation – planning process.	Production and assembly – primarily construction, but sometimes in design.	Developing and assembly of technical installations – construction process (possibly design).	Production – supplying from permanent production site to construction site.
Primary activities	Fulfilling the project needs through setting project objectives, selecting the team and following up.	Interpreting and (re)solving client problems and needs through problem finding, acquisition solving, choice, execution, control/evaluation, within the context of urban planning and other legal constraints.	Interpreting and (re)solving customer problems and needs through problem finding, acquisition solving, choice, execution, control/evaluation, within legal constraints.	Transforming input into output - assembly and coordination.	Transforming input into output - assembly and coordination.	Transforming input into output – production.
Key value and cost drivers	Fulfillment of project objectives – time, cost and quality. Costs related to coordination and control.	Reputation and knowledge (success, linkages and learning across projects and client problems). Costs related to man hours.	Reputation and knowledge (success, linkages and learning across projects and client problems). Costs related to man hours.	Man hours, skills, capacity utilization, economies of scale/ productivity.	Man hours, skills, equipment and functionality.	Man hours, skills, capacity utilization of equipment, economies of scale/productivity, product development.
Coordination modes	Contracts, planning and supervision	Contract, planning and mutual adjustment/interaction	Contract, standardisation, planning and mutual adjustment/interaction	Contract, standardisation, planning, and mutual adjustment/interaction	Contract, standardisation, planning, and mutual adjustment/interaction	Contract, standardisation and planning

Even if simplified and generalised, spelling out these characteristics of key actors in the construction industry and their economic logics allows us to start discussing the

implications of this diversity for innovation. Furthermore, the institutional logic needs to be taken into consideration. In our view, any understanding of how innovation happens in construction needs to consider its project-based character. A construction project consists of (1) a legal and economic framework in terms of contractual agreements, statutory controls, resource availability and budget(s), (2) several, overlapping sequential phases in which specific decisions and activities take place regarding design, specification, purchasing, assembly/production, delivery, commissioning, maintenance etc., (3) the different actors that need to adapt to the two former type of structures – economic/legal and institutional. Based on these structures, what are the incentives to introduce new solutions vs. using known solutions?

Empirical illustrations

Vignette 1. Innovation in technology and processes - the use of BIM

The first illustration concerns process innovation and the use of Building Information Modelling (BIM) in the design and construction process. The example is taken from the Skandion Clinic project in Uppsala, Sweden, the first facility offering proton-radiation treatment for cancer patients in the Nordic countries. The project was operated as a formal partnering agreement between a large public property developer (AH) and the Uppsala unit of one of Sweden's largest contractors (NCC).

Due to the complexity and risk level of constructing a new type of radiation facility, the property developer took several initiatives to facilitate the construction process, the project coordination and the future management of the clinic. One such initiative was a wide implementation and integration of BIM from planning to production and delivery. This was a new way of working for the developer and to most of the project organisation: the main contractor, a set of subcontractors, and the planning coordinator used BIM for designing, planning and producing the facility. The architect, a local unit of a Norwegian architect firm, was also a driver in this process as BIM was common practice to them. The use of BIM necessitated new meeting forums where the actors could discuss progress and particular adjustments during the entire project. The entire project staff, including all the production workers on site, was “*BIM-trained*” in using it as a communication tool and to detect any potential organisational and technical “*clashes*” beforehand on site. Production staff struggled, however, and often hard copy was used instead of the digital format. Another complicating factor was that in Sweden, a BIM model cannot be used as a legal document. Thus, its use becomes limited in formal communication between actors.

During the project, the property developer initiated the development of a “*BIM manual*” with the purpose of standardising the way BIM was used in future projects. The manual was to guide any future project manager in how to use BIM and, ideally, develop this use further. Thus far, this manual has been used in a subsequent large public property project and is further developed within a forum for public property developers in Sweden.

In this illustration, innovation relates to the way that BIM was used by the entire project organisation, and the development of a standardised BIM manual. Yet a short description, diverse interests, roles and incentives for the actors to drive the development are indicated. The actor responsible for managing the project and the future facility had clear economic incentive to initiate solutions facilitating the project and the maintenance of the facility. The architect was also a main driver as large customers in Norway demand BIM and thus this was their normal practice. BIM allows for the type of iterative problem solving that architects as well as consulting

engineers are involved in and offers a balance between standardisation and adaptation, which architects and consultancy firms need to create value (see Table 1). From a production point of view, benefits of BIM are harder to recognise. In traditional projects where activities of design and construction are split, the way that risks and rewards are specified in contracts will reinforce traditional practices, where designers detail the project and leave the contractors to build what is already decided and modelled in the BIM, leaving few incentives for either of them to innovate. Another interesting question that has arisen in relation to BIM is who owns the data and what are the risks in supplying the model with technical information and new solutions? Architects, engineering firms and technical contractors all supply the model with a large amount of data, which the client ultimately owns. What hampers the client in using this data in new projects with new partners? How would a sub-contractor's intellectual property in an innovative technology be protected? This is likely to influence the incentives to engage in BIM, and the development of technological innovations in general. Indeed, as long as technical subcontractors are paid only for installation, and appointed after the main contractor, the opportunities for them to influence the design decisions with innovative technologies are severely limited.

Vignette 2. Innovation in wet-room products

Industrial building products embody a significant share of research-based innovation in the construction sector (Hauknes and Knell, 2009). However, building product innovation is intimately related to institutional factors such as standards and technical certification. Orstavik (2014) shows how broad innovation processes in housebuilding after World War II transformed the way houses are constructed in Norway, and opened the way for novel industrial products to become major inputs in the housebuilding sector. The use of boards made of gypsum has become the *de facto* standard in this process.

In spite of being made from materials that are perishable and brittle (paper and gypsum), the mass produced boards have physical properties that make them well suited for building. The use of gypsum has been driven by builders themselves choosing cheap building materials over alternatives that are more expensive. However, the use would not have become an accepted standard without the boards being included in designs and specifications detailed by Byggforsk, the leading construction research institute in Norway in the post-World War II era. The involvement of this institution in development of technical standards was instrumental in establishing gypsum as a basic material in housebuilding.

In 2000, a start-up company introduced a novel building board as a specialised “*wet room board*” and offered it to Norwegian builders. As detailed in Orstavik (2014), the claim of the company was that basic gypsum boards are inadequate for wet room building, since water and humidity easily destroy these boards. The company referred to findings that wet rooms had emerged as a prime area of building faults and damages: the recommended practice of covering gypsum with a liquid waterproof membrane had proved ineffective.

The innovative board is made with a core of extruded polystyrene, in a sandwich structure akin to the gypsum board, but with waterproof and vapour-proof layers instead of paper. These boards are more robust in wet environments, and they do not lead to accelerating degradation in the same way as water-absorbing gypsum boards.

Entrepreneurial ventures are often short-lived, but this company survived. Still, results obtained were mixed. Interestingly, the early adopters of the board tended to be

individual housebuilders and do-it-yourself re-modellers. Building product retailers showed interest, but it proved to be difficult for the company to win over professional builders who opted for gypsum and the established ways of building wet rooms.

How can this pattern of diffusion of an innovative building product be explained? That the novel board is embraced most eagerly by single housebuilders and of those outside the ranks of professional builders can be explained by the fact that these actually profit from choosing the novel and more expensive board. They benefit from this investment over time, by becoming owners of a wet room that has a higher quality and a longer lifetime and avoiding all the negatives associated with a faulty wet room. Professional builders do not have the same incentives, mainly for two reasons: First, lower quality materials in the wet room are largely invisible, and will probably not influence significantly the selling price of what is being built. Second, problems in the wet room tend to occur only after any warranty period is over, and using gypsum is in line with accepted standards. Hence, investing in higher quality does not pay off.

The novel wet room board is certain to increase cost, and can normally not be expected to increase income. Since no other negative effects of choosing the lower quality option is to be expected, professional builders do not consider adopting the innovation a rational choice. This position is reinforced by the fact that gypsum is endorsed by Bygghälsan and in rules and norms for wet room building. Hence, in spite of the facts that the novel board is highly compatible with existing methods of building; few complications for builders and significant benefit for house owners and users over time, adopting this innovation is largely avoided by professionals today.

DISCUSSION AND CONCLUSIONS

In the first vignette, the introduction of BIM was driven by the client. The success of this innovation relied on the involvement of all members of the design and production teams from an early stage in the process. Although it is rather unusual to successfully include subcontractors and suppliers into this process, it was achieved in this project. But even if the contracts that bound each different participant to the project were changed in order to allocate liabilities for decisions to the parties who were taking them, was there any possibility for an innovator to share in the future revenue savings, or contribute to future revenue losses, in the event that an innovative technology failed? Clearly, this project involved a transformation of the usual economic logic because there was early involvement of subcontractors in the decision-making processes. But without the added incentive of future revenue from the operation of the building, innovative ideas depend on good-will and a kind of openness.

The second vignette illustrates how the business model of housebuilders differs significantly from building contractors. Housebuilding involves the development of land, so the housebuilder is acting in the role of a developer, even though they may have technical building skills in-house, especially at the local scale. Indeed, a housebuilder who is a builder/developer can overcome many of the business barriers to innovation, since the housebuilder reaps the rewards from the market for the introduction of new technologies. Such a company carries all the risk and stands to receive all the rewards. In this respect, they are completely unlike the contracting sector of the industry, where responsibility for decisions and choices does not rest with those who could innovate. The local housebuilder has an economic imperative and incentive to develop and maintain a reputation for quality. In larger scale work, where contractors are being used by national housebuilders, there is a distance between the decision-making around specifications, and the responsibility for

delivering and installing the materials. Moreover, the housing developer may not be so dependent on repeat customers, operating in completely different market.

One of the things that makes it difficult to understand the economic logics of innovation in the construction sector is that it is not simply a buyer-seller market. Quite apart from the huge network of contracts and separation of responsibilities that characterise the process, there are other constraints that preclude what might be thought of as typical market behaviour. The professions in the construction sector have a significant impact, especially in places like the UK. Professional liability extends beyond the buyer-seller relationship. Professionals owe a duty of care to anyone who may come into contact with their work. This has to be backed up with professional indemnity insurance. Public authorities make significant decisions that constrain designs, both in terms of aesthetics (planning legislation) and performance aspects (construction regulation). Planning and construction regulation may limit the scope for innovation not by dictating tried and tested solutions but by allocating financial liability for decision-making in a way that distorts the market for innovative technologies. In most countries, it is common for the municipal authority to be the decision-maker for these aspects of control. The politics of municipal decision-making may produce another layer of conservatism into the decision-making processes.

These vignettes show that the theory of economic logics provides explanations for the way that different business models emerge and survive in the construction sector. From just two vignettes, the extent of the diverse economic logics begins to be clear. They suggest that when innovation is successfully introduced in a construction project, it is usually because a central actor has managed to align the right competences and interests at the right time along the construction process. In both our illustrations this has been the clients/owners, and in the second case also the materials suppliers. This suggests that owners/clients are least hampered by the economic logics in the industry, and therefore have the largest opportunities for facilitating the introduction of innovations. The theoretical section suggested that the lack of connections of actors and their resources in the construction process induces particular incentives for how to act and (not) interrelate resources across projects. Together, the theoretical findings and our empirical illustrations indicate that the concept of “*connectivity*” might be a useful next step to understand the impact of diverse economic logics on innovation, and also vice versa. Innovative organisational models, such as partnering, are directed towards aligning the diverse goals and interest of the parties. However, to grasp the full implication of these new ways of organising the construction process, we need to understand the diversity of the firms, and more particularly the diverse economic, as well as institutional logics of the involved actors. Without this understanding, phenomena such as partnering will work in some situations and not others, and it will not be clear why.

Ultimately, the illustrations in this paper provide a clear demonstration that the ownership of the means of production is typically divorced from the ownership of decisions about what to build and how to build, as outlined in Table 1. This suggests that further research into the notion that the installers of technology should also be responsible for maintaining and operating the things they make, as well as ways in which this can be implemented, should be a fruitful line of investigation.

In this paper, we have sought to contribute to the stream of research, which deals with understanding innovation and innovation processes in the construction setting. We have made a first step in scrutinising the implication of diverse economic logics of

construction actors for why solutions to intricate and novel problems and innovative technologies are not routinely seen as assets and brought forth as successful and consequential innovation in the industry. The next step is to delve deeper into the concept of “connectivity”. This concept might help us in better understanding and conceptualising the relationship between economic logics and innovation.

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STRATEGIC ALIGNMENT WITHIN A TMO: PERCEPTIONS OF PROJECT SUCCESS

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Current research into the strategic alignment of projects makes the assumption that temporary organisations are formed within the organisational boundary of a single, parent organisation. Within the construction industry, the temporary organisation operates within an environment of overlapping organisational boundaries, where multiple organisations simultaneously seek to make representation on a single endeavour. As a consequence, it is proposed that there may be a lack of consensus among organisational actors as to the perception of project success. Instead, the TMO will be in a state of negotiation and compromise as it seeks to align the project with multiple organisational strategies. The aim of this paper is to identify the source of tensions in the alignment of organisational strategies by investigating how varied organisational actors' measure success on a single construction project. Using case study methodology, a model is presented identifying nodes where tensions in alignment of strategies may occur. Findings suggest that a lack of strategic alignment is inherent in construction projects with the client being the most influential stakeholder.

Keywords: alignment, strategic fit, project success, temporary multi-organisations.

INTRODUCTION

Commentaries on temporary organisational forms have predominantly focused on the implementation of projects within the boundaries of a single parent organisation (Lundin and Soderholm 1995, Packendorff 1995, Turner and Muller 2003). In contrast, the temporary multi-organisation (TMO) operates within an environment of overlapping organisational boundaries, where multiple organisations simultaneously seek to make representation on a single endeavour. As such, reaching consensus on the perception of project success among organisational actors may be difficult to achieve. This is because the TMO will be in a state of negotiation and compromise as it seeks to align the project with the strategic objectives of multiple organisational strategies.

This paper forms part of an on-going study into the strategic behaviour of TMO's, which makes significant contribution towards a greater understanding of how multiple organisations seek to maintain alignment of their strategies through a single construction project. The study responds to a current gap in the theory of temporary organisations (Lundin and Soderholm 1995) and expands on Cherns and Bryant's (1984) characterisation of TMO's. The aim of the paper is to identify the source of tensions in the alignment of organisational strategies, by investigating how varied organisational actors' measure success on a single construction project.

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The paper begins with a brief overview of the research themes within the strategic fit literature, followed by consideration of current models of strategic alignment within projects. The idiosyncratic nature of TMO's within the construction industry is then discussed, before revisiting the extant literature on project success criteria. A case study of a newly built university residence was selected to provide the empirical data for analysis. A model is presented identifying five nodes where tensions of alignment may occur leading to conclusions and recommendations for further research.

LITERATURE REVIEW

The concept of fit

The concept of 'fit' has become a central theme within the strategic management literature. As the core concept of contingency theory (Lawrence and Lorch 1967), the general notion of fit suggests that organisations function more effectively when individual components, are consistent with the needs, demands, goals, objectives and structure of other organisational components (Nadler and Tushman 1980). Conversely, if organisational components 'fit poorly' the organisation will not function effectively (Fry and Smith 1987).

Despite general agreement regarding the notion of fit, there remains criticism regarding clarification of the concept (Van De Ven 1979, Venkatraman and Camillus 1984). This can be partially attributed to the fact that differing perspectives exist of how fit should be achieved. Within the literature, there exist at least three themes to explain the concept of fit. The first draws on industrial organisation (IO) economics (Bain 1950) and focuses primarily on the fit between strategy and external elements. The key premise is that strategy should favourably align the business with the environment in which it competes, either through responses to various industrial barriers (Porter 1980), formulation of differential strategies through strategic grouping (Hatten and Schendel 1977), or through analysis of an industry's life cycle (Abernathy and Utterback 1978).

In contrast, the second theme focuses on alignment between strategy and internal elements with almost no direct reference to external influences. Within this perspective alignment is achieved by tailoring administrative and organisational mechanisms in line with organisational strategy (Venkatraman and Camillus 1984). This follows Chandler's (1962) proposition that a change in strategy requires change in all organisational activities so that the structure of the organisation fits with the new strategic objectives. The salient factor is that strategy is articulated at the outset and alignment is achieved by adapting mechanisms and structure to the articulated strategy (Ansoff 1965, Chandler 1962).

The third theme takes an integrated approach, where management of strategy involves both strategic formulation and implementation, with reference to both organisational and environmental decisions. Central to this theme is the proposition that there must be a match between the context, strategy and structure (Galbraith, Nathanson and Kazanjian 1986, Venkatraman and Camillus 1984). Models such as Miles and Snow (1978) attempt to specify a relationship between structure, strategy and process by proposing that firms should develop relatively stable patterns of behaviour in order to accomplish alignment with environmental conditions. Whereas, Nadler and Tushman (1980) take a total systems approach and suggests that fit occurs when each organisational component's needs, demands, goals and objectives are consistent with other components' needs, demands, goals and objectives.

The strategic alignment of projects

Within the project environment, strategic fit is accomplished when individual projects align with the organisational strategic objectives. Central to this premise is the implementation of organisational strategy through projects (Cleland and Ireland 2006, Gareis 1991). Following Hofer and Schendel's (1978) suggestion that strategy be constrained by the upper level of a strategic hierarchy, the proposition is made that alignment is achieved by setting strategy at the corporate level and implemented through projects. Archibald's (1978) hierarchy makes the proposition that objectives and strategies are developed at the policy levels and cascade down through strategic and operational levels. Kerzner's (2001) hierarchy illustrates how corporate strategic plans flow horizontally across strategic business units and vertically to supporting plans and budgets. Finally, in adapting Turner's (1999) model, Morris and Jamieson (2004) show how organisations position their programmes and projects to achieve strategic objectives.

The assumption in the literature is that implementation frameworks involve clear communication of strategic intentions and objectives, against which line managers devise their own operating targets and plans (Snow and Hambrick 1980). Consequently, the strategy implementation process is entrusted to the organisations internal systems and procedures (Hrebiniak and Joyce 1985, Mintzberg and Waters 1985), and in the form of projects becomes the responsibility of the project manager, who typically has little involvement in the strategic formation process (Pellegrinelli and Bowman 1994). It is this gap between formulation and implementation that is considered to be the main deficiency of most strategic planning models, mainly because such a separation hinders the rapid implementation of business strategies and ignore emergent influences on the strategy (Crawford 2005). Within a project environment the strategic plan is rarely acted upon in a prescriptive manner as models suggest, and most strategic actions manifest themselves in a more haphazard process (Hauc and Kovac 2000). The filtering of strategic objectives from the corporate to the project level involves a number of complex interactions, processes and various strategic constraints. Each strategic level will be subject to the environment in which it competes. Consequently, inevitable changes within the external and internal environments will result in strategies not being realised as wholly intended by the strategy makers.

Temporary multi-organisations

Whereas there has been a growth of studies exploring temporary systems within single organisational boundaries (Bakker 2010, Lundin and Soderholm 1995, Packendorff 1995, Turner and Muller 2003), discourse on inter-organisational relationships within the boundaries of a TMO has not received the same attention. This despite, recent research into social embeddedness within temporary inter-organisational projects (Jones and Lichtenstein 2008) and research into network analysis within the construction industry (Ruan *et al.* 2013). As a consequence, studies into temporary organisational forms have predominantly focused on the intra-organisational characteristics of temporary systems created by a single parent organisation, with the assumption that many of the propositions underpinning Lundin and Soderholm's (1995) basic concepts apply to all temporary organizational types.

It is the fundamental differences between inter and intra-organisational types that have significant implications for the pursuit of strategic alignment and the measurement of project success. Firstly, actors within TMO's are brought together under contractual

conditions to provide specific elements of management, services or resources to deliver a facility on behalf of a client body. Hence, much of the research into TMO relationships focuses on procurement strategies (Lizarralde, Blois and Latunova 2011). Secondly, the inter-organizational nature of TMO's often results in actors having different levels of expertise, overlapping areas of responsibilities and disparate strategic objectives (Jones and Lichtenstein 2008). Thirdly, engagement in a construction project is over different points in time and changes throughout the project lifecycle as specific organisational services or resources are required (Cherns and Bryant 1984). Consequently, actors within a TMO are never fully integrated, either within or between organisations (De Blois and Lizarralde 2010).

However, the most important distinction with regards to strategic fit concerns the degree of autonomy a project has in relation to a parent organization (Lampel and Jha 2004). The dominant discourse within the literature makes the assumption that temporary organizations are subordinate to a single parent organization and will serve as an 'obedient servant' to the parent organisation as its most important stakeholder (Arto *et al.* 2008). Alignment within the 'obedient servant' strategy is measured on how well the project implements and supports the parent strategy. In contrast within any given construction project there exist a number organisations that will have its own strategic objectives, organisational structure, individual set of stakeholders and its own rationale for joining the TMO on which the perceptions of project success will be measured. As such, it can be argued that within a TMO there is not one single parent organisation, but a number of parent organisations, all seeking to realize strategic objectives through a single construction project.

Project Success

Despite the concept of project success being discussed extensively within the project management literature (Baccarini 1999, Ika 2009, Pinto and Slevin 1988), the performance of temporary organisations remains notoriously difficult to measure (Bakker 2010). Traditionally, the dominant criteria on which to measure success has long been on achieving the specific project objectives within the 'iron triangle' of time, cost and quality (Atkinson 1999). However, since the late 1980's the concept has been perceived to involve broader objectives from the viewpoint of stakeholders throughout the project life cycle (De Wit 1988). As a consequence project success has become both subjective and ambiguous, with little agreement concerning the criteria by which achievement of the project should be judged (Pinto and Slevin 1988).

It is also interesting to observe that the majority of literature on the topic has tended to focus on factors that need to be in place for success to be realized, with less research into the criteria on how it should be measured (Ika 2009). Whereas, efficiency in managing projects may contribute to project success, it does not necessarily result in the project being successful (De Wit 1988). This is because varied stakeholders will have different opinions on what constitutes an effective project and make assessment on varied, often subjective, criteria (Belassi and Tukel 1996, Freeman and Beale 1992). Therefore, if we accept the complexity of measuring success within a single organisational boundary, this complexity will be significantly magnified when considering the multiple organisational boundaries in a TMO. This is further compounded when we consider that within the construction industry, success is also subject to problematic procurement systems, legislation, dynamic project teams, technologies, fluctuating market conditions and far-reaching stakeholders that all have an influence on the outcome of the project.

METHODOLOGY

A single case of a recently completed, university residency was selected to provide the empirical data for this study. The project involved the design, construction and fit-out of a new, 273 bed, student accommodation to be erected on the site of the rural university campus. Consistent with Lizarralde *et al's* (2011) categorisation of institutional configurations, there existed levels of strategic hierarchy as well as an established structure for both project procurement and a mechanism for project management within the client organisation. Prior to construction, the university established a Project Board and an Oversight Board to govern the project on behalf of the varied stakeholder representatives within the university.

Data was collected over a period of six months. Semi-structured interviews were conducted across actors from representative organisations within the TMO. Participant groups are shown in Table 1. Each interview, lasting between 45 and 60 minutes, was recorded and transcribed for analysis purposes. Documentation, including minutes of monthly progress meetings, was also collected for the purpose of triangulation.

Table 1: Project participants by group

Groups	Level	Participant
Client representatives	Senior Management	CI-SM
	Project Manager	CI-PM1, CI-PM2, CI-PM3
	Department Manager	CI-DM1, CI-DM2
Consultants	Senior Management	Co-SM
	Disciplines	Co-A, Co-QS
Contractor	Senior Management	Con-SM
	Project Management	Con-PM

FINDINGS

Within this study alignment was measured through the degree of fit between the strategic objectives and the perception of project success between TMO actors. Findings identify five nodes where tensions in alignment of strategies occur. These are illustrated in Figure 1 and discussed below.

Node 1: The first node is at the intersection of all organisations within the project and considers the degree of fit between strategic objectives at the project level. The strategic focus at this node was the short-term project management objectives of the project. Although the project was finished two months later than the original deadline and 15% over budget at completion, all TMO members perceived that the residencies being ready for the students arriving was the main priority, “...*come hell or high water, the students had to be in!*” (Con- SM).

“...*delivery to time was very difficult and very problematic and we delivered it five minutes before the students arrived. Five minutes! The paint was still wet on the walls when the students arrived with their parents, luggage and everything*” (Con-PM)

Success at this node is assessed on the implementation of the project and is measured by either *time, cost or quality* variables, besides *safety*. At the project level, completion of the project will take priority as the first measure of success, in particular when handover is of significant importance and there is schedule dependency on completion by end users.

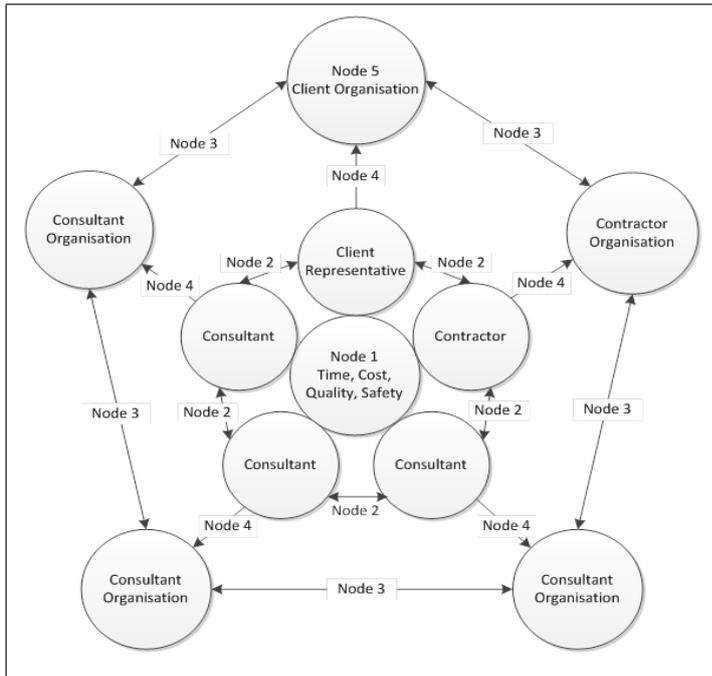


Figure 1: Tensions of strategic alignment within a TMO

Node 2: The second node considers the interaction of actors at the discipline level. Alignment at this node considers the degree of integration between varied actors in completion of tasks to achieve the short-term project management objectives. Consistent with the literature, findings suggest that TMO actors at this node are task focused and have a tendency to work in ‘silos’.

“You know they would all travel down to the same meetings from the same office but they would travel in separate cars and all take different routes” (Co-A)

Within the case, this had an effect on the dependency of activities and information flow. The key tension identified at this node appears to be the lack of mechanism for the efficient alignment between actors. Consequently, the lack of integration was perceived as contributory factor for the delays on the project.

“...there were gaps in our information ...as a consequence of that there was a lots and lots of disagreements all the way through the process. Information was being issued piecemeal and late and difficulties with the actual construction because of the structural and M&E solution. So there were delays...” (Co-A)

Success at this node is measured on the task efficiency. However, due to the silo behaviour within the TMO, each actor focuses on the success of their own task, independent of other tasks comprising the project.

Node 3: The third node considers the extent of alignment between the strategies of the individual organisations within the TMO. Success for each member organisation is measured on achieving the anticipated objectives through participation in the project. The main source of tension at this node was on achieving the financial strategies of member organisations within the TMO. *“I’m being obvious...but most issues in jobs come down to money” (Co-QS)*. Cost was the primary measure of success at the executive level of the client organisation with tensions occurring with the contractor.

“....the main conflicting objective is the contractors are there to make money. The clients are there to stop them making money so there you have a very confrontational

scenario right away and a mechanism by which both can operate is the design team... ” (C1-PM1).

Success in achieving the financial strategy for all parties is therefore dependant on the procurement route the client chooses to pursue and the project management of the contract and design team.

“...because the client is dependent on the design team to ensure that there’s no opportunity for the contractor to make money. And the contractor is dependent on the design team to make sure that they make as many cock-ups as they possibly can, so they can drive a bus through it and make money” (C1-PM1).

Other cited reasons for participation included market entry into the student residencies sector and market opportunities through delivery of a higher quality facility. However, success in both strategies are dependent on the client perception of the project being successful, as marketing strategies and reputation is determined by the satisfaction of previous clients.

Node 4: The fourth node concerns alignment between the member organisations within the TMO and their representative actors participating on the project. Alignment at this node considers the possible conflicts of allegiance between the TMO objectives and the strategic objectives of their employer organisation. More than one consultant commented that their respective employers felt that, as a consequence of delays, they have spent a disproportionate amount of time on the project in relation to the fee received.

“...because my Director would be asking me “Why’ve you spent so much time on this job, you’ve only got X amount of money, you’re spending more than that and you’re spending more than you’re earning and the time that you’re taking” (Co-QS)

TMO actors are therefore often put in a position where they need to seek a balance between the project management objectives and the strategic objectives of their employer. This is particularly the situation when there is an impact on the time and resources committed by a TMO member to complete the project, as in this study.

Node 5: The fifth node considers the individual strategies within the client system itself and measures success at different hierarchical levels and between internal departments. This node is particularly complex due to the varied stakeholders within the client system who have an interest in the project. At the Executive level alignment is measured on the long-term strategic goals of the university as a result of investing in the new residencies, identified as *reputation, growth and financial*.

“... I think, undoubtedly for the university is the fact that we make a promise to new and first year students that we will make sure they have accommodation. It’s got the added benefit that it actually stacks up commercially, but the primary motivation for the university is, or certainly has not been, because there’s money to be made in this. They do it because they have made a very public statement that first year students will be provided with accommodation” (C1-SM).

Although, there was general understanding and support for the university strategy, tensions existed between business units. Key stakeholder departments included Estates, Student Services and Hospitality and Catering. In terms of design, the strategic objective of Estates was to develop a sustainable and low maintenance facility through specification of selected materials and suppliers. The strategic objective of the Student Services was to ensure the quality of the building is of a high enough quality to enhance the student experience. In contrast, Hospitality and Catering measured success of the project on the cost of the facility.

“... student welfare went for a lot of what I would call ‘niceties’ and nice bits and pieces, etc., not looking at the bottom line; Estates were able to put in specifications that were not benchmarked against external business and the marketplace; they went with what they’ve done over the last 20-30 years and ... at the end of the day the cost comes out of my budget, therefore, the decisions I make tend to be very much related to the bottom line” (C1-DM1).

A consequence of tensions there was a lack of agreement and late changes to the design of the facility. This had an impact on both cost and delays on the project, which also contributed to the tensions in achieving strategic fit. Views were also mixed within the client organisation regarding the success of the project.

“Personally... I think it’s a great success, a lot of people have got caught up in thinking it wasn’t because of the financial impact but, longer term, people will forget about that and think we have an amazing high quality building.” (C1-DM2).

Although from a client perspective, the project was late and over budget, it was successful in realising the organisational strategies for which it was intended. However, the consultants did secure further contracts as a result of the project and the contractor reported financial losses. Which raises the question as to whether the project was a success or a failure, and from whose perspective?

CONCLUSIONS

The identification of tensions within a TMO is a useful tool for analysis and understanding at inter-organisational relationships. The findings suggest a lack of strategic fit is inherent in construction projects. At the project level TMO team members will focus on the short-term project management objectives and likely to prioritise completion of the project as the key success factor, with cost and quality becoming secondary factors. This is particularly the case when the handover date is of significant importance. Conversely, at the corporate level, the client is likely to measure success by achieving the long-term strategic benefits of investment in the project. The study also finds tensions between TMO actors, resulting in members becoming task focus and working in silos. We attribute this lack of integration to the procurement processes inherent within the construction industry, as under the contractual agreements, each organisation involved in the project will be solely accountable for the service they are employed to deliver. This is actually in contrast to general project management practices where project team members are encouraged to be mutually accountable for the project.

However, the main tension in achieving alignment remains between the client and other TMO member organisations. This we attribute to the complexity of the client system where the perception of project success will vary between hierarchical levels, business units and departments. Consequently, there is likely to be varied perceptions of project success and therefore mixed directives given to the project team. The findings suggest that conflicts of alignment occurring within the client system have an impact on all nodes within the model. It could therefore be argued that it is the client that is the driving force for alignment of strategies within a TMO. We therefore call for further research into client influence on project success. In particular, we see a need for further empirical studies into highly complex client systems where a single point of authority or leadership of a TMO is challenged. In such cases, where there exists a multifaceted organisational structure, such as universities or other public sector organisations, there is a higher likelihood that varied internal stakeholders will

strive to implement their individual, and often conflicting, strategic objectives through a single project.

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UNDERSTANDING COMPETITIVENESS IN COMPLEX AND DYNAMIC ENVIRONMENTS: THE CASE OF TURKISH CONTRACTING

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The aim of this paper is to explore how international contracting firms maintain their competitive position. The adopted stance is positioned against the positivist and rational perspectives, which currently dominate the construction competitiveness literature. In contrast to previous studies, the focus lies on the interpretations of senior executives within Turkish contractors, which have in recent years competed highly successfully in international markets. Emphasis is given to the dynamic capabilities view (DCV) and the extent to which it provides into the strategy of Turkish contractors. In contrast to other theoretical models, DCV is notable in the (rhetorical) emphasis given to dynamic environments within which firms continually re-position themselves. Static rationalist models of strategy have limited explanatory power in the context of the highly unstable markets within which Turkish contractors operate. An empirical research agenda is outlined together with a proposed set of research methods.

Keywords: competitiveness, dynamic capabilities, process perspective, sense making, international contracting.

INTRODUCTION

It is uncontroversial to suggest that today's dynamic business environment requires more than the rational competitive strategies proposed by the simplistic theoretical models of 80s (e.g Porter, 1980). Market stability can no longer be taken for granted. To be successful in the modern era requires firms to continuously adapt to an uncertain and rapidly changing business environment. Sustained competitiveness arguably depends upon highly developed dynamic capabilities which bridge between internal operating routines and the continuous analysis of an uncertain and ever-shifting external environment (Green *et al*, 2008a). Of particular importance becomes the need to understand the *process* through which contracting organizations enact their competitiveness. This represents a shift from an underling '*being ontology*' which assumes that reality is essentially static, towards a '*becoming ontology*' which privileges a view of reality characterised by continuous and emergent change (Chia, 1995). Such a shift in thinking focuses attention to organisational sense making processes and associated structural re-adjustments.

Numerous previous studies have discussed the concept of construction sector competitiveness. However, the vast majority of such studies give scant attention the *dynamic* and increasingly fractured environments with which firms compete. In consequence, they tend to emphasise the importance of the social, economic, and

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political parameters, which supposedly characterise different markets. What remains relatively under-researched is the way in which competitiveness is enacted and the sense-making processes, which shape strategic trajectories (cf. Pettigrew, 1997). The purpose of the current paper is to focus on Turkish contracting companies, which have achieved remarkable success in international markets, especially in terms of adapting and responding to market shocks and discontinuities.

The paper is structured as follows. First, attention is given to the development of Turkish international contracting sector from the 1940s onwards. The theoretical background of competitiveness studies is then reviewed with reference both to the construction literature and the broader management disciplines. Consideration is given to issues of research methodology, prior to a discussion of the rationale behind the proposed interview questions to be directed at senior managers with Turkish contractors. Given that the research is a part of a PhD study, the paper is specifically positioned to encourage feedback and critical reflection.

TURKISH INTERNATIONAL CONTRACTING FIRMS IN THE CONTEXT OF ECONOMIC AND POLITICAL CHANGE

Turkish contracting companies started to develop an expertise in domestic infrastructure development in the mid-1940s and this internal focus continued up until the mid- 1960s. They benefited from buoyant Turkish domestic market throughout the 1950s and 60s. Infrastructure development in this period was often funded by international capital linked with Turkey's admission to NATO in 1952. Working with foreign partners throughout this period enabled Turkish contractors to increase their technical and managerial capabilities to a level beyond those of other Middle Eastern contractors. In consequence they were then able to follow Western contractors into the expanding markets of the Middle East and North Africa associated with the 1970s oil price boom. While the oil boom created significant international opportunities, paradoxically it had a negative impact on the Turkish economy. Hence, investments in large-scale domestic construction projects came to a standstill and Turkish contractors had little choice other than to expand internationally to maintain turnover (Tayanc, 2011).

International activities thereafter increased rapidly as a result of the liberalization of the Turkish economy and its progressive integration into the global economy throughout the 1980s. For many years the most important overseas market for Turkish contractors was Libya. However, political uncertainties progressively caused Turkish contractors by the 1980s to shift their attention to other Middle Eastern markets such as Saudi Arabia and Iraq. Further opportunities for diversification followed the dissolution of Soviet Union in 1989, especially in former southern republics such as Turkmenistan and Kazakhstan. Turkish firms frequently found themselves operating in markets where Western contractors were unwelcome thereby maximising their competitive advantage. It is also notable that Turkish contractors consistently exploited Turkey's embedded cultural and political connectivity throughout the Middle East. In this respect, there was an historical path dependency with which Western contractors could not compete. The collapse of the Soviet Union dramatically increased Turkey's sphere of influence almost overnight, such that the ruling political classes became increasingly ambivalent about membership of the European Union.

It is clear from the description above that Turkish contractors have been highly successful in continuously adapting their business activities in response to uncertain and unpredictable market conditions. Most notably, they have successfully evolved

their strategic focus over a sustained period in a region characterised by conflict and political uncertainty. The destiny of Turkish contractors has been shaped by *realpolitik* in response to a series of regional crises. But they have also responded to new opportunities created by structural shifts in the international order - not least the collapse of the former Soviet Union. Such seismic changes were entirely unforeseen by the rationalistic approaches to strategy which prevailed in the 1980s. Approaches such as those famously advocated by Porter (1980, 1985) tended to privilege stability over discontinuous change. Hence planning was prioritised over opportunism.

The path followed by Turkish contractors therefore differs starkly from the planned strategies, which tend to be portrayed in the literature. In no small way, the competitive advantage of Turkish contractors rests on their ability to respond to extreme social, economic and political instability. It is contended that these 'big-picture' changes such as the collapse of the Soviet Union and regional conflicts such as the Iraq War are inseparable from the success of Turkish contracting companies. Yet the current literature goes no further than linking their competitive performance to routine analysis of external market forces and industry level discussions around efficiency (e.g. Giritli *et al.*, 1990, Öz, 2001, Özorhon, 2012). Few seem interested in any theoretical engagement with the story of Turkish success in international contracting as presented, or indeed in explaining the processes through which strategy is enacted in such circumstances.

THEORETICAL SHIFTS IN THE COMPETITIVENESS LITERATURE: FROM RATIONAL PLANNING TO DYNAMIC PERSPECTIVES

In many respects, the evolution of Turkish international contracting shadows the shift from a static predictable world to a world characterised by uncertainty, conflict and continuous upheaval. The conceptualization of competitiveness in the literature has followed a similar trajectory. Early theorists such as Porter (1980; 1985) advocated an essentially static analysis of competitive positioning. This progressively gave way to more dynamic perspectives arguably cumulating in the strategy-as-practice approach proposed by Jarzabkowski (2005). In the 1980s the literature tended to discuss competitiveness from a rational perspective with a focus on exogenous factors within different markets (i.e. Porter, 1980; 1985). Such perspectives emphasised industry level analysis; organisations were assigned a relatively passive role in that industry forces in essence shaped their competitive strategies. Strategic planning supposedly shaped decisions in respect of which markets to enter and how best firms could position themselves. Markets were conceptualised as essentially static, and firms were conceptualised as homogenous entities whose actions were determined by rational analysis. In the 1990s, the resource-based view (RBV) emerged as a new perspective and challenged the rational focus on exogenous industry-level factors. The focus of the debate hence moved to an organizational level of analysis with an emphasis on the importance of unique internal resources and capabilities that could not be easily imitated by others (i.e. Barney, 1991). Although the RBV moved the focus of competitiveness research to the organizational level, it tended to neglect the dynamic contexts within which organizations are embedded. Thereafter the dynamic capabilities view (DCV) emerged as an extension to RBV and effectively shifted the focus of research onto the adaptive nature of organizations (Teece *et al.*, 1997). Hence the challenge shifted from 'unique resources' (Barney, 1991) towards designing 'processes to enable responses to dynamic environments'. Teece (2007) is especially

persuasive in terms of the need to 'sense, seize and configure organizational competencies to answer dynamic changes'. Hence dynamic capabilities are defined as "higher level competencies that determine the firm's ability to integrate, build, and reconfigure internal and external resources/competences to address, and possibly shape, rapidly changing business environments" (Teece, 2012:1395).

Although there remains an empirical confusion regarding the precise meaning of 'dynamic capabilities', such a perspective nevertheless points towards the decision-making processes within organisations and the need to respond to dynamic environments. As such, the DCV may provide a meaningful framework for understanding the trajectories of Turkish contractors. DCV further builds on evolutionary economics in recognizing embedded processes of adaptation and reconfiguration in response to external change. More recently, the strategy-as-practice (SaP) perspective stresses the importance of the individual level in the strategizing activity within organizations (Jarzabkowski, 2005). The SaP perspective also privileges the sense-making processes of the individuals involved in the enactment of strategy. But it must also be recognised that there is little theoretical consistency within this broader literature. This is equally true of approaches, which seemingly adhere to the narrow specialism.

Competitiveness Studies in Construction Management Literature

There is of course a large existing literature, which addresses competitiveness in the context of construction. The general tendency is to follow the rational strategies promoted by Michael Porter in the 1980s (e.g. Ofori, 1994, 2003; Öz, 2001; Zhao *et al*, 2009; Lu *et al*, 2013). As commented above, such studies mostly treat the construction sector as homogenous while conceptualising competitiveness as a tangible static value.

There is also much variance in the adopted unit of analysis. Some studies focus on regional contractors (Chiang *et al*, 2008, Ling and Gui, 2009); others on large international conglomerates (Shen *et al*, 2006, Zhao *et al*, 2009, Lu *et al*, 2013). However, such studies routinely underplay the instability of the markets in which the contracting companies operate. There is also an overriding tendency to reify competitiveness as if were something to be possessed (e.g. Flanagan *et al*, 2007). Other studies have adopted more processual and discursive approaches to strategizing (Green, 2008a, 2008b). There is also an increasingly strong emphasis on empirical approaches, which seek to access the interpretations of senior managers (Kao *et al*, 2009). In broad terms there is a gradual shift towards the sense-making processes of senior managers when faced with an ever-changing contextual landscape. The trend in the literature has also shifted away from quantitative surveys towards a more qualitative and critical perspective.

The proposed research is therefore positioned within this emergent perspective, which promotes a focus on the enactment of competitive strategy over time. Such a perspective can be loosely positioned within the broad tradition of 'processual thinking' which focuses on change and transformation with a view to accessing 'reality in flight' (Pettigrew, 1997). What remains empirically elusive are the actual mechanisms through which strategy is enacted. Indeed, such mechanisms are arguably always subject to post-hoc rationalisation such that researchers are almost inevitably constrained in terms of the empirical data, which can meaningfully be collected.

Rather than focus on supposed 'mechanisms' it arguably becomes more useful to focus on accessing multiple narratives of organizational transformation. This is best

achieved through face-to-face interviews with the individual actors who purport to have been involved in key strategic decisions. Hence the research becomes rather less about how strategy was enacted and rather more about narratives of post-hoc rationalisation. This of course does not make the research any less important, because how senior managers make sense of the past inevitably shapes their response to the future - albeit not in an instrumental or easily predictable manner. It is also true that some post-hoc rationalisations are more persuasive than others. There is therefore a need to evaluate the legitimacy of the interpretations offered through a process of validation against known facts and the available grey literature. Some interpretations of course will be idiosyncratic, but other will become institutionalised within the firm to such an extent they become generally accepted as part of the organisation's culture. There remains a paucity of studies that adopt such an interpretative approach to the way senior managers make sense of strategy. One particular point of interest is the extent to which the historical path dependency of Turkish contractors shapes the interpretations of senior managers, and thereby informs future strategic decision.

PROPOSED EMPIRICAL RESEARCH

Research Methodology

The purpose of the proposed research is to explore 'the extent to which the dynamic capabilities view (DCV) can provide meaningful insights into the competitiveness of Turkish international contracting firms. More specifically, it aims to explore the extent to which the core narratives of DCV resonate with those mobilised by senior managers. This study is designed as exploratory research and the discussion below presents the logic of the interview questions that will guide the empirical analysis.

The interview questions are intended to access the ways in which senior managers describe competitive strategy. The questions were primarily informed by the DCV literature in addition to more mainstream approaches to strategy making. Reference was also made to the more descriptive models of international contracting (e.g. Mawhinney, 2001). . The questions aim to catch the 'reality in flight' as advocated by Pettigrew (1997). However, it is important to emphasise that the research focus is to understand the sense-making process of senior managers by accessing post-hoc narratives. With the aim of contextualising the research within a broader geo-political context, the interviews will be complemented by an in-depth analysis of the grey literature together with the time-series analysis of relevant statistics. The exploratory research described is seen to comprise a first step towards explaining the specificity of strategy as pursued by Turkish contractors.

Questions to understand 'how senior managers make sense of competitiveness'

A social constructionist perspective shapes the research with an emphasis on the understanding the way senior managers make sense of strategy making. Such perspective shares common ground with DCV literature, which highlights the role of managers in the enactment of competitiveness. Helfat *et al* (2007) is especially persuasive in arguing that it is important to understand the decision making process as perceived by individuals as a means of understanding broader processes of change. Sense making processes invariably involve a series of interactions with a defined a group of individuals. In the case of Turkish contractors competing in international markets, it will be interesting to explore the extent to such reference groups are contained entirely within the organisation, or if reference is made to external groups in

terms of foreign policy advice. Given that the big Turkish contractors have tended to adopt a common trajectory one suspects that there are receiving similar advice on the risks involving in individual markets. Indeed, the contractors seem to be operating within the conduits of Turkish foreign policy with the Government playing a significant role in negotiating contracts and underpinning the associated risks (c.f. Tayanc, 2011).

According to Weick (1995) how practitioners make sense of reality is shaped by both their individual position and the characteristics of the context within which they operate. Therefore, gathering the information about the interviewee and his/her role in the organization will be an essential starting point for each interview. Interviewees will be encouraged to share their own individual the story about the development path of their organization and the way in which strategy is enacted. The objective is to understand how the practitioners construct meanings, make sense of 'competitiveness' in reality and the process of strategy making. Specific prompts however will be used if necessary to explore areas identified in the literature review. Of particular interest will be the extent to which senior managers allude to the geo-political factors outlined above.

Questions to understand the 'key events' and the impact of 'internal and external context' that shape the strategy making process:

It is important to probe the extent to which the managers make sense of their previous experience. To this end they will be invited to describe the 'key events' that are critical to maintain their competitiveness over an extended time period. This will enable the perceptions of the interviewees to be validated against known facts. Reference will also be made to the available statistics relating to the turnover of Turkish contractors in different markets within different periods. Teece's (2007) categorisation of three sorts of activity –sensing, seizing, transforming- will also be important in interpreting the key events that are stated by interviewees. Such activities supposedly highlight the micro foundations of dynamic capabilities. Whether such categories relate to the perceptions of decision makers within Turkish contractors of course remains to be seen.

Also, as discussed by Pettigrew (1997), there is supposedly a continuous interaction between managerial actions and the 'contextual setting' within which they operate. Hence aspects of the 'broader context' must be questioned and conceptualized as an active part of any analyses. Green *et al* (2008b) similarly argue that local enactments of competitiveness are inevitably formed and shaped by broader contextual issues. Accordingly it becomes very difficult to envisage how the competitiveness of Turkish international contractors could ever be understood in isolation of their dynamic interaction with the broader landscape within which they operate.

It is notable that most of the literature on the competitiveness of construction firms treats the construction sector as a homogenous entity whilst reifying competitiveness as a tangible static concept which lends itself to measurement. However, the intention of this research is to emphasise the socially constructed nature of competitiveness and the impact of idiosyncratic decisions on subsequent strategic actions. The research therefore aims to explore to the extent to which the '*internal context*' of the organization shapes the process of strategy making. Green *et al* (2008b: 433) argue that 'socially constructed knowledge is created and disseminated by groups of individuals with vested interests in the diffusion process.... and the infrastructure within which such groups operate can also be read as a material manifestation of the

broader discourse of competitiveness'. Hence it will be important to understand the processes through which companies organize themselves. Furthermore it will be important to understand which specific aspects of both *external and internal context* are seen to be relevant to the process of strategy making.

Questions to understand the 'managerial and organizational processes' in the enactment of competitiveness:

The competitiveness literature refers to numerous different strategy making perspectives. At one end of the spectrum is the classical perspective, which equates organisations with rational decision makers (Ansoff, 1965; Chandler, 1962). At the other end of the spectrum is the more modern literature, which sees organisations as pluralistic with a focus on the dynamic interaction between the individual agents and context (Teece, 2007; Whittington, 1993; Jarzabkowski, 2005). As described previously, the shift is away from a long-term economic planning perspective towards a behavioral and processual-based perspective, which recognizes the emergent and dynamic nature of strategy making. Green *et al* (2008b) recognise that the sensing activities are often initiated by junior managers, and are only recognised in terms of their strategic significant retrospectively. This of course is unlikely to be the case in terms of the initial decision to enter new international markets. It is further intended to probe the relevance of Teece's (1997) key processes of integration, learning, and reconfiguration and transformation. These are supposedly the means through which organizations form their strategies to sustain their re-alignments. As stressed by Peteraf and Maritan (2007) such processes are an essential part of strategy making. The suspicion is that such concepts are too esoteric to resonate with the naturalised narratives of practitioners. Nevertheless it is important to understand how senior managers make sense of managerial and organizational processes, which provide companies with their point of departure.

Questions to understand the sense-making process on 'market selection' and 'entry mode', and how do such decisions impact the enactment of competitiveness:

The international construction literature emphasizes the importance of market selection and the entry mode for sustained competitive performance. For instance, Mawhinney (2001) argues that the level of competition, host country regulations and requirements, risks associated with host country, and geographical and cultural similarities affect targeted market selection in international contracting. The way that Turkish contractors enter the markets and the extent to which they gained competitive advantage differentiates. However, there is nothing told about the lived narratives associated with such decisions in the case of Turkish contractors. Also, of particular interest is the Turkish propensity for risk, i.e. to operate in regions where Western contractors fear to tread such as Iraq and Afghanistan. However, what remain starkly under-researched are the sense making processes that led Turkish contractors to withdraw from one market and compete in another. Similarly, existing research and theories say nothing about variations across firms and their differentiated performance.

Although some studies discuss the competitiveness of Turkish contracting firms (e.g. Öz, 1991, Özorhon *et al*, 2006, Dikmen and Birgönül, 2004), they have put little attention to explain the lived narratives that shape strategy-making processes related to market selection and entry mode. Therefore, it is important to access narratives of market selection with a view to understanding how Turkish contractors have remained so successful.

Questions to explore how does learning process from ‘past experiences’ impact the strategy making process and the enactment of competitiveness:

The dynamic capabilities view (DCV) emphasizes the importance of path dependencies -established routines and previous business investments and developments- to achieve sustained competitiveness. Teece *et al* (1997) argues that the historical background of the organization shapes the current position of the organization and the possibilities that are available. As such, Green *et al* (2008a) found strong support for the argument that strategic choices that are available for an organization are strongly shaped by the path they have travelled. Therefore, the last part of interview schedule intends to explore the extent to which path dependencies are seen to constrain strategic options. Furthermore, Kao *et al* (2009) pointed towards the importance of the ‘embeddedness’ and ‘localized learning’ in the enactment of competitiveness. It is therefore intended to explore to what extent senior level managers make reference to embeddedness and localized learning in the enactment of competitiveness.

CONCLUSION

The research aims to explore the competitive performance of Turkish international contracting firms. On the basis of an extensive literature review, the dynamic capabilities view (DCV) would seem to offer the most convincing explanatory narrative. The adopted research approach however is essentially interpretive in that the intention is to ascertain the extent to which the narratives mobilised by senior managers align with those of DCV. The focus of the proposed empirical research is not therefore the 'mechanisms' through strategy is achieved, but rather the ways in which senior managers make sense of the enactment of competitiveness. The empirical research is therefore focused on the multiple narratives of organizational transformation revealed through face-to-face interviews with the individual actors who have been involved in key strategic decisions. It is recognised that such narratives inevitably include large elements of post hoc rationalisation, but this does not mean that they are not relevant to the way strategic decisions are made in the future. The interviews will seek to explore the particular path dependencies, which are seen to shape the strategic options of Turkish contractors operating in international markets. The narratives mobilised by the interviewees will be compared to most (supposedly) factual descriptions of the changing market opportunities as found within archival sources and the grey literature.

Such processual perspective will challenge the dominance of positivistic and static competitiveness discussions and recognize the dynamic and changing nature of competitive performance and post hoc realizations in the discussion of construction management competitiveness. Rather, it argues that following an interpretive process with exploring actual mechanisms through which strategy is enacted and meanings are constructed by decision makers could capture the ‘reality in flight’ in terms of construction competitiveness research.

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AN EXPLORATORY STUDY OF A CSV CONCEPT FOR ACHIEVING FIRM COMPETITIVENESS IN HONG KONG CONSTRUCTION FIRMS

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The Hong Kong construction industry has both contributed to and benefited from the growth and development of the last decades. However, social and environmental challenges, particularly health and safety issues, manpower shortage, construction waste and landfill problems, pose significant constraints to the continued growth of the firms. Recent studies suggest that construction firms can embrace a ‘Creating Shared Value’ (CSV) concept to convert these issues into business opportunities and achieve long-term competitiveness. Despite this recognition, effort has not been made to investigate the CSV concept in construction management. Hence, this study aims to explore the CSV concept in the Hong Kong construction industry, and establish a link between the CSV concept and firm competitiveness using strategic management theory. This research employs multi-method approach, encompassing documents review and semi-structured interviews, adhering to the principles of building theory from the case study research and the grounded theory. Data are analysed qualitatively. The results show that construction practitioners have mixed attitudes toward the CSV concept and firm competitiveness. Various potential strategies that are in line with the CSV concept including the potential barriers in its implementation process are also identified.

Keywords: coding, competitiveness, grounded theory, shared value, thematic analysis.

INTRODUCTION

The construction industry in Hong Kong (HK) has experienced various social and environmental challenges, specifically related to health and safety (H&S) issues, labour shortage, construction waste and landfill problems, and inefficient use of resources. These challenges pose significant constraints to the continued growth of the firms (HKCA and Construction Industry Group 2012), and may undermine the long-term competitiveness of the construction industry in HK (GovHK 2015).

Recent studies suggest that construction firms can embrace a ‘Creating Shared Value’ (CSV) concept in order to address the social and environmental issues and achieve long-term competitiveness (Awale and Rowlinson 2014; Porter and Kramer 2011). The CSV concept or ‘shared value’ is an alternative strategy that simultaneously creates both social and business values by reconceiving products/markets, redefining productivity in the value chain, and enabling local cluster development (Porter and Kramer 2011). It can help firms to better respond to societal, environmental, and market needs as well as business activities. Studies from other sectors (food, beverage, agriculture, pharmaceutical, health care, financial services, extractives, and natural

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resources) advocate that firms can enhance their competitiveness by embracing the CSV concept in their business strategy (Hills *et al.* 2012). Despite this recognition, management or organizational fields, especially, construction management, is silent on this topic and effort has not been made to investigate the CSV concept. In this respect, a study is needed to investigate the CSV concept in construction management. Hence, the key question is: How can construction firms achieve long-term competitiveness by implementing the CSV concept?

This research builds on our previous studies on the CSV concept and firm competitiveness (Awale and Rowlinson 2014; 2015a; 2015b). Hence, the CSV concept is used as a point of departure (Charmaz 2014). The specific objectives are to: (i) define and unfold the anatomy of the CSV concept, (ii) identify the potential means of the CSV concept, and (iii) explore critical views of construction practitioners toward the CSV concept for achieving firm competitiveness. It also establishes a link between the CSV concept and firm competitiveness using strategic management theory.

FIRM COMPETITIVENESS AND STRATEGIC MANAGEMENT IN CONSTRUCTION MANAGEMENT

Companies mainly focus on achieving economic values but they fail to integrate the social dimensions in their competitive process (Tautila *et al.* 2006). Organization and management scholars, especially construction managers give relatively less priority to social and environmental issues while accessing their competitiveness (Walsh *et al.* 2003). Porter and Kramer (2011) argue that firm's competitiveness based on economic dimension alone would be incomplete and those firms that fail to integrate social dimensions while accessing their competitiveness may not succeed in achieving business target and future growth. Therefore, the recent view of construction firms on competitiveness is mainly short- to medium-term focused whereas long-term goals are overlooked (Shenhar *et al.* 2001). Hence, in this study, firm competitiveness is operationalized as: 1) achieving business success, and 2) preparing for the future (Shenhar *et al.* 2001), which may be attained by addressing critical social and environmental issues of the firm (Porter and Kramer 2011).

In construction management, various theories exist for conducting the corresponding strategic management functions that assist firms to achieve long-term competitiveness (Green *et al.* 2008). For example, Porter's (1980; 1985) competitive theories postulate that a firm's competitive advantage comes from the competitive strategy adopted to cope with the competitive environment. Resource-based view (Barney 1991; Prahalad and Hamel 1990) suggests that competitive advantage can be achieved from the possession and utilization of firm-specific resources, capabilities and competencies. Kay's (1993) distinctive capabilities theory proposes that companies can improve their strength through distinctive structure of relationships with employees, customers, suppliers, contractors and subcontractors. Such distinctive capabilities include capacity to innovate, key internal and external relationships, and corporate branding and reputations. Lastly, Porter's (1998) cluster development approach emphasizes on the enhancement of related and supporting companies and institutions in the location where the company operates to achieve competitive advantage. Above theories focus on various success factors or competitive dimensions. However, from a strategic management perspective, these dimensions can mainly be linked to three significant views: the market-based view (Porter's competitive theories), the resource-based view

(resources-based theories), and the relational view (distinctive capabilities theory, and cluster development approach) as shown in figure 1.

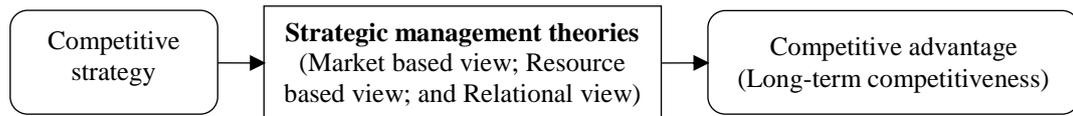


Figure 1: Application of strategic management theories in construction management

RESEARCH DESIGN

This research builds on our previous studies on the CSV concept and firm competitiveness (Awale and Rowlinson 2014; 2015a; 2015b), and adopts a symbolic interactionist (Corbin and Strauss 2008) and a constructivist/interpretive (Charmaz 2014) worldviews. It employs a multi-method approach in order to collect and analyse data, adhering to the principles of building theory from the case study research (Eisenhardt, 1989) and the grounded theory (Charmaz, 2014, Corbin and Strauss, 2008). In contrast to Eisenhardt (1989), this study doesn't generate theory but elaborates and unfolds the anatomy of the existing theory. In contrast with Charmaz (2014) and Corbin and Strauss (2008), this research doesn't perform theoretical sampling (i.e., the next data collection was not guided by theoretical sampling). However, data collection and data analysis by some means went hand-in-hand.

Qualitative data collection

It includes preliminary interviews, documents review and in-depth interviews. Informal preliminary interviews with 6 industry experts were conducted at the monthly social industry networking gathering, which lasted from 5 to 10 minutes. The main purpose of this phase was to get a rough idea of how industry practitioners perceive and understand the CSV concept. It was learnt that the participants are unaware and have not heard of the CSV concept. However, they are unknowingly participating in activities that align with the CSV concept. Importantly, this phase facilitated design of interview questions, and rendered a great insight and direction for this research.

Documents such as latest sustainability and annual reports, homepage, publications and press releases, etc., from four different companies were reviewed. In this phase, critical issues and potential strategies adopted by the companies to address those issues were explored. The main purpose of the documents review was to generate case examples (Bowen 2009; Eisenhardt 1989). Since the review of the organization documents might not represent the actual practices of the companies, the possible dimensions were later discussed with the interview participants from the respective companies during the in-depth interview phase. The purpose was to get further clarifications, substantiate evidences, and determine the accuracy of information in the documents (Bowen 2009). Documents review also provided background information of the companies (Charmaz 2014).

Semi-structured face-to-face interviews were also conducted with the industry practitioners, which facilitated the exploration of different subjective meanings and interpretations of the participants. A snowball sampling method was deployed to locate the participants because company practitioners were unlikely to take part without referral from their colleagues (Liamputtong 2009). At first, 2 participants were interviewed, who were approached based upon academic contacts. With their help and referral, other interested participants who might meet the criteria of the research were located. So, in total 17 in-depth interviews (lasting between one to two

and half hours) and 1 informal quick interview (lasting about 15 minutes) were conducted. Participants were from the strategic/management teams at business level, who have either direct involvement or responsibility to make business strategies in their respective firms. The participants were initially approached by e-mail for interview appointments. Written consents were taken from all participants prior to interviewing. All interviews were audio-recorded and verbatim. The demographic information of interviewees is summarized in Table 1.

Table 1: Summary of companies and interviewees

Company	Company profile	Participants (Total 18)
General Contractor: Company A	Largest construction company in Hong Kong (HK) in terms of market share with a strong turnover of US 1,471 million and US\$ 1,592 million in 2012 and 2013 respectively	Total 8: Division commercial manager; Senior commercial manager; Senior environmental manager; Director - health, & safety and sustainability; Manager - CSR & sustainability; Contracts manager; Project director; and Project manager
Client: Company B	Power company in HK with a turnover of US\$ 1,354 million and total earnings before interest, taxes, depreciation and amortization (EBITDA) of US\$ 993 million in 2014	Total 2: System operations manager; and Deputy general manager
Client: Company C	Largest railway corporation in HK with a turnover of US\$ 4,989 million and total EBITDA of US\$ 1,856 million in 2013	Total 4: Manager - innovation and knowledge management; Senior manager - corporate responsibility; Construction safety advisor; and Manager - project safety
Building Contractor: Company D	Housing developer and building contractor in HK with a turnover of US\$ 691 and US\$ 622 million in 2012 and 2013 respectively	Total 4: Deputy general manager(a); Deputy General Manager(b); Construction manager; and CSR manager

Open-ended questions were designed and the participants were asked identical questions to enquire about their critical views. The main topics discussed were:

- critical social and environmental issues in their organization;
- strategies the companies are undertaking or might have undertaken to solve the social and environmental issues and generate business opportunities;
- challenges the company might face while implementing those activities;
- measurement of social and business values generated from those strategies;
- impetus (resources, supports, etc.) to implement those activities;
- benefits companies might get implementing such strategies;
- possible relationship between such strategies and competitiveness

Qualitative data analyses and empirical findings

Qualitative analyses are inductive and divided into three folds:

1st Phase analysis - documents analysis

This phase includes documents analysis (skimming, reading and interpretation), reinforced by the in-depth interviews, in order to identify relevant information in the documents and finally generate case examples (Eisenhardt 1989; Bowen 2009).

1st phase empirical findings: case examples

Multiple case examples were identified and few are listed in Table 2.

2nd Phase analysis - case and interview analysis

This phase includes qualitative analysis of the case examples using a case analysis process: with-in case and cross-case analysis (Eisenhardt 1989) and a constant comparison method (Corbin and Strauss 2008). The interviews were analysed using a thematic analysis process (Braun and Clarke 2006), and coding and constant

comparison methods (Corbin and Strauss 2008). For the comprehensive description and analysis of the cases, and analysis of the interviews, refer to the recent papers by Awale and Rowlinson (2015a) and Awale and Rowlinson (2015b) respectively. The findings from the case analysis were triangulated with the findings from the interview data (Guba and Lincoln 1981) to generate resultant 2nd phase empirical findings.

Table 2: List of potential case examples

Potential case examples	Related to
Development of semi-automatic breaker rack, modification of bore pile head trimming method, and redesign of casings extractor	Health and safety (H&S)
Green treatment of marine mud to reduce construction waste	Waste and landfill issue
Contractor co-operative training scheme, and multi-skilling trainings	H&S; Labour shortage
Use of Forest Stewardship Council (FSC) timber products	Ineffective use of resources
Development and use of mechanical steel system formwork	H&S; Construction waste
New blood trainings or trainings to develop talent pool; Local supplier and contractor development programs	Labour shortage; H&S
Industry-university collaboration (university sponsorship program)	Labour shortage
Training and involving low income people in the construction industry i.e., development of workforce from low income people	Labour shortage
Worker health and well-being program (on-site health screening events)	H&S

2nd phase empirical findings: potential strategies to achieve firm competitiveness

Table 3 depicts potential strategies that companies are implementing to address various social and environmental issues - mainly related to H&S issues, manpower shortage, and construction waste and landfill problems - in the HK construction industry. Interviewees also cited these strategies as potential reasons for the companies being able to achieve long-term competitiveness. It was also surprising to notice that these companies were unknowingly implementing such strategies, which generated both social and business values/benefits simultaneously.

Discussions with respect to the 2nd phase empirical findings

Table 3 provides a notion of the firms using alternative strategies (potential strategies) to create tangible business opportunities by tackling social and environmental issues. In fact, there is a shift in companies' focus towards developing innovative approaches that address the critical issues in profitable ways. These companies may not have achieved both social and business values including competitiveness if they have approached the issues through compliance, philanthropic, corporate giving, ethical or responsible mind-set (Porter and Kramer 2006). Such approaches not just become defensive (Berns *et al.* 2009) but also largely fail to deal with key challenges in business-society relationship (Porter and Kramer 2006; 2011). Instead, the companies have prioritized the critical issues that have significant impact on their business operation, and proactively developed the potential strategies to address them. These potential strategies have emerged from companies' motive to solve social and environmental issues and simultaneously obtain social and business benefits including business success, and future growth and development. There is a manifestation of a compelling business case for a value creation and a long-term sustainability (Berns *et al.* 2009). Hence, such potential strategies can be considered as in line with the CSV concept (Awale and Rowlinson 2014; Porter and Kramer 2011).

Table 3a: Potential strategies to address construction waste and landfill problems

CSV-competitiveness model	Details	
Social and environmental issues	Waste and landfill problems	Construction waste; Pressure to dumping sites and landfill areas; Damage to marine environment due to excess dumping of contaminated mud; etc.
Potential strategies	Reconceiving product	Development of innovative product or construction method (e.g. use of mechanical steel system formwork to minimize the timber waste and increase the usability of formwork)
	Redefining productivity	Building of own crushing plant to reuse concrete waste as aggregate and sand; Recycling of concrete waste at the batching plant (e.g. development of new concrete for eco pavement blocks, road pavements); Green treatment of marine mud (e.g. converting contaminated mud to suitable backfills)
Benefits of potential strategies	Social benefits	Reduce in construction waste and landfill pressure; Reduced in raw materials use; Improved marine environment; Availability of new land (reclamation of land)
	Business benefits	Improved productivity (e.g. mechanized steel formwork is quick and easy compared to traditional timber only formwork); Cost savings (e.g. reduce in transportation cost and waste disposal charge); Reduced logistical and operating costs; Increased revenue
Long-term competitiveness	Business success Prepare for the future	(1) Win more projects (e.g. due to the innovative ideas); (2) Improved profitability and growth of the company (3) New source of revenue; (4) New market creation or creation of new product line; (5) Leaders in new market and ideas (e.g. marine mud treatment concept has now become a norm in government specifications); (6) Product differentiation and strong entry barriers; (7) Earn client and government's recognitions

Table 3b: Potential strategies to address health and safety (H&S) related issues

CSV-competitiveness model	Details	
Social and environmental issues	H&S related issues	H&S of workers (e.g. risk to workers working at height; site accidents, injuries, and fatalities; ageing of the workers; unknown health history of workers); H&S of subcontractors and suppliers (e.g. incompetent subcontractors and suppliers); Unsafe workplace (e.g. unsafe site entry and exit of vehicles; safety of road pedestrians in the vicinity of project); etc.
Potential strategies	Reconceiving product or service	Development of innovative product or modification of equipment and tools (e.g. semi-automatic breaker rack); Development of innovative construction method or modification of construction process (e.g. development of bore pile head trimming method; redesign of the casings extractor without the working platform; mechanical steel system formwork)
	Local cluster development	Safety trainings for workers, suppliers/subcontractor; Local supplier and contractor development programs; On-site periodic health screening of workers to explore serious common diseases; Proactive community engagement and awareness programs
Benefits of potential strategies	Social benefits	Improved safety records (e.g. minimize risk to workers working at height); Less accidents and injuries; Safe working environments (e.g. improved safety of road pedestrians, safety of vehicles); Safer, improved and capable subcontractor and suppliers; Safer industry
	Business benefits	Improvement in work efficiency and productivity; Safer method; Cost savings (e.g. lower insurance rate); Increased revenue; Secure supply and continuity of work from suppliers/subcontractors; Commercial gain or monetary return (e.g. contractors/suppliers quote less price for same quality service or product); Safety excellence awards (recognition); Improved reputation and markings; Good relationships with labour department
Long-term competitiveness	Business success Prepare for the future	(8) Improved profitability; (9) Win more contracts or projects; (10) Increase in market share (11) Access to new source of revenue or revenue growth; (12) Leaders in innovative safe products and processes i.e., championing new practices; (13) Attraction of new comers due to the safe nature of construction; (14) Retention of workers; (15) Access to capable subcontractors and suppliers; (16) Improved external relationship and public acceptance

Table 3c: Potential strategies to address manpower shortage

CSV-competitiveness model		Detail
Social and environmental issues	Manpower shortage	Lack of skilled-workers (e.g., welders, bar benders, scaffolders, etc.); Lack of direct construction labours; Shortage of young talents; Difficulty in attracting, recruiting and retaining young workers; Ageing of construction workers; Suppliers and subcontractors lacking required manpower resource (incompetent and incapable subcontractors); etc.
Potential strategies	Reconceiving product	Development of innovative product/method (e.g. mechanical steel system formwork to use unskilled workers instead of welders)
	Local cluster development	Multi-skilling trainings, training own workers, new blood trainings and youth development programs to develop skills and attract young talents; Industry-university collaboration (e.g. fellowship-training scheme, graduate trainings); Development of workforce from the local community and low income people (e.g. training and hiring of local people in the vicinity of project and prepare them for the jobs); Contractor Co-operative Training Scheme
Benefits of potential strategies	Social benefits	Employees get talent and high incomes; Students get skills and high payment job; Improved education, job skills and competences; New job creation; Low-income people get decent jobs; Subcontractor and suppliers gain capabilities
	Business benefits	Reduced costs (e.g. instead of costly welders low paid workers could be used); Access to talent pools (e.g. secure supply of skilled and sustainable workforce); Access to local and natural talents (know-hows) ; Improved distribution infrastructure (e.g. competitive construction industry; capable subcontractors and suppliers; improved contractor performance); Lower rates and quotations from suppliers and subcontractor as they become competent and competitive
Long-term competitiveness	Prepare for the future	(17) First-mover advantage (championing new practices); (18) Retention of workers; (19) Gain additional capabilities, skills and competencies; (20) Building new and secure capabilities for the future (e.g. sustainable workforce, suppliers and subcontractors); (21) Access to university graduates; (22) strong entry barriers

A CSV concept: an alternative strategy

The CSV concept is defined as policies and operating practices that creates business values by tackling or converting social issues into tangible business opportunities by using three means: (i) reconceiving products/services and markets, (ii) redefining productivity in the value chain, and (iii) enabling local cluster development (Porter and Kramer 2011). The first means focuses on meeting the unmet needs and reaching unserved customers by designing and determining new products/services. It also helps companies to identify new markets and opportunities. The second pillar includes new approaches to energy and resource use, logistics, and procurement. It improves efficiency and productivity of business operations. Lastly, the third pillar focuses on improving the external environment of the company, enhancing skills through trainings, and strengthening local stakeholders. In this sense, the CSV concept is an alternative strategy to achieve long-term competitiveness, which focuses on integration of a social purpose into companies’ business operations. Figure 2 depicts the CSV concept for achieving firm competitiveness (Awale and Rowlinson 2014).

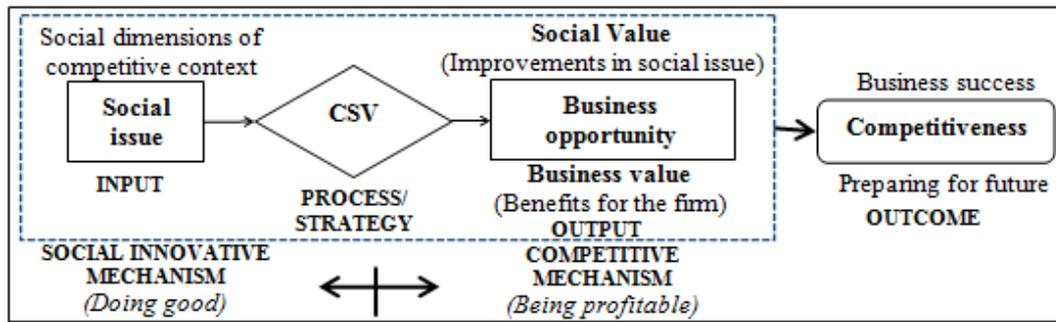


Figure 2: A CSV-competitiveness model (Awale and Rowlinson 2014)

Differences between traditional CSR and the CSV concept

Corporate social responsibility (CSR) and the CSV concept are both based on the same overlapping concept - “doing good by doing well”. CSR is about being responsible whereas CSV is about creating new values. CSR states that companies should be profitable, obey laws, be ethical, and be a good corporate citizen (Carroll 1991). These perspectives are reactive, defensive and lack active strategic choices within companies. Hence, CSR is limited to react against external pressure, mainly to satisfy stakeholder’s needs and maintain the firm’s reputation (Porter and Kramer 2006). It is typically an afterthought on how businesses operate and often remains at the periphery of business operation. In contrast, the firms embracing the CSV concept advance business operations proactively and place critical issues at the core of their business operations (Awale and Rowlinson 2014).

3rd phase Analysis - interview analysis

This phase includes analysis of interview data to explore the views of the participants towards the CSV concept for achieving firm competitiveness (Awale and Rowlinson 2015b). The analysis was similar to the interview analysis in the 2nd phase.

3rd phase empirical findings: views of the participants

Mixed perceptions regarding the CSV concept and firm competitiveness have been observed. However, the participants believe that firms can achieve long-term competitiveness through adoption of the CSV concept (Awale and Rowlinson 2015b).

a) Meanings and classifications of the CSV concept

The participants perceived that the CSV concept can be internal or external to the company, which may be well implemented by established companies than start-ups. It is pragmatic and context-based. It is a differentiation or a focus strategy that embraces the perspectives of the strategic management theories. It is a nascent concept that overlaps with strategic CSR, social innovation, and value co-creation concepts.

b) Challenges to implement the CSV concept

The participants expressed various possible challenges in implementing the CSV concept, which are mainly related to the government (ineffective and incompatible policy, rules and regulations; slow approval process; lack of long-term planning; slow to change etc.) and the nature of the construction industry (traditional mind-set; culture; structure; etc.). Besides, high investment cost, requirement of skilled personnel, laborious paper and administrative works, no marking system, volatility of market supply and demand may also hinder implementation of the CSV concept.

c) Linkage between the CSV concept and firm competitiveness

Based upon the strategic management theory, the competitive dimensions in Table 3 could be re-arranged as shown in Table 4, which provides a basic linkage between the CSV concept and firm competitiveness.

Table 4: Basic relationship between the CSV concept and the long-term competitiveness

Competitive theories: the strategic management perspective	Long-term competitive dimensions
Market-Based View (Porter 1980; 1985)	(1), (2), (3), (4), (5), (6), (8), (9), (10), (11), (12), (17), (22)
Resource-Based View (Barney 1991; Prahalad and Hamel 1990)	(13), (14), (18), (19), (20), (21)
Relational View (Kay 1993; Porter 1998)	(7), (15), (16)

CONCLUSIONS

This study explores the perceptions of construction industry practitioners, and defines and unfolds the anatomy of the CSV concept using a qualitative methodology. It also relates the CSV concept with firm competitiveness using strategic management theory. Although the participants are unaware of the CSV concept, they are unknowingly applying the CSV concept. Despite some hindrances and difficulties to implement the CSV concept, the practitioners perceive that construction firms can adopt the CSV concept to convert social and environmental issues into business opportunities and achieve long-term competitiveness. For this, the companies must integrate a social perspective into their core competitive frameworks while developing their business strategies. It is expected that the findings of this study will enhance our understanding of shared value creation. Furthermore, it highlights the effectiveness of social and psychological research methods in construction management research.

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THE EMPLOYABILITY SKILLS PROVISION WITHIN A CONSTRUCTION PROJECT MANAGEMENT DEGREE PROGRAMME

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This study was geared at assessing the employability skills provision within a construction project management degree programme through a questionnaire survey. Students were required to assess their level of ability in relation to the most common skills and competencies most sought after by construction project management graduate employers. The study identified team-working ability as the most sought after skill by the employers investigated followed by verbal communication, written communication and leadership ability. It was found that students were very confident of their ability in 12 of the 14 identified skills and competencies. But ironically, leadership, an important skill sought by employers is one that majority of the students felt most insecure in their ability. The study concludes that the BSc programme equips students with these employability skills and competencies, but more effort is needed to make the leadership development opportunities in the programme more conspicuous. With recommendations on how to achieve this proffered.

Keywords: graduate skills, graduate competencies, graduate employability.

INTRODUCTION

Graduate employability has always been in the spotlight, more so since the economic downturn of 2008 to 2010. At the height of the downturn, unemployment rate for 16 to 24 year olds was 20.7% (in March 2013) according to the Office for National Statistics (ONS) (McGuinness, 2013). The situation is even worse in the construction industry which seemed to have been impacted most by the resultant economic downturn. For example, the construction industry as a whole did not grow at all in 2009 and 2010 with a fall of 3.6% in 2012 and zero growth in 2013 (Construction Product Association (CPA), 2011). This resulted in very competitive job market for graduates entering the industry with companies becoming very selective in the calibre of graduates being recruited. This has made it ever so important for construction degrees programmes to equip graduates with not just the required technical ability but also the skills and competencies that will make them more employable in a crowded market. This study aims to improve the employability provision of the BSc Construction Project Management programme at Aston University by; (1) identifying the employability skills sought by leading employers of construction project management graduates; (2) unearthing the level of ability of the current final students in relation to these skills and competencies; and (3) evaluating how the BSc Construction Project Management curriculum at Aston University caters for these employability skills and how any identified deficiency might be improved.

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LITERATURE REVIEW

Research in the area of employability can broadly be categorised as (1) those on the role of higher institutions and other stakeholders in employability skills development; (2) perception of students in relation to employability; (3) what constitute employability skills and; (4) methods and models for successful development of employability skills in students. On the issue of the stakeholders involved in graduate employability, Tran (2015) highlighted that graduate employability depends on the relationship between higher education and the employment market and that efforts by universities will not work without the cooperation of related stakeholders such as employers. Speight *et al* (2012) found conflicted and confused views on employability among students, academics and employers. Academics were worried about the potential dilution of their discipline if integration of employability were imposed. But employers and students disagreed and believe that employability skills development should not be separate from the curriculum. This view by students is corroborated by Wilton (2008) who found that students greatly value the opportunity to apply the knowledge and skills acquired on their studies in a 'real world' environment. Ironically studies looking at the perception of students in relation to graduate employability are few and far between. The focus has mostly been on employers and higher institutions with often conflicting views. This led to Wilton (2008) arguing that the accounts of recent graduates should be the best source of dealing with the lack of consensus between academics and employers on how employability skills should be developed in higher education. Tymon (2013) also noted that graduates are increasingly aware that a degree on its own may not be enough and that they need additional skills and attributes for career success. Similarly, Jackson (2013) found that undergraduates place significant value on employability skills development in degree programmes, with the skills most valued by students being working effectively with others and communicating effectively.

From the above, it is apparent that students seem to think employability skills are synonymous to generic skills but opinions are diverse on what constitute employability. A view shared by Tymon (2013) who averred that the concept of employability is a multidimensional issue which cannot be easily defined. Hillage and Pollard (1998) defined employability as the capability of getting and keeping fulfilling work, and the ability to move self-sufficiently within the labour market. Yorke (2004) defined employability as a set of achievements, skills, understandings and personal attributes that makes graduates more likely to gain employment. Others have argued that employability involves more than skills. Bridgstock (2009) argued that employability is the ability of graduates to proactively navigate the world of work and self-manage the career building process. Similarly, Knight and Yorke (2002) posited that employability extends well beyond skills and is related to the concept of capability. On the theme of employability as capability, Arrowsmith *et al* (2011) argued that collectively, it is the sum of subject knowledge, technical competencies and personal attributes, assembled in appropriate ways, which define a graduate's employment capability. A number of studies have contributed to the area of employability skills development in students with a variety of approaches put forward. Recently, Kalfa and Taska (2015) argued that the traditional generic skill training is ineffective as it ignores the situated nature of learning. A conceptual framework of employability training that acknowledges the multiple contexts in which skills are acquired and transferred was therefore put forward. Earlier Fleming (2005) established that students who have undertaken cooperative education have a

competitive edge in the employment marketplace. While Cranmer (2006) posited that structured work experience and employer involvement in degree course design and delivery have positive effects on the success of employability skills training. Employer involvement also formed the crux of Tymon (2013) approach who recommended that promotion of work-based training and experience should be adopted for employability skills development. By far the most commonly recommended approach for successful employability skills training in higher education revolves around integrating employability skills development with the curriculum. However, this approach is fraught with a variety of nuances. Schaeper (2009) affirmed that although isolated, decontextualised standalone courses assist in acquiring key competencies, but they are less effective than integrated approaches. Similarly, Stoner and Milner (2010) suggest the need for educators to deploy strategies for building students' capacity to develop relevant skills across their whole degree experience. To underscore the perceived importance of integrating employability skills with the curriculum, Cranmer (2006) revealed that the embedding approach is more effective in developing employability skills than the bolt-on strategy. Specific techniques that have been recommended for integrating employability skills into curriculum include project-oriented classes which focuses around cross-disciplinary work (see Arrowsmith *et al*, 2011). Boahin and Hoffman (2013) also argued for competency-based training to be integrated together with technical competencies, while Kember and Leung (2005) are in favour of active learning because it has a strong effect on development of graduate capability.

RESEARCH METHOD

This study utilised an eclectic methodology consisting of both the qualitative and quantitative methodology. In carrying out the research, the first step involved investigation of target jobs, a graduate employment website and reviewing the job adverts of 10 leading employers of construction project management graduates in the UK. The skills required of graduates for their graduate trainee programme were then identified. Based on this a questionnaire was developed made up of three sections. The first section of the questionnaire was aimed at obtaining information on students' evaluation of their level of ability of the identified skills required by the leading construction project management graduate employers. There were 14 listed skills and competencies and a likert scale was used to ask the students to rate their level of ability in relation to these skills. In the second section of the questionnaire the students were asked to reflect on all the modules they have attended during the programme at Aston University and indicate which of them had equipped them with a particular competency and the specific activity, assignment etc. within the module that furnished them with the skills. The third section of the questionnaire was optional and asked students whether they had any ideas on activities they would like to see in the programme to equip them with the identified skills and competencies. The questionnaire was administered towards the end of the session to only the final year students as they were deemed the most appropriate to complete the questionnaire due to the fact that they are the only ones with experience of all the stages (years) of the BSc programme. The cohort was made up of 15 students, 11 questionnaires were returned representing a 73% response rate and all questionnaires were deemed suitable for analysis. Due to the small sample size a replica study was conducted two years later on a similar sized cohort to ascertain the reliability of the original study.

ANALYSIS AND DISCUSSION

As noted earlier, a content analysis of the adverts for graduate trainee programmes of 10 leading companies was conducted. Table 1 shows the outcome of this analysis. The next section discusses some of these leading skills.

Table 1 Leading skills and competencies in construction graduate job adverts

Skills and competencies	Number of graduate adverts requesting these skills and competencies
Team-working ability	8
Verbal communication	6
Written communication	6
Leadership ability	6
Flexibility	5
Problem solving skills	4
Initiative	4
Commercial and business awareness	4
Time management and meeting deadlines	4
Analytical skills	3
Drive	3
Self-motivation	3
Organisational skills/planning ahead	3
Creativity and innovation	3

Most Sought After Skills by Leading Employers of Construction Project Graduates

From table 1 it can be seen that the most sought after employability skills demanded by employers is team-working ability. This was demanded in the graduate job adverts of eight of the ten companies analysed. Although this is obviously an important competency in the workplace but it is even more important in an industry like the construction that requires contribution from various specialists. For example, in the construction of an infrastructure like a railway and associated stations, there will be the contribution of the civil engineer, the structural engineer, the cost consultant, the Architect, Land Surveying Engineer, Geotechnical Engineer etc. who will all work together to bring the project to fruition. Hence the ability to effectively work as part of a team is vital in this industry. Empirically, team-working has also been identified as one of the most sought after employability skills. For example, team-working skills was identified by Kreber (2006), Andrew and Higson (2008), Abraham and Karns (2009), Cumming (2010) etc. Communication skills both verbal and written emerged as one of the leading sought after skills by construction project management graduate employers. The reason for this is not far-fetched because as previously noted, construction is a multi-disciplinary and good verbal and written communication is important in order for graduates to be effective with the various professional they will be dealing with. Just like team-working, communication as an employability skill has been identified empirically as a leading skill normally demanded by employers across the world (see Pool and Sewell, 2007). Another leading employability skill worthy of

note is leadership ability, which featured in six of the ten graduate job adverts analysed. This skill is particularly important for graduates entering the construction industry because they are more than often tasked with some supervisory responsibilities early on in their career. Leadership was among the core skills launched in 1989 by the UK Secretary of State, Kenneth Barker in the call to include core skills in existing programmes (see Whitston, 1998).

The non-criticality of technical knowledge

It is important to point out that rather surprisingly; technical knowledge did not emerge as one of the most sought after skills by employers. This is despite the fact that construction project management is a technical discipline that requires an enormous amount of technical understanding of the domain. This situation seems to confirm the conclusion of Pool and Sewer (2007) that although employers want graduates with relevant subject specific (technical skills), they really value generic skills and competencies such as imagination/creativity, flexibility, willingness to work, working in team oral communication etc.

Final Year Students Perception of Their Level of Ability of the Most Sought After Skills

The next stage of the research asked the final year student to evaluate their level of ability in each of the identified most sought after skills. With students requested to rank their level of ability as either ‘exceptional ability’, ‘high ability’, ‘average ability’, ‘low ability’ and ‘no ability’. The responses were analysed and this is presented in table 2.

Table 2 Final Year Student’s Perception of their Ability

Skills and Competencies	Perceived Ability					Percentage that rated their ability as exceptional or high
	Exceptional	High	Average	Low	No ability	
Team-working	0	8	3	0	0	72.7%
Verbal Communication	1	7	3	0	0	72.7%
Written Communication	2	7	2	0	0	81.8%
Leadership	1	2	7	1	0	27.3%
Flexibility & Adaptability	3	5	3	0	0	72.7%
Problem Solving	1	5	3	2	0	54.5%
Initiative	1	7	1	2	0	72.7%
Commercial & Business Awareness	1	5	3	2	0	54.5%
Time Management and Meeting Deadlines	2	6	3		0	72.7%
Analytical Skills		10		1		90.9%
Drive	2	5	2	1	1	63.6%
Self-motivation	3	4	2	1	1	63.6%
Organisational Skills/Planning Ahead	1	5	4	1	0	54.5%
Creativity & Innovation	0	5	3	3	0	45.5%

The table above has been interpreted by categorising the results of the analysis of students’ responses into two groups. The first group is made up of skills and competencies where students perceive they have exceptional or high level of ability. Competencies were assigned to this category if more than 50% of the responses ranked a competency as either exceptional ability or high ability. The second category

includes skills and competencies where the students are not confident in their level of ability. Skills and competencies were assigned to this category if more than 50% of responses ranked a competency as either average ability, low ability or no ability.

Skills and competencies which students are most confident they possess

From table 2 above, the skill that most students are confident in their level of ability is analytical skill which 90.9% of students rated their level of ability as high. The reason for this was provided by responses to the second section of the questionnaire where most of the students indicated that all the modules of the programme have helped developed their analytical skill. The students revealed that that most of the modules course works, essays, reports or assignments have required them to utilise analytical skills. This resonates with literature; Boahin and Hoffman (2013) assert that higher institutions should integrate such employability skills, together with technical competencies in order to achieve the best results. Communication both written (81.8%) and verbal (72.7%) also emerged as skills students were confident of their ability. With all the modules again being pointed as having contributed to this capability through required written, group and/or individual presentation components. One final year student commented as follows: *“All modules undertaken so far have required the submission of work, and this has given the opportunity to develop written communication skill”*. This is not surprising because Wilton (2008) found that the most widely used skill in managerial employment was communication. While Tymon (2013) and Jackson (2013) both found communication as one of the most commonly cited skills and attributes valued by graduates.

Other skills student were very confident of their ability are flexibility/adaptability (72.7%) with students indicating that the nature of the BSc programme itself an enabler of this. This is due to the fact the degree programme is made up of a combination of subjects ranging from technical areas to commercial and business disciplines, geology and even economics. In the words of one of the students, *“the degree itself and the mixture of areas allows for flexibility in itself”*. 72.7% of the students were also confident they possess team working ability, while the same proportion was confident they possess initiative. Majority of the students believe that the use of assignment and coursework had helped them to develop this, as this usually involve using their initiative to plan, research and produce their independent or group assignments and working together in groups. In addition to the course works and assignment the final year independent project work was also indicated by students as instrumental in helping the development of their initiative ability. This is no surprise because the final year project would require students to follow a line of enquiry for their selected topic, develop their objectives and plan their work incorporating various forms of data collection methods to enable them achieve these objectives.

Skills and competencies which students think they are deficient in

The study revealed that students consider themselves deficient in only two areas; these are Creativity/Innovation and leadership. Creativity less so, as 45.5% of students indicated that they have a high level of ability, hence a borderline rating. The rating for leadership on the other hand is a alarming as only three students assessed their leadership ability as being high or exceptional. Most students (72%) judged their leadership ability as being average or low. This is rather concerning in light of the fact that as can be seen in table 1, leadership is one of the leading competencies sought by construction project graduate employers. When students were asked to indicate the activities within the modules that might have helped them develop their

leadership ability, there was usually no dedicated leadership activity indicated apart from the rare reference to being group leader during team exercises. This reinforces the argument of Jackson (2013) who asserted that employers' expectations are not being met in students' possession of generic skills like decision making and leadership. Paradoxically, the study shows that students would like leadership development opportunities within the programme. Their perception is that more could be done to increase the leadership development opportunity within the programme. For example one student commented as follows; *“None (of the modules) really spoke about the art of a leader other than Human Resources Management.”*

Improving the leadership provision within the degree programme

This study has uncovered that students perceive that the construction degree programme is equipping them with nearly all the most sought after skills by graduate employers apart from one of the most important ones - leadership. Analysis of the programme reveals that the programme is abound with leadership development opportunities. For example there are team, group and project-based tasks all through the programme. According to Arrowsmith *et al* (2011) problem based learning and project oriented classes are some of the high impact approaches used to successfully integrate employability skills into curriculum. It has also been argued that through teamwork a number of generic skills are developed including leadership (see Kalfa and Taska, 2015). Additionally, the programme also has a one year work-placement. Work placements have been lauded as one of the most successful means of developing employability skills including leadership. Research by Wilton (2008) indicates that graduates who completed a work placement are almost universally positive about the benefits of having done so. So why are students not confident in their leadership ability and feel there are not enough leadership development opportunities integrated in the programme despite this being the opposite? The answer to this question lies in the literature. Firstly, the concept of overt curriculum (Tymon, 2013), needs to be embraced in relation to leadership skill development. Tymon (2013) found that skills can be developed and are embedded in the curriculum through a number of activities and programmes but if students are not aware of the benefits of these programmes they would usually not engage with these activities. Hence, educators need to make skills development activities more overt. As individual benefits were clearly the main reason why students thought employability mattered. The implication of this for Aston University Construction Project Management Degree is that the outcomes of the programmes (e.g. work placement and project-based work) should make explicit the generic skills and competencies e.g. leadership they have been designed to enhance and not just the technical skills. This will ensure that student dedicatedly strive to develop the generic skills when participating in such activities and tasks.

Additionally, it is not just sufficient to make the curriculum overt, gaining student buy-in to employability skill development is also crucial if it is to be successful (Jackson, 2013). One of the reasons for this according to Jackson (2013) is to ensure effective learning as research suggests that effective learning requires a clear understanding of the value of presented material and associated activities. One of the key ways students buy-in can be gained especially for the work-placement year is to include employability skills and not just technical skills in the learning agreement established at the outset. A self-appraisal of the various employability skills should be conducted by the students and this should be discussed with the tutor, with plans formulated on how the student should seek to develop the agreed ones during the placement year. The placement report, which currently evidences mainly the technical

and managerial experience gained during the placement year, should also now report and evidence how the student felt they have developed the employability skills agreed at the outset. Wilton (1998) argues that key skills relating to personal relationship encompassing a competency like leadership should be integrated into the curriculum. Additionally, since there are already many group tasks and activities from various modules of the programme, students should be required to lead a group so that all students have led their peers in completing a group task at least once during every academic year. This will also incorporate self-assessment of leadership ability before and after the exercise. To augment this, as part of the programme, students should be required to compile a leadership development portfolio every year. This would involve students preparing a reflective report on the leadership style(s) they adopted on the group work they have led in the year, justification of this and reflection on effectiveness.

Alleviating the small sample used - the issue of generalisation and reliability

This is an action research aimed at reflective practice and improving the current employability skills provision of the author's affiliated institution hence why the sample was based on a cohort of the degree programme. This small size is reflective of the usual cohort size of the final year. However, critiques would argue that although the author's hand might be tied in relation to the number of respondents utilised, the generalisation of the findings is questionable. The author does not seek to generalise this research to construction programmes of other universities, but it would be interesting to ascertain if the findings can be generalised to final year cohorts of the construction programme at the same university for any given year. That is, if not widely generalisable, is this study reliable? To ascertain this, the same questionnaire was administered to a subsequent final year cohort two years after the original study.

Results of replica study conducted on a separate cohort of students two years later

The size of the cohort was 13 students and the questionnaire was administered via email as previous. A total of 10 questionnaires were returned representing a 76.9% response rate and all questionnaires were deemed suitable for analysis. Analysis of this set of questionnaire revealed similar results to the previous cohort. Just like the previous cohort students were confident of their ability in 12 of the 14 skills and competencies such as team working (90%), written communication (90%), verbal communication (70%), flexibility and adaptability (70%), problem solving (70%), initiative (80%), commercial and business awareness (70%), time management (80%), drive (80%), self-motivation (100%) organisation and planning (100%). Furthermore, just like the previous survey, leadership emerged as a competency students were not confident they possess as 50% of them perceive their leadership ability as average. This is very similar to the previous survey and further confirms that the leadership skills development provision of the degree programme needs to be improved.

CONCLUSIONS AND RECOMMENDATIONS

This paper has investigated the employability skills most sought after by construction project management graduate employers and a total of 14 skills were found as the leading skills and competencies. Team-working was the most sought after skill with verbal communication, written communication, leadership ability and flexibility not too far behind. The study found that most students were confident of their level of ability in most of the skills and competencies with more than 50% of students indicating a high or exceptional ability for 12 of the 14 identified skills and competencies. Skills like analytical ability, written and verbal communication skills,

team-working ability, flexibility and adaptability received a resounding endorsement from students in terms of their level of ability. But rather surprisingly and concerning, leadership was the skill that majority of the students were most insecure of their ability with a whopping 72% of students indicating an average or low leadership ability level. However, the study highlighted that the construction project management degree programme had abundance of activities and programmes which provide leadership employability development skills, such as a one year work-placement. But students do not seem to realise or embrace these as leadership development opportunities. To improve the situation the study drew on two concepts in literature (overt curriculum and student buy-in) as important ways of making the leadership skill development opportunities more efficacious. This will be augmented by compulsory hands on leadership culminating in the compilation of a reflective leadership portfolio all through the programme. Finally, a more elaborate research that will utilise a bigger sample is recommended since this study is limited in that a small population was used as constrained by the small size of the cohort, therefore making these findings difficult to generalise. The use of a larger sample will yield more insights and lend itself more to generalisation.

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INCLUSION OF HIV/AIDS AWARENESS IN CORE CURRICULA FOR CONSTRUCTION ECONOMICS AND MANAGEMENT STUDENTS

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With the maturing of democracy in South Africa, there has been a realisation that active measures need to be taken to develop a sense of inclusivity in graduates. Given that graduates move into management, their attitudes and knowledge are pivotal to growth. Attitude and knowledge surrounding HIV/Aids is required for both personal safety and workplace management and skills. Mixed methodology was used in a study in 2014 on the inclusion of HIV/Aids awareness in main curricula for third-year courses within the Faculty of Engineering and the Built Environment at the University of Cape Town. Lecture, workshop and presentation modules were conducted through Professional Communication courses. These inputs of career path, citizenship and discipline-specific content were based on pre-assessment results and were given to two cohorts of Construction and Economics and Management students comprising 27 (first cohort) and 54 students (second cohort). The students attended a 2-hour lecture/workshop and, in pairs, gave 10-minute presentations on themes on the topic. Marks were awarded according to criteria based in HIV/Aids content and professional delivery. After judgment by two staff members and one industry representative, the four winning pairs received cash prizes. Post-assessment following the workshop and presentations was through a questionnaire (100% completion). Conclusions were that given effective collaboration between course convenors, integration of the topic within core curricula was effective; contributed to inclusivity; achieved the aims of developing workplace knowledge and skills in social and public health; and allowed Professional Communication course objectives to be achieved.

Keywords: H&S, HIV/AIDS, curriculum development, inclusivity.

INTRODUCTION

In July 2014, the Executive Director of UNAIDS called for an end to Aids by 2030. (UNAIDS, 2014). For such an achievement he noted that voluntary testing and treatment must be able to reach everyone. To quote his speech at the 20th International AIDS conference, Melbourne, 20 July:

“I am calling on the world to adopt a new, ambitious target: 90% of people tested, 90% of people living with HIV on treatment and 90% of people on treatment with suppressed viral loads.” (Sidibe, 2014)

However, George (2006, in Bowen, 2014) states that deaths this year in South Africa are expected to reach 2.1/100, up from 1.7/100 in 2005. Reaching the UNAIDS’ objectives can only happen with the commitment of all involved: governments,

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industry and individuals. It can also only happen through education. Of the major sectors on which HIV/Aids has had a negative impact: mining, transport and construction, construction work has had and continues to have a particularly high incidence because its association with migrant and out-sourced labour. A factor of out-sourced labour is that it is unregulated and informal, making this sector more vulnerable to socio-economic problems, such as HIV/Aids. Studies over time in South Africa about construction and the relationship between attitudes (based in knowledge and beliefs) and types of employment all show the problem as inadequately managed. (Haupt and Smallwood 2005; Ugwu and Haupt 2005; English *et al.* 2006; English and Bowen 2012; Bowen *et al.* 2014)

In a local study (Western Cape construction firms), Bowen *et al.* (2010) surveyed workplace policies and programmes. The study covered 42 companies with data being collected via a web-based survey. Major findings were that 67% of respondents had an HIV/AIDS policy but only 19% had implemented a treatment programme of some description. The reasons cited for not having implemented a programme were cost, insufficient management resources, management being focused on productivity, and meeting time constraints. The study also referred to stigma as it felt employees wanted to avoid HIV positive stigmatization, and anonymity could not be guaranteed. For construction students, therefore, this intervention was particularly apt.

Recent extensive research by Bowen *et al.* (2014) described the need for the private sector in construction to be involved, particularly given the sector's high prevalence of Aids with its informal employment, fragmented work patterns and diverse locations. The literature on this topic indicates the challenges these conditions raise with researchers. Bowen *et al.* (2014) describe Haupt, in particular, among others, as having looked at the particular problems of contractor awareness (2003), age (2005a) and good health (2005b). Policy is fundamental to meeting the challenges – without it, there will be no drive for funding or implementation of preventative and curative measures. In a study in 2010 (see Table 1), Bowen *et al.* (2014) found that only a slight majority (53%, n=16) of the 30 firms questioned considered HIV/Aids as a long-term threat to the industry, although the majority (73%, n=22) had a programme in place. Having a programme, however, does not necessarily translate into its being active. An example of this was found in a response from a participant who knew her company had a policy on the virus but was unsure about its content:

“They [employees] know the company has an HIV/AIDS programme but cannot remember what it entitled them to. Though all employees, subcontractors, etc. (everyone on site) has to have a lecture by the H&S officer before they are allowed on site, are given the written safety conditions on paper, including rules of behaviours expected of them on site; and the company’s policy on AIDS. They have to sign they have received this information before they can move onto site.” (English and Bowen, 2012:43)

A later study by Bowen *et al.* (2014) found that construction under-performed in terms of programmes and investment compared with finance, transport, manufacturing and mining (Bowen *et al.*, 2014), with only 31% of construction companies having implemented an awareness programme. Given this industry being one of the most at risk, this is a poor result for the needs of the country. Of further concern is the negative effect of stigma leading to lack of uptake of treatment when needed and offered. Whilst HIV/Aids needs to be flagged as a critical concern in the construction industry, Bowen *et al.* found that only just over half of the sample conveyed

considered it a problem. For 47% it was not a problem of importance, as illustrated in Table 1.

Table 1: Survey respondents' opinions regarding HIV/Aids as a long-term industry threat (n=30) Bowen et al. (2010:1000)

Perception of HIV Aids	% Response
Not a problem	7%
Slight problem	17%
Neutral	23%
Problem	27%
Significant problem	26%

Negotiation for the integration of HIV/Aids content into core curricula at UCT presents challenges. Where the integration was not possible in core curricula, co-curricular interventions were designed that placed emphasis on using the existing knowledge and skills relevant to the industry. The University of Cape Town (UCT) acknowledges integration of HIV/AIDS education into curricula in its HIV/AIDS policy. The need was to include the areas in which practitioners need competency – that is, knowledge and understanding of the condition and its environment; its effect on attitudes and values; and related activities in the workplace, for example, respect for confidentiality, empathy, good communication and good interpersonal skills. (HEAIDS, 2010a).

While various interventions have shown that HIV/AIDS can be successfully integrated into academic curricula (Volks, 2012), common challenges arising during practical application of the policy include staff loyalty to their area of expertise and the concern surrounding the relevant discipline specific integration of HIV/Aids education into core curricula (HEADS, 2010a). Two structural barriers often occur when encouraging integration of core content with HIV thematic issues: first, the lecturer's personal discomfort with the topic, which results in shunning the possibility of alignment; second, the lecturer not being able to visualise the fit with the core content.

Aim

Overcoming these two barriers has been part of the success of a study undertaken at the UCT Faculty of Engineering and the Built Environment (EBE). An organisational management theory of collaboration was successfully applied with faculty staff leading to two sustainable results. First, one foundation course for all engineering students incorporated the HIV/Aids and contextual content, and second, a co-curricular exercise managed through the EBE faculty was conducted. An overview of the process of integration and course alignment is outlined in the following paragraphs. The evaluation of the study presented in this paper will be used to inform the process by which the UCT HIV/Aids, Inclusivity and Change Unit (HAICU) initiates the integration of discipline specific HIV/Aids education into core curricula in the other five UCT faculties. This has relevance for other South African and African Higher Education Institutions with a need to integrate discipline specific HIV/Aids curriculum material. The strength of the study is inherent: it is grounded in theory emanating from robust research (conducted by Department of Health and Higher Education bodies) and has great relevance for construction – a growth industry in South Africa. Its weakness is that the sample group, while being 100% of the third-

year Department of Construction, Economics and Management students, the overall intake was lower than in previous years, amounting to only 81 students.

Background to Aids in Education

In 2012, it was estimated that 12.2% of the population in South Africa (6.4 million persons) was HIV positive, which is 1.2 million more than in 2008 which represented a significant change over the 2008 HSRC survey (Shisana *et al.*, 2009). Since 2008, the 15–24 year-old age group has had the highest HIV prevalence, with the prevalence within this age group only recently decreasing. Currently, the HIV prevalence is 7.1% of 15–24 year olds (N= 5,890; C.I 6.2–8.1). As 17.8% of students enrol at university, the case for adequate support services, as well as learning spaces that interrogate South Africa's contextual issues within each academic discipline, becomes more urgent.

Given that the most affected age groups are women aged 20 to 34 (32.7% of all women) and men aged 25 to 49 years (23.7% of all men), universities need to take cognizance of the crisis (Shisana *et al.*, 2009). Shisana *et al.* (2009) also described 15% of the population between ages 15 and 49 as being affected. Higher education bodies in South Africa have been aware of the crisis and in the new millennium, the South African Universities Vice-Chancellors Association (SAUVCA) sought to identify the scope of the virus and its impact on education. The areas looked at were the management planning, programmes and policies that had been put in place (HEAIDS, 2010a). Findings regarding students confirmed the general ones from the HSRC enquiry described earlier – male students (19%) on average had had more than one partner in a month, which was more than women students had had (7%), but women (4.7%) were twice as likely to be affected as men (2%). (HEAIDS, 2010a:23)

Education, both formal and non-formal, is being increasingly packaged according to qualifications, delivered through pre-packaged curricula which are based on predetermined outcomes and integrated in a discourse of improving competitiveness, jobs, standards and quality (Batjes, 2005). University graduates coming out of UCT's Construction Economics and Management courses move into management and thus, can be predicted to be future drivers of Aids awareness and action in their companies. The HAICU is mandated by the office of the Vice Chancellor to work in the areas of peer education, communication, policy and curricula. The latter was the focus for this research project, with HAICU collaborating with Professional Communication Studies (PCS) in EBE to integrate public health education on HIV/Aids into core curricula so that students engage with social justice issues through their course work. It is only if the topic is thus entrenched that it will be taken seriously and not be a lightweight option or dropped entirely (HEAIDS, 2010b). For universities, this means it is linked to the degree, through Duly Performed (DP) requirements or evaluation.

Conventional wisdom suggests that engaged and relational learning is more likely to grow out of a learner-centred, rather than teacher-centred, instructional environment as learners are strongly influenced by their peers (Sulcas and English, 2010). The shift therefore, was made towards creating students that are critically engaged with their discipline and the context in which they live and work, which requires lecturers to view the university space as part of a complex social system (Rakow, 1991) dependent on the students' social context rather than as a siloed classroom space. Lecturers need to generate critical and emancipated learning spaces so that the 'temporary relationship of [lecturer] and student continues to be influenced by the larger world – a world in which classifications of gender, race and class are among the most

paramount.’ Rakow (1991:10). Lecturers who are component in their technical fields are not always comfortable, however, in moving into this nuanced environment.

Higher Education HIV and Aids Programme (HEAIDS, 2010b) described preferred modes of delivery of such material. HIV/Aids education programmes in particular require good social and interpersonal skills in the leader because of the danger that if the right climate is not created, the lecturer could come across as moralistic and the programme consequently fail (HEAIDS, 2010b). Studies indicate that a workshop rather than a lecture construct is preferable. HAICU's approach has been to offer one-day modules for students – a format it has used in the faculties of Commerce and Medicine. However, the block of time required has to be factored into the curriculum and is not necessarily available in all courses. Thus, in courses, such as the one in the EBE faculty, it was preferable to incorporate the HIV/Aids material into current course material despite the risk of staff resenting the additional material as an added burden to their preparation and delivery. The preferred model, therefore, involved team teaching – necessary where the core course teacher has no knowledge in the area of HIV/Aids – and adding an HIV/Aids component to an existing course (HEAIDS, 2010b).

In this case, Professor Paul Bowen of the Department of Construction, Economics and Management, an established researcher in this field, was able to provide expert knowledge, which meant automatic cross-disciplinary connections and support, and that no additional work for staff of the carrier department (PCS). These are factors that make for successful team teaching. A summary of the relative approaches to integration, by Mathison and Freeman, is given in Table 2.

Table 2: Levels of integration Mathison and Freeman (1997:8)

Level of integration	Theoretical features
Intra-disciplinary discipline-led	Enhances connections within disciplines Promotes success for all students
Cross-disciplinary correlated	Coordinated themes/content across separate subjects Emphasis of certain skills across disciplines Processes, concepts, skills, or elements of two or more disciplines together
Interdisciplinary	Processes, concepts, skills, or elements of two or more disciplines together Common themes or modes of inquiry form interdisciplinary connections Inquiry skills and discipline content are enhanced
Integrated	Disciplines lost in global perspective Theme or issue oriented Inquiry oriented
Integrative	Disciplines lost in global perspective Student/teacher negotiated themes and issues direct Inquiry oriented

If integration of the topic is done via a carrier subject, certain factors come into play. Fewer specialized lecturers are needed, but it needs to be clear who is plays which role and who is responsible for the various tasks, although the expert team needs to facilitate the assessment. In some cases, material may have to be dropped for the HIV/Aids input to be included – the HIV/Aids content may have to be truncated. Lastly, despite enthusiasm in the specialist team, there is no surety that it will be matched by the staff of the carrier subject. (HEAIDS, 2010b).

The carrier subject tends to be one of the soft skills, such as communication, which was the case in the UCT study, added to which, there is a preponderance of female lecturers in such areas. Thus, while a predominantly male faculty drives the curricula in areas such as engineering, female staff members will deliver the HIV/Aids modules (HEAIDS, 2010b). Indeed, both PCS lecturers on the CEM module were women. This reflects the changing role of teachers to include care about social issues affecting students.

To go beyond the traditional requirements of teaching, the academic needs faculty support as skills are required beyond the usual requirements for teaching a technical subject. Personal knowledge and workplace knowledge are of importance for this topic – as well as disciplinary knowledge. In the study outlined, some lecturers described the problem of keeping up with HIV/Aids topics and that some of the material they access may be dated. A further issue to be considered was duplication of activities and resources within the university, taking into account the number of participants involved (HEAIDS, 2010b).

Academics in many South African universities have provided examples of the various ways social consciousness about HIV/Aids and related health issues can be incorporated into course content. By providing students with a consciousness that helps them “*move away from thinking in terms of rules that give clear-cut, readily definable answers and toward conceptualising both problems and answers in terms of particular perspectives within the multiple, conflicting possibilities presented by experience*”, lecturers have a rare opportunity to assist students in building their individual and academic voices (Weber, 2010:131).

In all these contexts, lecturers should provide the intellectual space for students to forge connections between their experience and class material, and to honour their experiences and insights rather than quickly dismissing them as anecdotal, an obstacle in their path to real knowledge. Establishing an appropriate method for creating emancipated learning spaces often generates anxiety for lecturers who have not had to adapt or align HIV content and socio-contextual concepts within their course context.

THEORETICAL AND PRACTICAL FRAMEWORK FOR COLLABORATION

Volks (2012) demonstrated in the evaluation of HAICU’s HIV/Aids pilot courses that had adopted Campbell and Cornish’s theory (2010) in the Health Sciences, and Science and Engineering faculties that the following beliefs could be discounted:

- a compulsory examinable course on HIV/Aids will automatically lead to “*Aids fatigue*” and will increase knowledge, or will change attitudes or be valued.
- compulsory HIV and Aids courses cannot be fitted into packed curricula.
- information for personal use cannot be integrated successfully with information for academic learning.

The research study on integrating HIV/Aids in Engineering and Science courses in 2012 had positive outcomes and the evaluation disproved the above statements. A pivotal outcome was the appropriateness of PCS as the carrier for the intervention. Research has indicated that this intervention needs to be couched in the curricula design by an over-arching body (in this case, HAICU) to ensure neither omission nor repetition of material (Wood, 2014). Woods also found extensive evidence that service courses such as PCS are the best drivers for HIV/Aids education but that the content must be made relevant to the core subject (in this case, construction) and to

the social and physical environment in which the students live (Wood, 2014). The challenge in the 2012 study was maintaining a cohesive programme across four different departments in EBE. In this study, the programme was contained to cohesive groups of students studying Property Studies and then to those studying Construction Economics and Management. Thus the alliance between the faculty's course objectives and HAICU's organisational objectives was kept.

The approach was that the students attended a 2-hour lecture/ workshop and, in pairs, gave 10-minute presentations on themes on the topic. Marks were awarded according to criteria based in HIV/Aids content and professional delivery. After judgment by two staff members and one industry representative, the four winning pairs received cash prizes. Post-assessment following the workshop and presentations was through a questionnaire (100% completion). A further success factor was the esteem given to the programme. This was evident in senior staff addressing students and in the mark weighting. The presentation project carried 200 out of the total of 700 marks for the course.

Clear communication and clarification of intent typified the HAICU project officer's role. Theory described by Wood (2014) shows that a department needs support in integrating HIV content into a special subject. The importance of it needs to be stressed and its relevance to the core curricula for preparing functional graduates (Volks, 2012). Therefore, part of the communication process included presenting the concept to members of the PCS department. As the members of staff were also course convenors for the programme, it was critical to clarify the concept and establish their commitment to the process. Part of this process included allaying their anxieties about addressing a topic some felt awkward about, addressing their stereotypical views and imbuing them with the confidence and tools to become involved. Wood's 2014 review showed a number of studies which recommended that the department have the outside input of an expert; this was the role played by HAICU.

Good teaching practice is that evaluation is essential to creating and maintaining collaboration. Therefore each course was evaluated to give feedback to the group members. These objectives were to preserve and enhance the course aims and outcomes, while invoking critical thinking about HIV/Aids as it relates to industry. The objectives of the curriculum integration were to focus on areas of synergy in course content to prepare UCT students to adequately respond to HIV/Aids within peer and workplace environments. The course structure included quantitative pre- and post-evaluation to measure levels of understanding both before and after the knowledge share. The results of the pre-assessments were used to define the course content. The post-assessment results informed the development and implementation of the courses for the following year, and assisted in curriculum discussions with course convenors.

COURSE INTEGRATION AND STUDENT ENGAGEMENT

HAICU and PCS practitioners worked on conceptualising the inclusion of information on HIV/Aids into the professional communication course content, assessment of learning, and relevance to industry. The core subject selected for the module was the Construction Economics and Management programme. While the pilot study in 2012 had students volunteer with only volunteers attending the workshop, all the students in the two courses (27 from Property Studies and 54 from Construction) in 2014 attended a two-hour lecture / workshop. Input was given by a key researcher on HIV/Aids in construction in South Africa, Professor Paul Bowen, and by HAICU. Research was

presented on workplace programmes currently used within companies in South Africa to further the students' understanding that successful HIV/Aids education is complex. The focus on students' understanding of their roles as future leaders within the industry was emphasised during the course. They were required to understand the socio-economic context of HIV and how this could affect the labour force. Discussions about innovation in programmes that made an impact demonstrated the application of the students' critical consciousness in HIV/Aids education and workplace programmes. Thus the emphasis on HIV/Aids was not so much on personal experience, but in the context of how it affects their peer-group and employees. This objectivity took personal pressure away from the participants. Students conducted research before choosing their presentation topics.

This further engagement with HIV/Aids career-specific content piqued the students' interest, and their self-motivation to learn more about how HIV/Aids affects the construction industries was evidenced in their research. The brief for the competition was: mandatory attendance at the lecture/workshop; selection of an HIV/Aids topic; completion of an on-line pre-assessment via the university intranet; and delivery of a 10-minute oral presentation adjudicated by a panel. Benefits from this module were a certificate of competence, information inserted into personal curriculum vitae, cash prizes for the top four presentations, video recording of presentations, and recognition of work by the EBE faculty at an awards ceremony.

Summated research was presented to their peers and adjudicated by panellists comprising the PCS course convenor, a guest examiner from industry and the HAICU project officer. Adjudication of the oral presentation was graded according to certain criteria which included using more than two sources in the research, showing consideration of the challenges faced by employers, understanding of the impact of HIV and benefits of workplace programmes, and giving current examples to support any claims made. Examples of topics were:

- Project Specific HIV/AIDS Programme – on-site support, awareness and treatment
- An HIV/AIDS Clinic in Gugulethu
- HIV/AIDS Task Force Package Research
- Aids Core Training Consultants

All the talks passed the criteria set by PCS and HAICU, with the winning pairs achieving over 75%. The post-course assessment was conducted through recorded discussion. The discussion was based on questions such as the usefulness of the workshop; the connection for the student between the theory and their findings; and what connections they had made between the HIV/Aids course content and their particular construction career path. On a personal level, they were asked if they had acquired new knowledge and/or skills during the research process and whether these skills were transferable beyond the university. Finally, they were asked how they would manage a workplace with people living with HIV/Aids. It was found that the content of the workshop connected with the student's discipline and career path as these responses indicate:

“Knowledge is power; I will do what I can to inform people.”

“Encourage family living environment so that the unit stays together and reduces prevalence of HIV.”

Thus these results demonstrated that the students had acquired a thorough understanding of basic treatment, health and safety in HIV-related matters and matters pertaining to management and industry.

CONCLUSIONS

The inquiry into infusing input on HIV/Aids into the core curricula of the Professional Communication course began in 2012 with a voluntary group. The expansion into a course with it being mandatory for all those students showed equal measures of success in terms of the quality of the input and student engagement, and the collaboration between HAICU and PCS. For HAICU, the objectives of increasing students' awareness to HIV/Aids through social and public health discourse were achieved. Overall the study and student evaluation showed that through integration of the topic into core curricula, the Construction, Economics and Management students were alerted to the importance and complexities of the subject for them as future managers in an industry which has a high incidence of the disease. The project closed with the intention that it continue to be rolled out in an integrated format to all students and in many disciplines within the University of Cape Town.

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TOWARDS AN UNDERSTANDING OF BUILDING ENERGY MANAGEMENT EDUCATION – USERS’ EXPECTATIONS OF A UK DISTANCE LEARNING COURSE

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Recent EU policy and UK governmental guidance highlight the need for improving building managers’ knowledge and competencies on energy issues in order to better manage the operation and use of buildings. Whereas scholarship on building energy management offers insights into potentially helpful tools and techniques for improving energy management practices, it focuses less on educational processes and methods. A study of a distance learning course as run by a professional institution, on building energy management reports on some of the students’, tutors’ and facilitators’ expectations and concerns. The analysis draws on documentary evidence of the course background and content as well as 12 semi structured interviews with different stakeholders. Preliminary findings point to some of the conflicting and competing approaches to what constitutes ‘building energy management’ and more importantly how knowledge on the topic is obtained, assessed and disseminated through distance learning. The contribution of this paper is threefold. First, the study reflects upon some of the conflicting opinions of distance learning curriculum design on emerging topics in evolving vocational fields such as energy management. Second, there are opportunities for developing and connecting knowledge on educational practices to the field of energy management in the built environment. Third, the findings offer valuable insights for a fast developing energy policy agenda in defining the role and responsibilities of future building energy managers in the UK and more widely.

Keywords: building energy management, built environment education, distance learning, energy policy.

INTRODUCTION

There has been growing policy and governmental pressure in the UK on the construction sector to improve practices associated with the operation and management of buildings, in particular associated with energy use (HM Government 2010). In addition, recent UK governmental reports call for improved skills and competencies building managers require in order to contribute to a ‘sustainable economy’ (HM Government 2011). Built environment education increasingly includes building energy management content within various undergraduate and postgraduate degree programmes, however, there is little discussion regarding pedagogical practice, approach or modes of learning on the topic (Gelengis and Harris 2014). Scholarship on the other hand engages with the issue through suggesting ways for improved energy management tools and techniques that building managers could implement into their existing practices (Costa *et al.* 2013; Haji and Lee 2005). While scholarship on

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building energy management offers insights into potentially helpful tools and techniques for improving energy management practices, it focuses less on educational processes and methods.

The purpose of this paper is to reflect upon some of the pedagogical issues for building energy management education by drawing on recent experiences of a distance learning short-course managed by a recognised professional institution. Building upon emerging research on educational practices associated with energy management and discussions in distance education scholarship, the paper examines the ways students and tutors discuss their expectations of 'energy management' distance education. Distance learning research argues that a greater appreciation of students' expectations would provide a better understanding of curriculum requirements (Baxter 2012; Stevenson *et al.* 2006). Yet, despite the high importance placed in pedagogical research on understanding expectations, the nature and potential of such expectations remains unclear in built environment education in general and energy management in particular.

In addition, most studies focus on students' expectations, overlooking the role of educators and course facilitators. Few studies examine the role educators' expectations have for instance on the content or mode or delivery of distance education particularly in the built environment context on developing topics such as energy management.

The authors examine students' and tutors' expectations of building energy management in a distance learning professional development course curriculum development. The analysis focuses on the content, mode of delivery and perceived competencies building energy managers need. The next section defines 'expectations' in the context of distance education and discusses recent research on building energy management education. The following section discusses the research methods, followed by an outline of key findings. The conclusion reflects upon some of the practical and analytical challenges educators and practitioners are faced with when teaching and working against conflicting expectations within industry and education on an increasingly important topic of building energy management.

LITERATURE REVIEW

Definitions of the term expectations in distance education literature are mainly taken from business and marketing research and are seen as "*desires or wants of consumers*" (Parasuraman *et al.* 1988). Within the distance learning education much of the research focuses on analysing expectations of students in order to best determine the gap between their initial expectations and the reality of the course (Gilroy *et al.* 2001). Scholars report on attributes that influence students expectations such as prior experience, interest in the chosen subject, perceptions of an institution and self-perception (Byrne and Flood 2005). Expectations are mainly studied in relation to a distance course mode of study (Baxter 2012) or quality of output (Gilroy *et al.* 2001) and relevance of curriculum. It is known that students hold variable expectations regarding distance education courses regarding the levels of service and support they will receive from their tutors for instance (Stevenson *et al.* 2006). Also, the cultural context within which a distance education system operates affects students' expectations and learning styles (Howland and Moore 2002; Morgan 2014).

Research in built environment education has largely failed to examine pedagogical aspects such as 'expectations' students might hold prior to embarking on a course

specifically related to the issue of curricula content or required competencies. Also, despite the growing number of distance and blended types of learning in the built environment, there is a lack of research examining the development of their curricula, pedagogical challenges or required student competencies (HM Government 2011). An emerging research agenda highlights the need to better understand the developing ‘expected’ roles and competencies of building managers as well as improved techniques and tools for improved energy management of buildings. However, discussions overlook educational needs or pedagogical techniques required to develop necessary competencies. Instead discussions emphasise the evolving nature of expected roles building managers are required to fulfil at various organisational levels (Aune *et al.* 2009). Building managers are expected to take up multiple overlapping roles at ‘strategic, tactical and operational’ levels of decision making in order that energy efficiency and wider sustainability measures can “*materialise*” (Elmualim *et al.* 2010). In addition to increasing multiple roles and related competencies, Shah (Shah 2007) emphasises the growing expectations regarding complex knowledge and skills building managers are required to possess in order to manage energy sustainably within buildings. The expectations suggested in the literature relate to changing industry and increasing regulatory demands. There is also a wider recognition of the lack of ‘professional’ recognition of the building management sector (Lawrence *et al.* 2012) currently seen as situated within varied organisational structures leading to potential difficulties in providing relevant education guidance.

The empirical study by Aune *et al.* (2009) report on increasingly complex tasks building managers are expected to entail as they “*mediate between end-users and technological systems in order to make “their” buildings energy efficient*”. Building managers are also expected to hold a broad knowledge base in order to fulfil the interchangeable role of “*administrators, service personnel and technicians*” regarding the energy efficient operation and management of buildings. Elmualim *et al.* (2010) discuss the consequent slow progress in uptake of sustainable facility management practice across organizations. Their research highlights the barriers to improving sustainable facility management practices including time constraints, lack of knowledge, growing complexity of required expertise and lack of senior management commitment. Their study concludes by suggesting that building managers have been historically undervalued contributing to the lack of initiative and wider sustainable investment in promoting better understanding of facilities management practice.

Solutions to improving practice and addressing some of the expectations regarding the required competencies of building managers’ are mainly seen in the development of new tools and technologies. A number of studies focus on new tools that would assist building energy managers in specifying, monitoring, analysing and optimising building and system performance. Costa *et al.* (2013) review current energy management approaches suggesting a novel integrated toolkit would enhance skills and knowledge. The toolkit is designed to assist energy managers at “*different stages of their activity relating to systematic energy management in buildings*”. Doukas *et al.* (2007) similarly present a decision support model using rule-sets based on a typical building energy management system.

However, few studies have examined empirically or theoretically how students and educators view learning, skills and knowledge on a relevant and important topic such as energy management for buildings. Although scholarship and policy have stressed the importance of gaining competencies, skills and knowledge on the topic, discussions have largely overlooked pedagogical issues that shape building energy

management. Instead, most discussions as reviewed above highlight barriers to wider professional recognition of building energy management and the need for improved tools and techniques to better current practices.

THE EMPIRICAL SETTING AND RESEARCH METHOD

The distance learning course 'Case T' has been administered and run jointly by two organisations in the UK (a higher educational institution and a professional industry institute) for over 10 years with a primary focus on energy management for buildings. The professional development course includes 14 learning elements covered over 18-24 months through flexible open distance learning. It is primarily targeted at building managers and facility operators with flexible learning viewed as a key aspect of the course delivery approach. Support is provided to students by a body of tutors who are not based at the higher institution but remotely. Throughout the duration of the course, facilitators periodically carried out surveys with students to assess their engagement and experience of the course. Recently, outcomes of surveys carried out by the course facilitators had revealed growing dissatisfaction with the structure and relevance of course material, which led to a review of programme content informed by research that sought to explore students and tutors expectations of the course.

The research design is based on a descriptive case study qualitative method (Bassey 1999) drawing on multiple data sources including documentary evidence and semi-structured interviews. Recent studies on understanding expectations of students in distance education call for qualitative approaches that provide a deeper and richer account of expectations in education settings. A recognition in the literature for the need for a greater qualitative input and more fine-grained analysis led to an approach utilising semi-structured questions allowing for detailed expression of student views, motivations and expectations (Fung and Carr 2000; Stevenson *et al.* 2006).

Qualitative information relating to something cognitive like expectations is viewed as a necessary compliment to aggregated statistical data. The approach in this study responds to this wider call drawing on sets of documentary evidence including course descriptions and specifications, informal discussions with course facilitators, course briefing guides as well as semi-structured interviews with students and tutors. With regards to interviews 25 participants were contacted; to date 12 interviews (out of which 4 were with tutors and 8 with students) lasting 30-45minutes have taken place.

The data was collated and analysed in NVivo initially using descriptive themes (Richards 2009). A theme captures something important about the data in relation to the research question and represents some level of patterned reasoning within the data set. The initial stage of the analysis focused on the identification of codes related to participants expectations of the course, views on mode of delivery, content and role of energy management. This coding resulted in initial descriptive codes from which 3 key themes were extracted around expectations on curriculum competencies, content and mode of delivery. The initial themes and subthemes are illustrated in Table 1.

FINDINGS

Initial findings show a set of student expectations primarily driven by career aspirations and a need to formalize existing knowledge and establish organisational roles. Tutor expectations on the other hand were characterised by career availability and a need to maintain and extend existing knowledge. Key aspects of the findings are discussed in detail below.

Table 1 Key themes regarding users' expectations of the course overall, mode of delivery and content

Expectations	Course overall	Mode of delivery	Course content	Future aspirations
Students	Formalising knowledge	Time (learning)management	Practice drivers	Management career aspiration
	Implementing learning	Personal contact throughout	Future competencies	Personal development
	Career enhancing	Additional learning	Personal relevance	
Tutors/facilitators	Transitioning career	Time (support) management	Theory makeup	Greater involvement in course curriculum
	Availability	Initial contact	Requirements communicated	
		Knowledge base		

Expectations regarding the course overall, content and mode of delivery (Student Participants)

Formalising knowledge

A number of student participants often discussed their expectations of the course through reflecting upon their career aspirations. In particular a number of students conveyed a sense of requiring status and recognition within their work place as an important aspect of undertaking and completing the course. For instance, one of the participants reflected upon the effect the course had on his standing within his firm:

"...it's helped to improve my standing within the department, sort of build my skill knowledge level and it's helped build respect amongst colleagues..." (Participant N)

Student participants also expressed a need to formalize existing knowledge in order to be able to implement novel ideas and energy management proposals within their workplace. A number of student participants discussed their current work activities that were not necessarily brought about through learning from the course but had been reaffirmed after the completion of the course. Participant R discussed her workload and application of energy management techniques regarding benchmarking. She suggested that although most of the knowledge on the topic of building energy management had not been necessarily gained through the course but reaffirmed, it enabled her to *"start to apply that and produce sustainability documents for a number of trusts"*.

Most students discussed their knowledge of energy management through their experience in their professional roles in work settings across diverse organisations from local authorities, telecoms, leisure and health industries. Knowledge on energy management issues was directly linked to students' engagement of work practice within their specific settings. One of the participants suggested that he *"had an idea of what energy management was...because he had been in the "role a couple of years before he started the course, so it reaffirmed more about it"*. He also suggested that although *"he hadn't touched on more of the industrial side of it"* because his background was in housing and therefore less applicable to his daily activities. A number of students also remarked that their thinking on energy management had not

been altered through participation on the course but provided motivation to progress further in their career:

“It didn't really change my thinking, it more motivated me as to which direction I wanted to take my career in, so it's made me realise what part of the course I found easier than the other parts and that's the areas where I would rather focus my work” (Participant U)

Overall most students approached the course as a way of furthering their career and gaining respect amongst their colleagues. Expectations regarding the course were strongly infused with career aspirations and formalising what is already known.

Time (learning) management

When discussing how the course was delivered (currently primarily as paper based rather than blended or internet based) students mainly referred to issues regarding availability of personal and professional time. In particular, a number of students remarked on needing to spend significantly more time than anticipated on the course. One participant discussed his need for personal time and difficulties with anticipating time management issues accurately:

“Obviously, it depends student to student and their abilities, but they guided 360 hours- I'd say I spent a lot more on it, to be honest with you...I was doing it in my own time, so I was doing a couple of hours two/three nights a week, so it's something you'd pick up and put down, so I would say there was more time involved” (Participant E)

In addition to personal time students also discussed difficulties of managing course requirements within their professional obligations and time at work. A participant reflected upon the need for support within the workplace as dependent upon the nature of the company whether in the public or private sector. He discussed his work as being within the public sector noting difficulties with ‘top management’ and the lack of a ‘supportive director’. Unless energy management was viewed as a priority area that required training and upskilling within the company it would be difficult to justify time spent on a course.

“... they still have not got that energy management savvy head on at the moment, it's more middle managers that have got the task of trying to reduce budgets and therefore we're looking at trying to reduce our budgets through electricity and gas reduction through sorting out their plant operations, you know, fitting it to their building occupancy. We tried, a number of times, in rolling out some energy management schemes, but again, unless the board approves it and are prepared to support you on it, then it is hard pushed” (Participant U)

Most students did not discuss expectations of the course mode of delivery as paper or internet based. Expectations regarding mode of delivery mainly led to reflections on time management and difficulties in planning time accurately and effectively.

Practice drivers

Students tended to describe their expectations of the course content in relation to their professional background. For many students energy management had become an issue encountered at work and many had previously worked in non-scientific contexts such as leisure or healthcare. One of the participants described his expectations of the course content being driven by his professional background in the fitness industry and his progression into a head office management position. His ‘disposition to deal with

data' meant that 'he was left to' deal with any energy management issues within the company.

Students also conveyed their expectations in relation to their geographical location often discussing the course content in relation to their national background. One of the students discussed the specific conditions within Seychelles noting how:

"...daylight hours are the same all year round, the temperature's about the same all year round and he's having a bit of difficulty trying to establish any ways of saving energy because they don't use much" (Participant E)

Expectations regarding the course overall, mode of delivery and content (Tutor Participants)

Transitioning career

Tutors discussed expectations of the course through reflecting upon their career over time and in particular transitions from industry to teaching. A number of tutors described their experience of industry as evolving around issues of energy and the environment in various ways. Upon reaching the end of their career many chose the part-time flexible tutorial role within the course as an extension of their career.

"Then, after university - 1964 I graduated - I went back to the research laboratory, where I spent 20 years and I was dealing with...I think I mentioned in that letter, with fuel, energy and the environment. And after that, when I was the age of 40, I decided that the fuel industry had finished in Britain and I took redundancy and had a complete career change" (Participant B)

One of the tutors reflected upon their career in a major power company over 30 years as enabling the expertise needed for a tutorial role on a course. He had chosen to develop into a teaching role mainly in order to maintain his knowledge of the energy field. In particular many tutors discussed the need to 'remain in contact in the energy field' and not lose connections and knowledge built up over many years as a key expectation of the course overall. Many tutors when asked about any perceptions of education support expectations they may have had conveyed a sense of openness and flexibility in providing 'whatever level of support was required'.

"I didn't know what to expect...I was prepared for anything really" (Participant S)

Time (support) management

Tutors conveyed their expectations of the course mode of delivery through discussing difficulties in managing different levels of required support for students. Although many tutors (as above) discussed being prepared for providing any level of support many discussed difficulties in managing diverse capabilities within students. One of the tutors discussed the importance of making knowledge available to students at an early stage and relying on industry experience to provide adequate support.

"So, having had some experience of doing it, I would go back and give real world comments, people had queries and questions as to what, why, how...well, we do these things because in various ways, so I was trying to give a rather truly academic input, which is fine, but does have its limitations if you have a real world aspect to it" (Participant PM)

In addition to difficulties in managing time and support effectively tutors discussed the need to manage students' expectations better. One of the tutors reflected upon his

experience of a student who had recently undertaken the course coming from an accounting background.

“She works in accounts and was given the job of dealing with all the energy accounts so she wanted to know more about energy...but the theory floored her” (Participant S)

Tutor S discussed in detail his experience of managing expectations the student (discussed above) had of the course not anticipating the mathematical content and focus on physics.

Theory make-up

Tutors discussed their expectations regarding the course content through recalling their industry experience. In particular a number of tutors discussed the need for theory within the course as dependent on students particular work activity needs. One of the tutors reflected upon a students' experience of the course who *“decided to set up on his own as an energy consultant and he did very well”* without relying on the theoretical aspect of the course. Tutors also recalled their own experience in industry.

“So, some basic energy savings are absolutely obvious, so no, you don't need the theory, the theory's useful, don't get me wrong, the theory is very useful and some of the calculations that we're asked to do in the assignment are relevant, but no, the is a bit overpowering for most people” (Participant S)

DISCUSSION AND CONCLUDING COMMENTARY

Although the focus of this study has been on a single distance learning course in the UK, there are some helpful insights for educational studies of building energy management more broadly. Through drawing on distance learning literature and highlighting 'expectations' as a parameter by which to explore how users approach a course, a number of valuable observations are reflected upon regarding the course overall, its mode of delivery and the course content.

First, students studying building energy management are often located in diverse professional settings from health to local authority, to leisure and energy brokering. The diverse professional backgrounds have varying effects on how students approach the course content from a focus on organisational hierarchies to an emphasis on operational issues.

Second, most students approach the course overall through being motivated by a need to formalise knowledge and enhance professional status. Formalizing knowledge is primarily approached through enhancing and applying existing skills rather than expecting to learn anything novel. Tutors on the other hand approach the course overall as a way to interact with a well-known subject and maintain knowledge built up through many years working in the energy sector. For many tutors prolonged experience of professional settings in industry have led to an educational role and engagement with learning as a way of maintaining interest and expertise in energy management issues. Few participants conveyed the expectation to learn anything novel or a need to extend knowledge as discussed in the distance learning literature.

Regarding the course content it can be observed that most students approach and discuss their expectations of the course content in relation to their workplace or geographical location. While students focus on the nature of their work daily activities in relation to course content requirements, most tutors approach the course content as a way of extending and building knowledge. Also, with regards to the course mode of

delivery most students discuss issues of time management as a personal or professional issue highlighting difficulties in anticipating and planning appropriate time to complete course tasks. Tutors on the other hand approach the course mode of delivery through issue of time management as different levels of support, often emphasising limitations in their ability to correctly anticipate sufficient support that students might need.

In addition to differences in discussing expectations of the course, participants overall conveyed varying understandings of energy management itself as either an operational, strategic or individual issue often dependant on the nature of the organisation they worked in. Scholars have discussed the need to better understand the role building managers play at different organisational levels in order to advance a firm's sustainability agenda emphasising the need to retrain and upskill (Morgan 2014). However, there is a lack of research exploring the requirements, needs and expectations regarding the educational aspects of energy management. The challenge for educational institutions is to provide tailored content appropriate for diverse range of professional backgrounds, size and nature of organisations within public and/or private sectors taking account of the complex nature professional expectation of a course have. The course is primarily approached as a way to either formalise or maintain knowledge rather than develop novel learning. Potential ways to develop the course through increased practical learning and situated problem solving within multiple organisational settings are being considered.

Future studies would benefit from further explorations of students expectations in particular across diverse organisations in order to better understand how competencies and skills are approached within varied sectors. In addition more empirical research is required to extend insights into definitional requirements for the education of building energy management particularly through flexible distance and part time learning routes.

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ASSESSMENT FEEDBACK TO ENHANCE STUDENT DEVELOPMENT AS EFFECTIVE CONSTRUCTION INDUSTRY PRACTITIONERS

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Assessment feedback has been identified as playing a key role in enhancing student learning and academic success, and effective feedback can also promote self-regulating learners which in turn translates to more effective practitioners. There is a considerable amount of literature concerning assessment feedback, however most of the research is generic and does not focus on the needs of particular academic disciplines, nor of relevant professional practice. For built environment students, assessment feedback can strengthen links between academic learning and professional practice, supporting the development of effective construction industry practitioners. To evaluate assessment feedback within this context, a study focusing on links between assessment feedback and professional practice is being undertaken. Early findings are presented here, based on content analysis of assessment feedback on submitted assignments. Data was analysed using a numeric approach, recording frequency of key words. Findings suggest there is scope to enhance practice via the use of revised documents and thus enhance the student learning experience as well as promoting deep learning and development of reflective practitioners. This preliminary study indicates the need to re-consider wording of key documents provided to students.

Keywords: assessment, feedback, professional practice.

INTRODUCTION

Assessment feedback to students has been recognised as a valuable device to enhance student learning (Sadler 1998; Prosser and Trigwell 1999; Hyatt 2005; Hattie and Timperley 2007; Giles, Gilbert and McNeill 2014). For built environment students, assessment feedback can also strengthen links between academic learning and professional practice, supporting the development of effective construction industry practitioners. To evaluate assessment feedback within this context, a doctoral study focusing on links between assessment feedback and professional practice is being undertaken. The study is concerned with assessment feedback as a key device to enhance links between academic learning and professional practice, and which turn contribute to students' professional development as effective industry practitioners. If used in this way, feedback has potential to enhance learning by closing the loop of course design, assessment, student performance and professional practice. It also may be perceived as enhancing the value of feedback for students on professionally recognised courses.

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The number of undergraduate students in higher education in the UK has expanded considerably over recent years. One important rationale for and benefit of this expansion is economic growth (De Meulemeester and Rochat 1995), as it is recognised that skills developed in higher education are important contributors to a healthy economy (Leitch 2006; Smith *et al.* 2012). However, the UK higher education system has evolved from being elite to a mass system, one of low-cost high-quality provision (Salmi 2011). The challenge now for Higher Education Institutions (HEIs) is to provide a high-quality teaching and learning environment, and for professionally recognised courses such as construction management to develop students as effective industry practitioners.

Undergraduate courses have Learning Outcomes that identify knowledge and skills it is intended that students develop, and assessment is designed around Learning Outcomes. Early findings of this study indicate assessment feedback may be a weak link in the assessment process. Biggs (1996) coined the term ‘constructive alignment’ whereby learning activities and assessment align with Learning Outcomes: this paper proposes that assessment feedback should be considered integral to constructive alignment. Such feedback would represent an important opportunity to enhance students’ development as effective practitioners, providing direction and guidance. At this time of national economic stringency and debate surrounding the cost and funding of higher education (Tatlow and Conlon 2013), efficiently providing a high quality teaching and learning environment that supports students’ academic and professional development is more important than ever, and enhanced use of assessment feedback has the potential to add value to the student experience and support development of industry practitioners.

This paper is based on the preliminary work of a doctorate that is currently in progress. The main study intends to develop the data gathering and analysis, and include exploration of qualitative aspects of this topic.

THEORETICAL PERSPECTIVES

The nature and value of assessment feedback

Assessment is often considered “*a form of testing or evaluation*” (Sambell, McDowell and Montgomery 2013: 3) with feedback to encourage learning (Hernández 2012). In a construction management discipline assessment is frequently designed around professional practice, which may be regarded as an important part of the context the tutor creates (Proser and Trigwell 1999) and is important for learning. Although the student learns, the tutor plays a central role in creating and maintaining a suitable environment to promote learning; assessment and assessment feedback are central to this environment. Black and William (1998) found a positive impact of effective assessment, designed to facilitate learning.

Assessment feedback “*includes all feedback exchanges generated within assessment design, occurring within and beyond the immediate learning context, being overt or covert (actively and/or passively sought and/or received), and importantly, drawing from a range of sources*” (Evans 2013: 71). Feedback as an exchange suggests a two-way dialogue. It is important both parties share a common understanding of such dialogues, and how they may benefit the student. To be effective, assessment feedback should be read and acted upon by students, timely and help students improve their learning (Higher Education Academy 2013). Feedback should be integral to the learning process, regarded as being linked with improvement (Sambell, McDowell

and Montgomery 2013) and enhance the learning experience (Shute 2008). Positive feedback is that which helps learning (Askew and Lodge 2000). This paper suggests that feedback should also encourage students' development as effective practitioners.

“Written feedback plays an important pedagogic role” (Hyatt 2005: 351) and is *“part of the teaching process”* (Hattie and Timperley 2007: 82). Quality Assurance Agency (2012) identify assessment feedback as playing a fundamental part in promoting learning. In order to add value and aid student learning feedback needs to be of high quality (Sadler 1998). Eraut (2004: 803) develops this further asserting *“the most important factor in learning is usually the quality of the feedback on performance.”* A learning environment where assessment feedback promotes learning is integral to the student learning experience.

The nature of feedback students receive is important in shaping its efficacy (Hattie and Timperley 2007). It is important to recognise that dialogue is central to valuable feedback, and should encourage the learner to take a qualitative approach to learning, which is encouraged by a *“student-focused approach to teaching”* (Prosser and Trigwell 1999: 68). Feedback is one means by which tutors can encourage learners to engage with actively learning for themselves. Cramp (2011) argues the benefit of first year personal tutorials to discuss and develop the use of individual feedback. This could potentially encourage students to link their learning experiences as they progress through their course and make good use of feedback, making connections between subjects and taking forward their feedback. This reflective activity would also provide an opportunity to explore professional practice issues. As Kolb (1984) acknowledges, reflective observation is an important part of student learning. Reflection is important both for the enhancement of student learning and also reflective practitioners, which in turn is essential for students' development as effective practitioners.

It is worth noting that feedback does not automatically lead to enhanced performance. This may be because the learner does not act on feedback they receive: possible reasons including lack of student application, lack of knowledge about the next steps required or not understanding the feedback. If the feedback is too remote from professional practice, students may feel that it is not relevant to their work. Alternatively, feedback indicating good performance can subsequently lead to reduced performance if the learner becomes complacent (Kluger and DeNisi 1998). To aid students to use feedback effectively, students need information to help them understand the value of feedback and how to use it well (Entwistle 2009).

Many students do not use their feedback and lack of knowledge as to how to do this is a key reason (Jonsson 2013), which suggests potentially the dialogue aspect of feedback may be under-used as a teaching device, and students may benefit from information and discussion regarding how to use feedback. It is important that tutors are assessment literate and understand *“how to gather dependable evidence of student achievement and use the assessment process and its results either to support or to certify student achievement depending on the context”* (Stiggins 2014: 67). But it is also important that tutors are able to assess and provide feedback to develop students academically and also address their professional practice.

Factors impinging on student learning

Assessment influences student learning behaviour (Boud and Falchikov 2007) and so assessment literacy of academic staff is of *“paramount”* importance (Ball *et al.* 2012: 17). Assessment literacy is concerned with achievement targets in the areas of i)

subject knowledge, ii) demonstration of thinking skills, iii) behaviour exhibited, and iv) products created, and assessment should direct students to a clear achievement target (Stiggins 1991). In a built environment discipline assessment often is around real-world professional practice scenarios, which is the focus of student learning.

Assessment feedback is one part of the learning process. Lublin (2003) argues that teaching has become facilitation and tutors facilitators. As such, the role of assessment feedback is increasingly important as part of this facilitation to aid student learning. Ball *et al.* (2012) recognise feedback contributes to student learning, and that students should be involved with the feedback process, for example by monitoring and reflecting on their own progress. However, feedback may be linked to assessment criteria or mark scheme rather than to the learning process (Hughes 2011). This reinforces the importance of constructive alignment for student learning and the value of assessment feedback as integral to this. Unfortunately mark schemes and professional practice are often little used in literature, for example see Quality Assurance Agency (2012).

In summary, the examination of the literature thus far has revealed that there appear to be key essential elements of model feedback on student assessment. These elements are required to aid student learning and help their future academic and professional development, and are shown below.

From the student:

- An element of self-assessment before and self-reflection after the assessment submission. This enables the student to take ownership of their performance.

From the tutor:

- Feedback on the student's performance compared to what is expected and linked with Learning Outcomes;
- Feedback on progress made in comparison to the mark scheme;
- Feedforward on what the student should work on and improve for their future learning; and
- Professional practice issues and how these link to the student's work.

If any of these elements in the model are missing, it is likely that the student may not be able to gain the maximum from the experience to enhance their learning.

METHOD

The goal of this preliminary research was to explore assessment feedback provided to undergraduate students in a built environment discipline and feedback on students marked coursework was analysed. It was felt that "*unobtrusive measures*" (Gray 2014: 498) were valuable as it was important to maintain discretion and anonymity. Such data has the advantage of being independent of the researcher. In this preliminary study, feedback on mark-bearing assessed coursework was used.

The sample used was one of convenience, comprising $n = 43$ items of assessed coursework that had been submitted by $n = 31$ students. This had been marked and feedback provided on scripts and mark-sheets, but had not been collected from the returns office within the required timescale, and would otherwise have been destroyed. Students could not return collected courseworks to the returns office for

any reason. Coursework items ranged across all undergraduate levels of study. The reason for using these particular items of coursework was to avoid delaying return of work to students. A level of 'quality' within this sample was assured as the external examiners for all of the courses from which the sample assessments were gathered had acknowledged that 'good feedback' had been provided for students in terms of quality and quantity. External examiners raised no issues regarding quality of feedback provided and one examiner identified feedback provided as an example of good practice.

The sample was not random, in the sense that it was not taken from the complete number of all submitted coursework. However, there is no reason to believe that this form of sampling would have led to any serious bias - that is that the work left uncollected would have received feedback that differed significantly from that collected by other students. Nevertheless, the ability to generalise from these samples is limited as the sample size is small (Gray 2014).

In order to explore the feedback provided, content analysis (Tonkiss 2004) was undertaken of the sample assessments. Three areas of interest were explored: Learning Outcomes, marking schemes and professional practice. Explicit reference to the phraseology was required, to ensure there would be no ambiguity regarding the tutors intent in this respect and that students would have had the opportunity to recognise these aspects within the feedback.

The three elements - reference to Learning Outcomes, mark scheme and professional practice - were chosen as it was felt that these should each be central to undergraduate learning and assessment in professionally recognised built environment courses. Learning Outcomes are the bedrock of undergraduate courses, mapping intended learning. Assessment should be designed around this intended learning with mark schemes designed accordingly to develop appropriate skills or knowledge in students. Reference to Learning Outcomes or mark scheme were clearly either present or not, and there was no ambiguity here in the data gathered. However, reference in feedback to professional practice could have been more nuanced. The analysis searched for phrases such as "*in the workplace*" or "*in practice*" throughout the narrative. If a reference to professional practice was too opaque for the researcher to register then it is highly unlikely students would have appreciated it. Professional practice is at the heart of built environment courses, which are designed to accommodate demands of relevant professional practice activities and requirements of professional bodies. External examiners are alert to assessment briefs delivering this, and their annual reports suggest they are satisfied this is achieved. Teaching, learning outcomes and assessment should be constructively aligned (Biggs 1996). Including reference to professional practice in feedback has potential to alert students to the importance of this and shape the direction of their learning.

There are limitations of this study. First, content analysis is arguably limited in its approach and the depth of analysis that can be undertaken. Second, the sample used will have constrained the study, being limited in size and that it was not a truly random sampling technique. There is no analysis by subject or level, nor consideration of student or tutors perspectives, as it is intended to examine these later in the research, although it is recognised that there are many constraints and pressures for the actors involved. However, it is suggested that this approach does not lead to any significant bias and is suitable for the early stage of this research. The analysis is able to provide initial insights into the aspects of feedback considered in this paper,

and therefore begin to set out relevant directions and structure for the future research proposed in this area.

FINDINGS AND DISCUSSION

The feedback provided encouragement and direction for students to consider their work, its strengths and failings which if remedied would enhance the work. Staff generally provided both annotated comments written on the text of students' work and also prose regarding the generalities of the work. This research was concerned with particular aspects of the feedback, not all of it.

Reference to Learning Outcomes

First, the number of items of coursework where the feedback explicitly made reference to Learning Outcomes was counted. The number of items of marked work that included Learning Outcomes in the feedback was ten (23%). Of these, one item (2% of the total) made explicit reference to Learning Outcomes with a narrative regarding the coursework vis-à-vis Learning Outcomes. The remaining nine items (21% of the total) allocated a mark or grade against achievement of each Learning Outcome so that students could understand how they had fared in that area, but did not provide detailed feedback that could be used to improve achievement against the Learning Outcomes.

Reference to the mark scheme

Second, the number of items of coursework where the feedback made explicit reference to the mark scheme was counted. Thirteen items (30%) made explicit reference to the mark scheme. All modules have a mark scheme or mark criteria contained in the module guide, a copy of which is provided to students at the start of each module delivery. This suggests opportunity to enhance feedback provided with reference to the mark scheme in order to help students understand clearly why they have achieved their mark, the level of their performance and what they may do differently in future to achieve a higher level of attainment.

Reference to professional practice

Third, the number of items that explicitly linked academic work with professional practice was counted. No items explicitly or implicitly made a connection between academic work and professional practice in the assessment feedback. Findings in this section of the work were surprising, as many of the coursework briefs were designed explicitly around professional practice scenarios, frequently assessing skills and knowledge that would be needed in professional practice. This suggests there is opportunity to enhance links between academic study and professional practice, developing student learning as well as developing students as effective industry practitioners. If the link is not made explicit then for students the meaning and application may be more difficult for them to appreciate or understand. Students may have to make links between professional practice and academic learning for themselves. It is not fully understood regarding the extent to which students make such links, but will be explored in a subsequent phase of this research.

Discussion

Assessment is central to student learning and feedback is a device to enhance learning. Student involvement with learning is encouraged by teaching methods, Learning Outcomes and assessment being constructively aligned (Biggs 1996). However, findings from this study suggest that such constructive alignment does not always

embrace feedback to students and thus complete the loop. Using feedback to enhance the learning loop of constructive alignment may be under-used yet represents an opportunity to enhance undergraduate learning, potentially enhance the student experience and most importantly encourage development of professional practice knowledge and skills in students as effective construction industry practitioners. As Walton (2011) observes, constructive alignment influences the quality of learning. In the current economic downturn, findings of the study suggest scope to enhance the student experience and learning at little or no additional cost.

Assessment feedback is a potential means to enhance undergraduate students' development and learning as effective professional practitioners. There is scope to enhance feedback practice, to re-consider assessments and mark schemes, and to re-consider the links between Learning Outcomes, assessment, mark scheme, professional practice and assessment feedback. In turn this may enhance the student learning experience as well as promote deep learning and development of reflective practitioners. However, currently there is under-use of feedback as a device to enhance learning. It is not fully understood how feedback may be used to promote students achievement of Learning Outcomes and develop their skills as reflective practitioners. This work has assumed that feedback which signposts Learning Outcomes, mark scheme and professional practice is beneficial for built environment students learning. Professional bodies are concerned professional skills and knowledge are developed in those who wish to join them, and these are reflected in course design. Using assessment feedback to help develop these skills in students aids the industry as well as forming part of constructive alignment. In view of students at most HEIs continued evaluation of feedback as being a weak part of their learning experience, this is an area worth exploring. Further, it may be that revised documents to signpost Learning Outcomes, mark scheme and professional practice would encourage students focus on these aspects of their learning. Encouraging constructive alignment of assessment and feedback with professional practice may enable students to become more aware of the knowledge and skills needed to develop this and links with academic work.

Although surprising, these findings must be treated with caution owing to the small sample size and limited analysis. However they do suggest the need for further research to explore this issue in depth. These findings structure future research towards further investigation regarding the nature of the feedback provided and perspectives of the actors. Investigating actors' perspectives of feedback and exploring the potential of feedback to explicitly link Learning Outcomes, mark scheme and professional practice with learning and development of students as reflective practitioners will require an in-depth qualitative approach. Future work in this study intends to develop the data gathering and analysis to explore qualitative dimensions of the issue under investigation. This will be an exploration of the social world as "*the subjective experience of individuals*" (Cohen and Manion 1994: 8). The object is to gain an in-depth understanding of human behaviour, of both students and tutors. The world is regarded as "*socially constructed and subjective*" (Amaratunga *et al.* 2002: 19). Exploring this subjective world, within which student learning takes place, will illuminate how students and tutors interpret and engage with the issues around feedback and professional practice. This will be important in the research as assessment feedback is a human experience and needs to be examined in this light.

CONCLUSIONS

Effective practitioners are important for the industry to promote an efficient and productive service for clients. Additionally, effective practitioners make a positive contribution to team performance and should be reflective, able to develop their own professional practice and career enhancement. Providing opportunities to develop these qualities should be encouraged through enhanced feedback.

Although this study identified potential scope to enhance learning opportunities and to provide more powerful support for students' development as effective practitioners, results suggest that feedback does not always offer such support. Whilst professional practice informs course design, and in particular Learning Outcomes for modules, neither Learning Outcomes nor professional practice were routinely evident in the feedback examined in this initial study. Effective feedback needs to be linked more clearly with Learning Outcomes and professional practice in order to support student development as effective practitioners.

Constructive alignment is identified as important in the provision of an effective learning experience for students, and this research explores the value of assessment feedback as part of that provision. Developing students as effective practitioners as well as developing their academic rigour is valuable both for students, their employers and society by enhancing firms' efficiency and contributing to a healthy economy.

Feedback practice that is effective in developing and reinforcing professional practice should be based on:

- Explicit linkage between Learning Outcomes and professional practice;
- Use of or reference to Learning Outcomes in providing feedback on assessment; and
- Reference to professional practice in feedback narrative.

These findings structure the next phase of this research towards investigating the qualitative dimension of feedback, tutors perspectives and interpretations of feedback held by students on professionally recognised courses.

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NEGOTIATION AND CONFLICT MANAGEMENT

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FORMAL EDUCATION AND THE PRACTISE OF NEGOTIATION: BENEFITS FOR QUANTITY SURVEYORS

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Negotiation is the most common alternative dispute resolution processes used in the construction industry. It is cost effective and quicker than most of the other dispute resolution processes and the Quantity Surveyor is a core participant in that process. The main aims of this research were critically to analyse the negotiation styles used by Quantity Surveyors and the level of consciousness the QSs had on the negotiation styles they used. A quantitative study was undertaken using an online questionnaire survey to generate the research primary data. A total of 30 respondents, all QSs from consultant practices or contracting organizations with formal or no formal educational backgrounds, were involved in the survey. The findings indicated that three negotiation styles were most frequently used: collaboration, problem solving and compromise. The findings also indicated that QSs were not often conscious of the negotiation styles they used, but still showed that those with a background in formal education exhibited better awareness of these styles. The research concluded that formal education was seen as a worthwhile initiative for the improvement of the way Quantity Surveyors negotiate.

Keywords: formal education, negotiation styles, quantity surveyors.

INTRODUCTION

There is an increase in demand for the use of negotiation as a method of conflict resolution in the construction industry due to the increase in conflicts caused by the complexity of construction projects and also the need to prevent conflicts from escalating to the expensive legal resolution process (Patton, 1999). Whilst lawyers are provided with adequate formal education on negotiation as a core module during their tertiary education, Quantity Surveyors whose role involves carrying out negotiations in the construction industry are not so provided.

According to Hampson *et al* (2001), negotiation is a discussion aimed at reaching an agreement. It is a method used to resolve conflicts in the construction industry ranging from claims to disputes and other forms of problems between parties that are bound by a legal contract. According to Ren and Anumba (2003), formal education may be able to improve the ability of practitioners to perform new tasks that they could not perform before, or to perform old tasks better. It can thus be argued that improving the methods in the way practitioners learn to negotiate may help them reach more successful outcomes.

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One aspect of negotiation skills that can be learned is the 'negotiation style' and this is the term used to describe the approach applied during negotiations (Corvette, 2007). The negotiation style can also be associated with the manner of delivery and attitude adopted, including the negotiator's behaviour or demeanour (Taylor, 2006).

Negotiation style is the way the negotiator plans to interact with his opponent and this usually involves the way he exchanges information, makes and seeks concessions, as well as the overall strategy used to achieve his goals and objectives (Taylor, 2006).

Although it has been found that the strategic negotiation behaviour is complex and varies from one person to the other, there have been strategic patterns or styles that have been most frequently identified (Taylor, 2006). According to Yiu *et al* (2008) the styles used by the negotiators are linked to the overall outcome of the dispute.

Corvette (2007) further stated that while it is believed that the various negotiation styles are already being applied in current negotiation practice, there is a gap in knowledge that does not tell if formal education could improve the practise of negotiation and the overall understanding of the negotiation process for Quantity Surveyors in the construction industry.

Law Schools and Business Schools have long incorporated negotiation courses as a core module because it is believed that negotiation courses provide students with a detailed overview of the use of negotiation, its impact on society and the role lawyers play during a negotiation. In addition, there is a set goal for all students or professionals wanting to become qualified lawyers to acquire knowledge about the theoretical and practical aspects of negotiation to develop the student's effectiveness and competence in negotiation skills/approach.

In today's construction industry the Quantity Surveyor is engaged almost on a daily basis in dealing with claims and disputes emanating from different sources, such as contractual, behavioural or technical issues. Therefore it can be said that QSs, just like lawyers, are engaged in settling conflicts as part of their core roles, but lawyers are provided with formal training in negotiation styles whereas Quantity Surveying academic curricula do not include a core module (i.e. stand-alone module) on negotiation (as noted following a review of the course structures for Quantity Surveying programmes currently being run by Glasgow Caledonian University, London South Bank University, Nottingham Trent University and a host of other established tertiary institutions). Although this research does not seek to specifically evaluate why the current situation exists in these tertiary institutions, it will focus on the extent the introduction of negotiation would have an influence on the way the QS negotiates.

Another issue that will be reviewed in this research concerns the styles used in negotiation by QSs. Positional bargaining (competitive negotiation style) is believed to be the most common style practised by the majority of practitioners where the negotiator will manipulate his opponent to achieve the best possible deal or outcome for his organisation or company. This form of bargaining involves taking and justifying concrete positions and resisting concessions (Patton, 1999). This style of negotiation may be seen as one of the reasons why conflicts in the construction industry may often escalate to the more expensive litigation or arbitration stage. Most negotiation curricula taught within tertiary institutions mainly concentrates on mutual gains bargaining. The training is aimed at improving the styles used by practitioners from a more adversarial style to a more cooperative or problem-solving (Wheeler, 2000).

According to Patton (1999) an academic practitioner, John Dunlop, stated that there is no articulated theory for negotiation, hence there are no possible ways of learning negotiation except through experience. He then further states that it is just common sense and you either you have it or you do not (Patton, 1999). Some others believe that negotiation is a skill that could be influenced mainly by practical, or to some extent, prescriptive theory rather than descriptive theory as there are no right answers to questions like ‘who should make the first offer?’ (Lewicki, 1999). Others practitioners feel that the negotiation programme for formal education institutions may be streamlined in such a way that the competencies could become narrowed to certain standards, and this could threaten the methods already being used by experienced negotiators in the industry.

Previous studies have stated that negotiation has been made a compulsory core module for law and business students in order to improve their overall competencies in this area. Lewicki (1999) stated that negotiation courses have been enjoyed in business schools because students have been largely involved in role plays, simulations, theory and discussions where the experiences are remembered long into the future and applied in practice on the job. These law and business courses on negotiation have been found to satisfy the needs of students both skilfully and theoretically therefore adding significant value to the practice of negotiation (Lewicki, 1999).

Negotiating Styles

According to Corvette (2007) there are five ways to deal with conflicts and these are: avoidance, integration, collaboration, compromise and competition.

Avoidance is a style of negotiation that involves the practitioner failing to engage with his opponent or ignoring the existence of the conflict in its totality (Corvette, 2007). Avoidance could be total or partial. Partial would be when there is the intent to negotiate but not completely aiming at resolving the actual substance of the current conflict. This overall approach ignores the potential for both parties to come to a common understanding and mutual benefits and this style is associated with some common behaviours such as sulking, making sarcastic comments and hiding ones thoughts (Craver, 2000). The outcome of this style is “lose / lose” to both parties (Corvette, 2007).

The competitive style, also referred to as an adversarial or domineering style of negotiation, is a win/lose style of approach to negotiation (Taylor, 2006). The behaviour associated with this style is when the negotiator refuses to back down, uses power-over tactics and exhibits negative behaviour which includes being tricky and self-centred. The style is based on one party seeking to maximise his own gains by taking a strong stance with the aim of making his opponent succumb to his demands.

The compromising or accommodating style occurs when a negotiator gives up some part of his gains just to arrive at a middle ground with the opponent. The aim of this style is to meet some of the needs of his opponent as well as maintain his own. This style falls under the category of a win/win and also a lose/win situation where one party’s gain is not completely achieved at the pain of another party.

The collaborative or co-operative style can be categorised under the win/win approach where, unlike the compromise style, the parties find ways to get what they both want without any pain. This method requires a lot of creativity in order to meet both parties’ desires (Corvette, 2007). This style can also be referred to as soft or cordial bargaining

style where both parties create an open, trusting atmosphere by making concessions and sharing valuable information.

Integrating or problem solving is when both parties decide jointly to identify the needs and objectives of both parties with the aim of creating a solution that meets the needs of the parties. The negotiators will endeavour to understand the shared, compatibility and the potential conflicting interests of both parties with the aim of distributing all resources to solve the problem and this could fall into the what can be distributed, to whom, when, how and how much.

Negotiating Outcomes

Negotiating outcomes may be categorized under seven major possibilities: problem solved, conflict escalation, relationship deterioration, inaction, further disagreement, relationship maintained, and conflict reduction (Cheung *et al*, 2006)

Problem solving, conflict reducing and relationship maintaining are the desirable outcomes for all parties in a dispute because they reach a positive agreement and the needs of all parties are met so this situation can be categorized as a functional negotiation outcome whilst further disagreement, conflict escalation, inaction and relationship deterioration may result in more conflict even at a higher level than the initial situation and can be categorized as a dysfunctional negotiation outcome and this is usually undesirable for the parties involved.

According to Stark and Flaherty (2003) a successful negotiator has an understanding of the subject of negotiation and also a strong knowledge of the negotiation practice. Most negotiators do not value the impact negotiation styles have on their negotiation. Most negotiators use the same approach and are surprised when they do not continue to succeed.

In order to avoid being in deadlock situations the negotiator needs to be flexible with their negotiation styles because using the same style frequently can create situations where both negotiators are bound to lose. Therefore, successful negotiators change their approach and styles to suit the situations created in the negotiation process by their counter parts (Buell, 2011).

Research Methodology

The research involved finding out the possible influence of formal education on negotiation practice of Quantity Surveyors in the construction industry through the test of selected variables and concepts to develop a new conclusion. The research developed literature about the contents of formal education and then tested their influence rigorously through the respondents. The research also involved the investigation of respondents on the type of negotiation styles they used during negotiations. The research approach was, therefore, a mixed approach where the research tested some existing literature to find its validity as well as investigate to find out new information that could lead to new theories. Having carefully considered both Case Study and Semi-structured Interview approaches it was decided that, whilst recognising the richness of the data provided by these research methods, a survey would deliver the opinions of very many more surveyors and, therefore, be more representative and valid.

Primary data was collected using online web survey. The online questionnaire contained standardised questions that were simple and focused, and these questions can be interpreted similarly by all respondents. The questions were distributed across

the three data type of variables: opinion, attitudinal and behavioural questions. The questionnaire technique was selected because it allowed the collection of quantitative data which can be analysed using inferential statistics. Using the online survey method allowed control over managing the data collection process. This online questionnaire method also provided an easy medium to reach the respondents who were scattered all over the UK. The rating scale was implemented in the questionnaire to narrow down the complexity of respondents' answers to prevent them from being out of scope and distorted. The Survey Monkey software had already been predesigned through its developers to help the collection and analysis of data, although the data received was further analysed through the use of Excel software.

The research population was practising Quantity Surveyors in the construction industry in UK. However, online questionnaires could not be sent to all of them and, therefore, a sample was created. The sampling techniques utilised was the Probability sampling. This technique was used because the probability sampling technique is best used where the research strategy involves the use of surveys and the researcher needs to make inferences from the selected population to answer the research objectives.

Simple random sampling is one the several types of probability sampling where all the individuals or units within this sample have the same probability of being utilized for the research. The suitable number of respondents required for this research is 30-50 but the overall sample frame was a total of 180 practising Quantity surveyors, most of them drawn from a directory of Quantity Surveying firms and the RICS website. The selected participants were collated from the sample frame into the SurveyMonkey software and the questionnaires were sent via email automatically. This method has been found to be reliable as the survey is sent directly to the respondent's email where she/he would be the only person that has access to it. The online survey is also time-friendly as the responses are recorded as soon as the respondents makes them and the time taken to complete the questionnaire is seven minutes which helps to enhance the overall process. The total response received was 30 out of 180 participants contacted and 47 emails came back as ineligible and unreadable. The analysis was, therefore, based on the 30 responses received, which is statistically a small sample size. It is recognised that conclusions drawn from this sample have limited importance and the survey is, therefore, regarded as a pilot study only.

Findings

The total number of respondents to the survey questionnaire was 30, of which 27% had formal education in negotiation and 73% had none. Some 50% of the respondents were consultant surveyors in private practice, 36% were contractor's or sub-contractor's surveyors, 7% were client surveyors and 7% were others. The split between private Qs and contractor's Qs was, therefore, roughly two thirds/one third. It was found that 44% of respondents were engaged in negotiations 1-5 times per month, 20% negotiated 5-10 times per month, 23% negotiated 10 or more times per month and 13% did not negotiate at all, i.e. 87% negotiated regularly in their job.

Fig. 1 Negotiation Styles

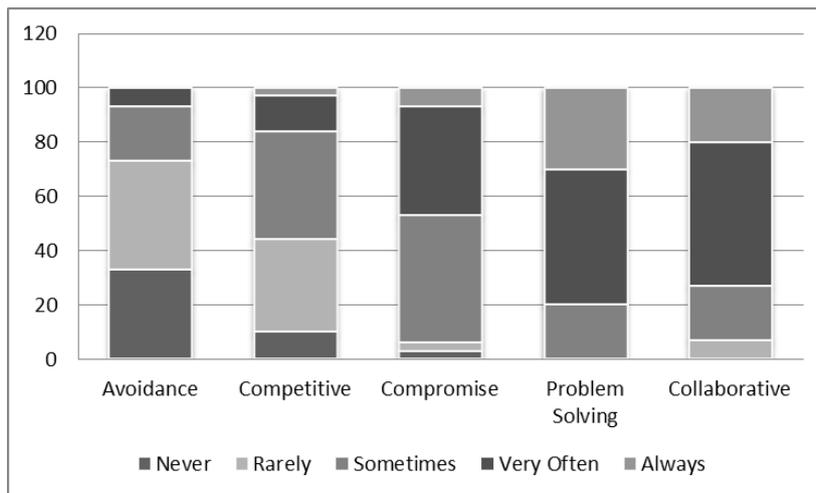
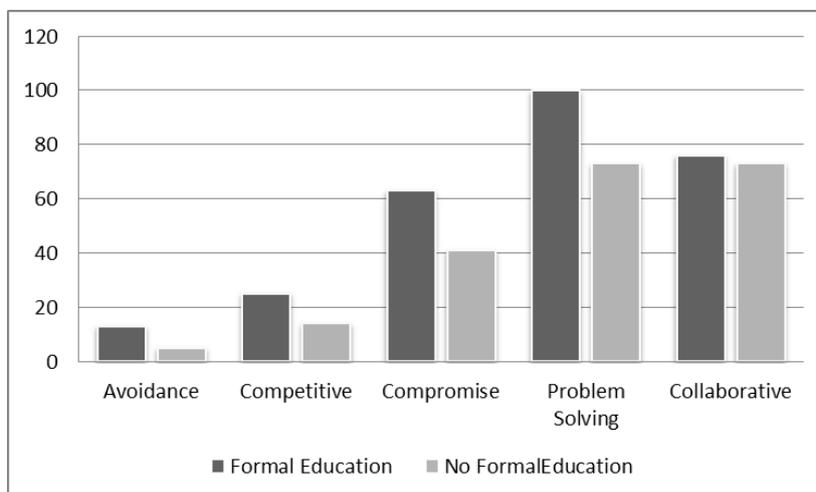


Fig.1 shows the usage of five different negotiation styles. Some 73% of Qs never or rarely used the avoidance style. Only 16% of Qs used the competitive style very often or always, whilst 40% competitively engaged in win/lose negotiations. The compromise style was sometimes used by 47% of Qs with a further 40% using it very often. The problem-solving style was sometimes used by 20% of Qs, very often by 50% and always by the remaining 30%. More than half of the Qs (53%) used the collaborative style very often with a further 20% claiming to always use it. In summary, the problem-solving style was used most frequently (80%) with the collaborative style following closely behind (73%) and the compromise style thereafter (47%).

Fig. 2 Negotiation Styles and Education



These findings were mirrored in Fig. 2 which shows the effect of formal education on the choice of negotiation style. The problem-solving style was most favoured, followed by collaborative and compromise styles. Competitive and avoiding styles were least favoured. In every category those Qs with formal education used a chosen style more often than those without formal education, some markedly so in the cases of problem-solving and compromise styles. This implies that Qs with formal education have developed the ability to use and adapt the various negotiation styles to a better or greater extent than those without formal education, therefore allowing them

to use a variety of styles. It may also indicate that those with formal education have a better understanding of the various negotiation styles and how best to apply them.

Fig. 3 Negotiation styles and experience

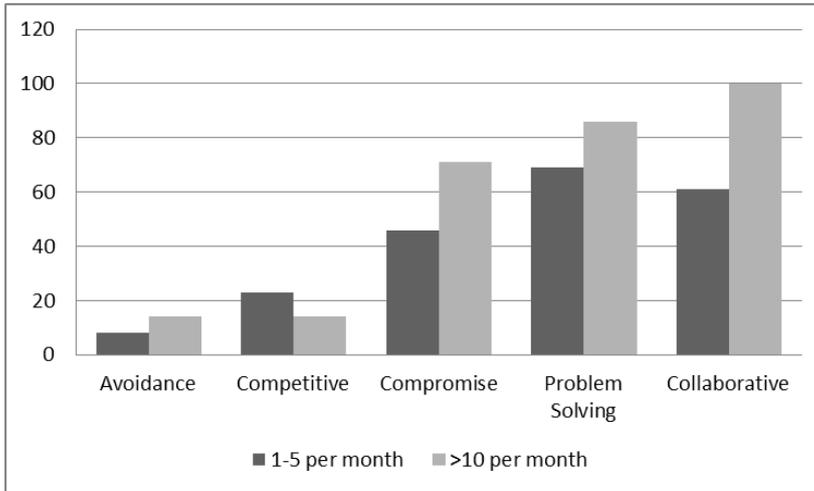


Fig. 3 shows how choice of negotiation style varied with experience. QSs with no negotiations and between 5-10 negotiations per month were removed for clarity. More experienced negotiators preferred the collaborative style followed by problem-solving and compromise styles. Competitive and avoidance styles were seldom used. Less experienced negotiators, in contrast, preferred the problem-solving style, followed by collaborative and compromise styles. Significantly, they preferred the competitive style more than experienced negotiators.

Fig. 4 Negotiation Styles and Roles

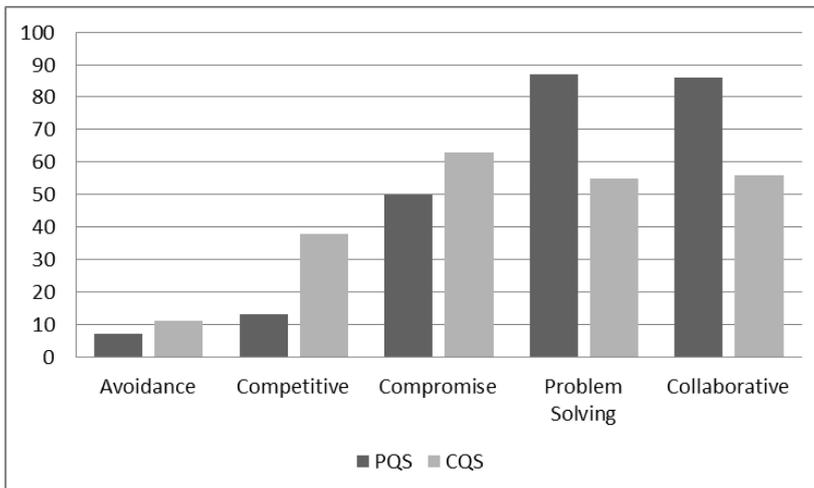


Fig. 4 shows how choice of negotiation style varied with the role as either private QS or contractor's QS. Private QSs favoured problem-solving and collaborative styles equally, with compromise a poor third. Surprisingly, contractor's QSs favoured the compromise style above all others, but, significantly, used the competitive style more often than their private QS counterparts, which was not at all surprising.

The analysis examined the level of attention QSs gave to negotiation styles during the negotiation process. It was found that over 70% of respondents very often repeated the same negotiating style and a further 3% said they always used the same style. There was only a small difference between those with formal education in negotiation and those without (76% and 73%). In contrast, however, those with formal education paid

26% more attention to their own style of negotiation than those without (50% and 41%). The results suggested that knowledge of negotiation through formal education provided the skills that increased the awareness on negotiation styles used during negotiations.

Limitations of Findings

A limitation of the research was that the results obtained were based on self-evaluation of practising QSs which may possibly be biased because most negotiation processes are done in private and there is no direct observation of the negotiation process by the researcher.

The results may be skewed because 50% of the sample was consultant surveyors in private practice and only 36% were contractor's surveyors. This may not be a representative sample of the UK population of QS employment. Also, as only 27% of the sample had any formal education the findings may lean towards the majority.

The results may be socially biased because as the construction industry now strives to encourage collaboration and problem-solving negotiation styles through various means, such as the form of contract, company policies and procurement methods, this could influence the respondents to consciously or unconsciously select the negotiation styles that suit the requirements of the construction industry. That said, however, it is worth mentioning that the extent of disputes reaching litigation stage has been reduced by a third since 1995. This suggests that whilst negotiation seems to be demonstrating some success there are still some cases that make it to the litigation stage potentially due to failed negotiations. This could also mean that whilst the QSs attempt to use the collaborative/problem-solving styles they may not be using them effectively and may lack the required skill to undertake successful negotiations.

The foregoing limitations are recognised and the conclusion must be tempered accordingly.

CONCLUSION

The foregoing research involved the study of the possible influence of formal education on the current negotiation practice of Quantity Surveyors in the construction industry and concentrated on their use of negotiation styles. The research critically analysed the styles used by the QSs in negotiation and the level of awareness they had on the various negotiation styles.

It was found that negotiation theory or practice had not been studied by the majority of QSs during their formal education. Whilst the survey results showed that 27% of the QSs had some form of negotiation training it did not say particularly if the training was undertaken as part of their QS academic qualification course.

It was found that the QSs demonstrated that the compromise, problem-solving and collaborative negotiating styles were the styles they most frequently used in negotiation. This suggests that QSs in the construction industry tended to lean towards win/win situations where all parties leave with something beneficial from the dispute. When the collaborative, problem-solving and compromise styles were applied there was a higher potential for the dispute to be resolved and not prolonged to the more expensive litigation/arbitration process. The competitive style was practised amongst the QSs, but not vastly used. This does not support the theory stated by Patton (1999) that most negotiators engage in adversarial negotiating methods contributing to escalation of conflicts in the industry.

It was found that the QSs who had a formal education on negotiation applied a greater variety of the negotiation styles than those without formal education which gave those with formal education an advantage to change styles that suit different negotiation environments to attempt to reach a final agreement. Similarly, it can be concluded that more experienced QSs apply a greater variety of negotiation styles when compared with less experienced QSs. This made them able to change tactics with ease, able to reposition themselves in the dispute and able to re-strategise more during negotiations. Therefore, with the combination of formal education and work experience most QSs are more likely to excel in their use and application of negotiation styles in dispute resolution.

It was found that contractor's QSs used the competitive and compromise styles to a greater extent than consultant QSs, while the consultant QSs used the collaborative and problem-solving styles more than contractor's QSs. The results supported the theory that the role/position of the QS could affect the way they used negotiation styles. The contractor's QSs were more likely to adopt the competitive style in order to get the client to pay compensation for works they have carried out or may want to carry out to improve their employer's (contractors) chances of an increased profit for the works done, similarly with the use of compromise.

It was found that QSs did not consciously pay attention to their own styles during negotiation processes regardless of their depth of experience. Whilst the QSs were able to state the negotiation styles used, they did not use them knowingly or consciously during negotiations, but only admitted they do afterwards. It was also found that the QSs with formal education demonstrated a better consciousness in paying attention to their negotiation styles applied than those without formal education. Therefore, formal education improved the QSs awareness on the negotiation styles used during negotiations. It was found that the more experience the QS had the more conscious they were about their opponent's negotiation styles. The QSs with a background of formal education also demonstrated more consciousness to their opponent's negotiation style. Therefore, formal education can be used as a means for the less experienced QS to learn to improve their consciousness of the way they negotiate and also the consciousness of the way their opponent negotiates leading to more effective negotiations.

Notwithstanding the small sample size and possible biases, the study demonstrated that formal education was influential on Quantity Surveyors' negotiation styles and practices. Experience was also shown to improve negotiation practice and made QSs more conscious of both their own negotiation styles and those of their opponents.

It is concluded that the introduction of a non-elective negotiation module in the curricula of Quantity Surveying under-graduate degree programmes would be of significant benefit as negotiation is as essential a professional life skill in the construction industry as it is in the legal profession.

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THE INTERACTION OF TRUST AND CONTRACTUAL GOVERNANCE ON DISPUTE NEGOTIATION STRATEGY IN CONTRACTOR-SUBCONTRACTOR RELATIONSHIPS

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Supply chain scholars have increasingly gained attention to using governance mechanisms to manage inter-organizational relationship and have pointed out their significant impacts on performance outcomes. However, the typical relationship between general contractors and subcontractors is still potential adversarial and disputes are almost inevitable during the construction process, and using governance mechanisms to promote cooperation and eliminate conflicts in the construction industry has been a relatively new topic. Through a comprehensive review and analysis of literature on governance mechanisms, the study has presented the reasons for the inconsistent findings of the interactions between trust and contract, identified different dimensions of trust and contract with consideration of the characteristics of the construction industry. In spite of the links between governance mechanisms and performance outcomes are well established, less well established is how they influence behaviours which intermediate between governance mechanisms and outcomes. By providing a theoretical framework, we can reach a better understanding of how and when trust and contract interact with each other to influence the development of negotiation strategy, so that both general contractors and subcontractors can promote better cooperation in dispute resolution and better manage their relationship. Drawing on governance mechanism literature, we argue that trust can be approached from the goodwill dimension and the competence dimension, while contract can be approached from the control function and the coordination function in the construction industry. These dimensions of trust and contract may interrelated with each other in promoting the development of dispute negotiation strategy. As our research is in progress, subsequent empirical studies are expected to test our theoretical model and focus on each dimension of the constructs in more detail is needed.

Keywords: dispute resolution, governance mechanisms, trust, contract, negotiation, relationship management.

INTRODUCTION

Construction projects are often characterised by large size and high degree of specialisation, which makes it almost impossible for one company to accomplish a project with the entire technical expertise, resource base, or investment capital (Gunasekaran, 1998). Thus, the contractor-subcontractor relationship is very common in construction projects. As both general contractors and subcontractors are the most direct participants, how they interact with each other has a direct impact on project performance outcomes. However, the typical contractor-subcontractor relationship is

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still cost-driven and potentially adversarial (Greenwood, 2001). Many of such relationships end up in disputes. In addition, technical complexity and uncertainty of construction projects also contribute to the manifestation of dispute between general contractors and subcontractors. Disputes are almost inevitable in most of today's construction projects (Song *et al.*, 2013). If not resolved proactively and for early settlement, disputes will aggregate negative impacts on project performance outcomes. Negotiation is often firstly initiated to get disputes resolved, for it is the least-costly way and most flexible way to reconcile disagreement in terms of time, money, and emotional energy involved (Brett, *et al.*, 1990).

Using governance mechanisms to manage inter-organizational relationship is beginning to attract interest from academia and industry. Most of these researches are primarily in manufacturing, marketing, strategic alliances. Although the concept of governance mechanism has been adopted to the construction industry, there is still large amount of work to be done to improve the relationship management of the construction industry. There are two common types of governance mechanisms that come into play in inter-organizational relationship, as suggested in existing literature (Carey *et al.*, 2011). Contractual governance refers to the formal rules to safeguard parties from opportunism and disputes. The other one is trust which is used to mitigate exchange hazards caused by uncertainty and transaction-specific investments. The two types of governance mechanisms are quite distinct but interrelated with each other in managing inter-organizational relationships. Trust and contractual governance have been traditionally viewed as either complement or substitutes in impacting project performance outcomes.

The aim of this paper is to explore the attributes of contractual governance and trust in the construction industry from a multi-dimensional perspective by conducting a desk study. We also introduce the expectations of continuity as an important moderating variable as suggested by several researches (Axelrod and Hamilton, 1981; Poppo, *et al.*, 2008), to provide a nuanced understanding of how and when governance mechanisms impact the actual behaviours of participants. This study argues that both the complementary and substitute relationships of the two governance mechanisms are possible, due to different contextual factors and contents of the two governance mechanisms

GOVERNANCE MECHANISMS IN THE CONSTRUCTION INDUSTRY

The existing literature has suggested two types of governance mechanisms in managing inter-organizational relationships. Contractual governance refers to legal safeguards which explicitly stipulates the responsibilities and obligations of each party (Lui and Ngo, 2004). Transaction cost economics (TCE) is one of the main theories in explaining the effectiveness of contractual governance. It argues that contracts are designed to reduce opportunism and minimize transaction costs caused by uncertainty and transaction-specific investments (Williamson, 1985). Contract structure may vary to a large degree due to different transaction attributes. An effective contract related to complex transaction involving transaction-specific investments and interdependency typically includes clauses to clarify different dimensions of a transaction (Crocker and Reynolds, 1993). For a long time, contracts are considered as control instruments to contend with the potential risk of opportunism (Williamson, 1985). The threat of intervention of a third party is the primary means by which contracts act as the instrument to control both parties' behaviours (Lumineau and Henderson, 2012).

Researchers are coming to realize that contract serves different functions to stipulate a transaction. However, exchange partners also formulate contracts to foster coordination of the relationship formally. Coordination is especially important when the contracted tasks are highly uncertain and complex (Ren *et al.*, 2009), as is true in construction projects. Construction projects require high level of coordination, for there are so much interface of activities and concerns due to the high level of specialisation. Coordination provisions aim at mitigating the risk of misunderstanding and structure collaboration in an efficient way (Mayer and Argyres, 2004). This is also in accordance with the logic of TCE, for the coordination provisions contribute to reducing transaction costs and informs the selection optimal governance choices (Schepker *et al.*, 2014). Both control provisions and coordination provisions are designed in construction contracts, as can be seen from several models of contracting (e.g., FIDIC, 1994; 2011). Empirical studies suggest that different functions of contracts may shape parties' behaviours, and consequently the outcomes of the relationship (Lumineau and Malhotra, 2011). Therefore, we suggest the distinction of control and coordination functions of contracts in our research.

Trust is another governance mechanism to mitigate exchange hazards caused by uncertainty and transaction-specific investments, and the social exchange theory (SET) is the underlying theoretical foundation of trust. Trust is a common phenomenon that exists at multiple levels, like the personal, organizational, inter-organizational, even international level. SET maintains that trust derives from social interaction and it is an effective tool to govern inter-organizational relationships (Cropanzan and Mitchell, 2005). Trust in inter-organizational relationships can be defined as the positive expectation held by one partner that the other party would behave in a mutually acceptable manner and to act fairly even given the chance for opportunism (Morgan and Hunt, 1994). Researchers have identified a variety of antecedents of trust. The various sources of trust indicates that it is not a one-dimensional construct. Trust can be classified into three types—deterrence-based, knowledge-based, and identification-based according to Sheppard and Tuckinsky (1996). Barney and Hansen (1994) suggest that trust at the inter-organization level can be classified into weak form, semi-strong form, and strong form, depending on the degree of potential opportunism.

Barber (1983) divided trust into the competence trust and goodwill trust. Goodwill trust is the confidence that a partner is benevolent and honest, and will not do harm to another's benefits even when given the chance (Das and Teng 2001). In contrast, competence trust refers to the expectation that a partner is technically competent to fulfill its obligations (Rempel, *et al.* 1985). Construction projects are faced with environmental uncertainty and technical complexity. It is almost impossible to anticipate and delineate all the contingencies that may arise during the construction process (Malhotra and Murnighan 2002). Therefore, goodwill trust is essential to handle the relationship in construction. Competence trust is especially important in the construction industry, for construction projects often involve large scales of investment and high risk. Failure of a project means great loss for both parties, or even bankruptcy. Since the division of goodwill and competence trust covers a partner's ability to perform and its intentions to do so, which presents a clear distinction, we adopt the two dimensions of trust in our study.

As both contractual governance and trust have their own effective domains and limitations in promoting cooperation, researchers have devoted in investigating how they interact. One research stream argues that contractual governance and trust act as

complementarities in improving performance outcomes (Poppo and Zenger, 2002). Firstly, trust can complement contract in reducing ex post transaction costs of contract noncompliance and negotiation, for the reason that trust can help overcome the inherent inflexibility of contractual governance. Secondly, well-specified contract may decrease the degree of uncertainty and risks, so that can provide a sound foundation for the development of trust. However, another research stream has provided empirical evidence for the substitute relationship between trust and contractual governance. Firstly, detailed contract may be a signal of lack of trust, and may destroy the existing trust between exchange parties, consequently weaken the positive effect on trust on performance outcomes (Malhotra and Murnighan, 2002). Secondly, trust may also weaken the positive effect of contracts on performance outcomes in turn. For the reason that, parties will less likely to enforce contracts strictly if they have a high level trust (Antia and Frazier, 2001). Obviously, the nature of the interplay between the effects of trust and contractual governance remains equivocal.

DISCUSSION ON CURRENT LITERATURE

With our analysis of articles related to governance mechanisms in different industries and institutional environments, we found that the paradox of the contractual-trust governance interplay can be attributed to several reasons. Firstly, most of existing literature do not make the distinction that whether they are talking about the mutual relationships between the two governance mechanisms or their interplay on performance outcomes. Most of these literature implicitly assumes that the logic of how the two governance mechanisms relate to performance outcomes is always in accordance with the logic of how the two governance mechanisms relate to each other. However, Cao and Lumineau (2014) provided evidence that the two kinds of logic are not always in accordance with each other by conducting a meta-analytic research on 139 published journal articles.

Secondly, both the complementary and substitute arguments are possible, depending on the emphasis on different dimensions of trust and different functions of contractual governance (Woolthuis *et al.*, 2005). As contractual control and coordination are rooted in different frames, they may have different impacts on relational governance.

Thirdly, the existing literature we employed to analyse is conducted in various industries and institutional environments. The inconsistent findings on the interplay between the two governance can be explained by the existence of possible contextual factors. However, the investigation of the possible moderating variables is fragmented and far from perfect. In this study, we chose “*the expectations of continuity*” as our interest moderating variables. “*The shadow of the future*” means whether exchange partners have expectations of continuous cooperation in the future. It is an important factor that may have effect on reconciling disputes mentioned in several studies (e.g., Schepker, *et al.*, 2014). From the logic of game theory, the behaviours of continuous reciprocity depends on sufficient value being placed on future returns (Axelrod and Hamilton, 1981). In the construction industry, subcontractors are in different professional fields. Due to the characteristics of specialised market, the degree of market competition may vary to a large degree. Thus, general contractors and subcontractors may have different expectations of continuous cooperation, which may result in different behaviours. However, prior literature has not offered enough attention to it.

In addition, most of existing literature focused on how governance mechanisms impact performance outcomes, less well established is how governance mechanisms

influence actual behaviours of both parties. To the best knowledge of the authors, how the two governance mechanisms interact to impact the behaviours in dispute negotiation in the construction industry is far less researched.

THEORETICAL FRAMEWORK OF THE INTERACTIONS OF CONTRACT AND TRUST

Researchers in inter-organizational relationship have revealed that trust and contractual governance can function together to influence the actual behaviours in dispute negotiation (Lumineau and Henderson, 2012). We envision that the view may be applied to the construction context as well. Including the possible moderator of the expectations of continuity, the authors developed a comprehensive theoretical model to explore the effects of all the dimensions of governance mechanisms on negotiation strategy. Following prior study, we classified negotiation strategies into a cooperative strategy and a competitive strategy. Parties using a competitive strategy primarily focus on demands, penalties and interruptions. Using such a strategy is more likely to result in a win-lose outcome. In comparison to the competitive strategy, parties using a cooperative strategy are more likely to behave cooperatively in order to solve the dispute. They tend to negotiate with a view of underlying interests. Such a strategy entails reaching a mutually acceptable settlement. However, the two kinds of strategies are not mutually exclusive, they are just two extremes of one thing. In our research, we evaluate the degree to which kind of strategy is adopted in negotiations. The theoretical framework is presented in Figure 1

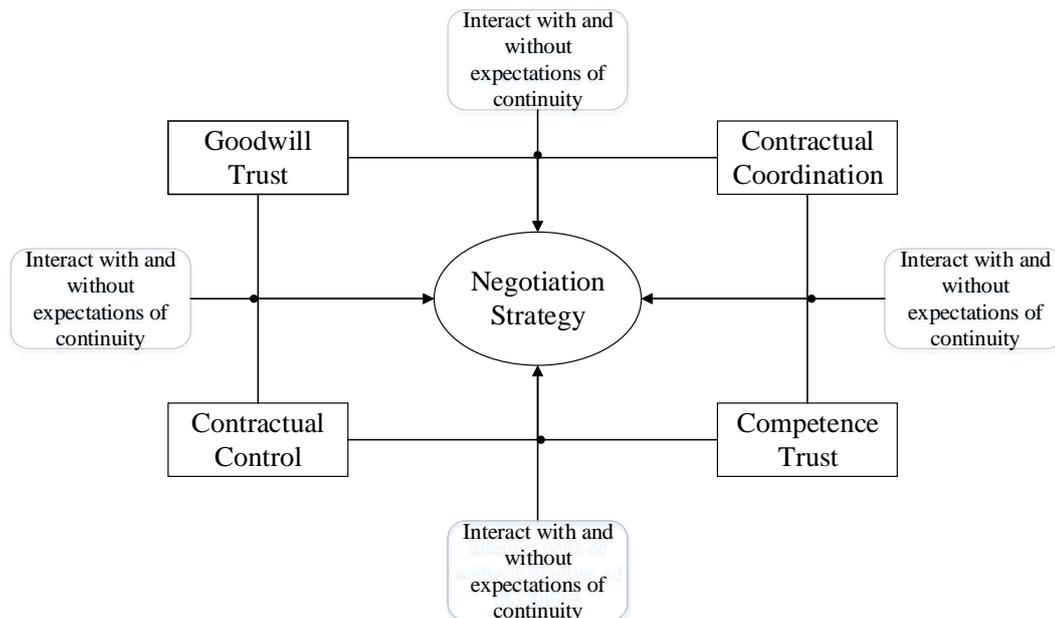


Figure 1: Theoretical Framework

The interaction between goodwill trust and contractual control governance

From the logic of game theory, an expectation of continuous interaction is crucial to promote perceptions of goodwill trust (Axelrod and Hamilton 1981). Based on a rational assessment of forward-looking conditions, it can be rewarding to behave cooperatively if parties trusted their partners. As the increase of confidence in its partner's goodwill to fulfil their responsibilities, more open information sharing and a closer cooperation will be adopted (Paulraj *et al.* 2008). Considering an example in which the level of one's goodwill trust in its partner is rather high, it will devote less time and resources in formulating and monitoring the contractual control. When

disputes arise, it will seek integrated solutions through better communication to enhance efficiency, rather than rely on the contractual control governance to safeguard short-term interest. Because relying on contractual control governance too much will do harm to the relationship, and the gains from cooperation and repeat business are higher than short-term gains (Poppo *et al.* 2008). Therefore, with expectations of continuity, more contractual control will weaken the positive effect of goodwill trust on the adoption of a cooperative negotiation strategy.

Although one's goodwill trust in its partner can facilitate a closer cooperation, one of the strongest incentives for parties to be honest is that he can obtain continuous patronage from his partner. If without expectations of continuity, the finite endpoint of exchange will loom large on the horizon. One's goodwill trust in its partner will be more likely to be exploited by its partner to seek for gains. As contractual control governance will impose a higher cost of declining or terminating the relationship, contractual control provisions as safeguards devices to give a credible commitment to parties (Helm and Kloyer, 2004), thus increase the effectiveness of goodwill trust in promoting better cooperation when disputes arise.

The interaction between goodwill trust and contractual coordination governance

When exchange partners have positive expectations of their continuous cooperation, it means that they can gain more from the forward-looking conditions. Considering the best financial interest, exchange partners tend to cooperate through many value-sharing behaviours, like sharing some key information and tacit knowledge, to increase the level of goodwill trust, and consequently, better cooperation and performance outcomes. The coordination aspect of contract aims to make explicit of both parties roles and goals, and can facilitate better communication and timely information sharing in case of contingencies (Mesquita and Brush 2008). Information sharing and communication have been shown to be critical in developing mutual understanding (Paulraj *et al.* 2008). With better mutual understanding, both the parties can align expectations and make great endeavours to search for integrative solutions. Both the partners can leverage flexible behaviours and efficient collaboration, for the coordination provisions provide how to make bilateral adjustments and communication flows (Lumineau and Henderson 2012). In this way, the goodwill are enhanced, and the relationship is strengthened.

Coordination provisions in a contract aim at structuring the means of efficient collaboration by providing formal procedures to promote cooperation (Lusch and Brown 1996), and maintain their relationship. Although contractual coordination is in line with the logic for reducing transaction costs, however, more contractual coordination means more time and resources devotion in coordination to reach a mutual-benefit solution when disputes arise. When general contractors and their subcontractors don't have prospect for future business, transaction costs involved in coordination may outweigh their one-shot gains, so more contractual coordination may have a negative influence on the adoption of a cooperative strategy other than a positive influence.

The interaction between competence trust and contractual control governance

If a general contractor and its subcontractors have the belief that they can cooperate repeatedly in the future, a competent partner means sufficient resources and abilities to fulfil its roles and performance outcomes, not only in the present construction project, but also in a series of projects subsequently. Also, the high level in competence in exchange partners may lead to an inferior position when disputes arise,

the potential vulnerability to opportunism can be countered by contractual control governance. In this sense, contractual control governance can make exchange partners perceive to be protected by the contract. Thus, the confidence in its partner is increased to some degree, ultimately leading to better cooperation (Lui and Ngo 2004).

The same logic can be applied to the situation when general contractors and subcontractors don't have expectations of continuity. Under this situation of one-shot transaction, exchange partners will rely more on contractual control governance to protect their own interest when disputes arise, as contractual control governance have the legal enforcement to safeguard interests of both parties (Lumineau and Henderson 2012). It can help to make up for the deficiency of exposure one's greater vulnerability to risks (Das and Teng 2001) and give the parties a sense of being protected by the contract, thus increase the confidence and will to better cooperation to some degree. Therefore, we propose that, without expectations of continuity, competence trust and contractual control will have a strengthened positive effect on the adoption of a cooperative negotiation strategy.

The interaction between competence trust and contractual coordination governance

One's competence trust in its partner will lead it to higher probability of potential vulnerability of opportunism (Lui and Ngo 2004). That's mainly because its partner is the expertise in its particular field, it may grasp more knowledge and key information. It will be easier for its partner to hide or deceive key information and knowledge. However, given expectations of future interaction, they will regard the competence trust as a signal of continuity patronage from their partners. Parties learn how to transact with each other in a more effective manner (Poppo *et al.* 2008). They expect to establish standard routines and procedures to facilitate adaptation to unexpected disputes. In this way, they can maximize the use of potential resources and competence of exchange partners and focus on mutual interests of both parties. Coordination provisions in contracts can facilitate better communication and timely information sharing in case of contingencies. Information sharing can positive effect the development of mutual understanding. Ultimately, one's sense of inequity in positions in transaction can be weakened, and they can perceive to be protected, hence better cooperation can be reached.

However, without the expectations of continuity, short-term gains would derail parties' will to better cooperation. The competence trust in its partner may be interpreted as higher probability of potential vulnerability of opportunism. As coordination provisions in a contract may be not so legally binding as control provisions (Woolthuis 2005), they are not easily verifiable or observable. This may leave the back door open to making such provisions to interpret and enforce. Considering the lack of long window of continuity, parties may be more easily to interpret the coordination provisions in their own favour and use this opportunity for self-gain. Thus, competence trust may weaken the positive effect of contractual coordination governance on the adoption of a cooperative negotiation strategy.

CONCLUSIONS

Scholars and practitioners in supply chain management have devoted much attention to using governance mechanisms to manage inter-organizational relationships. However, more attention should paid to the construction specific supply chain

management, especially the contractor-subcontractor relationships. For the reason that, the typical relationship between general contractors and subcontractors is potential adversarial and disputes are almost inevitable. The importance of using governance mechanisms manage contractor-subcontractor relationship should never be underestimated. Proper combination of different types of governance mechanisms can have a positive impact on cooperation behaviours, and thus improve performance outcomes.

By conducting a desk study on governance mechanisms in different context, we present a comprehensive understanding of the paradox of the interactions of contract and trust. We also analyse the research gap and the possible reasons for the inconsistent findings in current literature. After analysing the characteristics of the two governance mechanisms in the construction industry, we propose a theoretical framework of how and when different dimensions of contract and trust interact with each other to influence the development of negotiation strategy. This paper introduce the argument that both trust and contractual governance can be viewed as multi-dimensional constructs which are intertwined with each other to influence exchange partners' behaviours. We provide a conceptual base for how to use governance mechanisms to promote cooperation behaviours during dispute negotiations in the construction industry. The theoretical framework is what is needed so that further empirical research can verify the arguments, focus on each dimension of the constructs in more detail, and provide managerial implications for construction practitioners.

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THE IMPORTANCE OF CONTEXT IN CONFLICT MANAGEMENT: EXPLICATING THE NOTION OF CONFLICT MANAGEMENT CLIMATE AND AGENDA SETTING FOR FUTURE RESEARCH

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Dual concerns models of varying specifications have been developed by theorists to describe different styles available to conflicting parties for conflict management during a conflict episode. Most of the research employing dual concerns models has exhausted its efforts to find a local-optimum solution in a particular situation or what Kenneth Thomas has described as short term conflict management. This major stream of research, although important, is void of descriptive value if one's goal is to achieve best possible solution by introducing structural changes in a system and the emphasis is on proactive conflict management rather than reactive. A theoretical distinction between short term and long term conflict management is at the heart of this scholarly effort. In line with the theoretical underpinning for long term conflict management, the structural framework for conflict management proposes parameters of a system which lead to a behaviour theorized to be aligned with proactive conflict management. Measuring structural parameters of a system for the purposes of empirical research could become difficult when the level of measurement shifts from micro (e.g. individual) to macro (e.g. organization). Industrial and organizational psychology has conceptualized and researched a notion known as climate that could adequately address the measurement challenge. Conflict management climate therefore is a notion that measures shared perceptions of people with regard to structural parameters of a system and is theorized to be an aggregated construct of organizational level. In a logical sequence, this paper further explicates the dimensions of the construct of conflict management climate. Thus, in a bid to develop research agenda for conflict management climate, this paper builds a case for long term conflict management and draws on the theory of climate to theorize and explicate the dimensions of conflict management climate. The paper culminates by setting a research agenda for this newly conceptualized construct.

Keywords: conflict management climate, interface management, structural framework for conflict management.

INTRODUCTION

Among all the models of conflicts, dual concerns models have provided a dominant paradigm to study conflict behaviours (Thomas, 1976). However, they have been criticized for their over simplistic approach of representing reality as only two variables have been theorized to be determining the strategic intentions of a conflict party (Thomas, 1992). For example, in Blake and Mouton's model (1964), two variables 'concern for people' and 'concern for production' are theorized to be determining intentions of a conflict party. Similarly, in Rahim and Bonoma's model

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(1979) conflict management behaviour is theorized to be a function of ‘concern for others’ and ‘concern for self’. Also, dual concerns models provide theoretical underpinning to find ‘local optimum’ solution to a conflict in given circumstances but they are void of descriptive value if one’s desire is to find a ‘global optimum’ solution (Thomas, 1992). In response to these theoretical shortcomings, Thomas (1992) proposed process model of conflict and structural framework theoretically aligned with the notion of long term conflict management and ‘global optimum’ solution. Where the proposed structural framework enriches researcher’s mind about the ways to achieve long term conflict management in an organization, it also poses a challenge for empirical research especially when one is to measure the structural variables at the organizational level of analysis. Fortunately, industrial and organizational psychology has conceptualized a notion known as ‘climate’ that deals with the shared perceptions of individuals in particular settings about a distinct phenomenon. Climate of a distinct phenomenon may inform researchers/practitioners about individuals’ prioritization and consensus with regard to distinct phenomenon through its attributes of ‘level’ and ‘strength’ respectively. Hence, we submit that the notion of climate once combined with Thomas’ (1992) long term perspective of conflict management will allow researchers to measure the prioritization and consensus with regard to structural variables and in turn allow the measurement of variation in theorized outcomes. Accordingly, conflict management climate is a notion that measures shared perceptions of people with regard to structural parameters of a system which are theorized to shape reasoning and in turn determine the course of conflict management. Hence, this conceptualization is expected to serve four purposes primarily by: (1) allowing researchers to empirically test the structural framework proposed by Thomas (1992) (2) contributing to conflict management theory by showing the variation in theorized conflict management behaviour with the variations in level and strength of conflict management climate (3) allowing researchers to see the influence of variation in conflict management climate on those notions which are conceptually linked with conflict management e.g. intra-organizational interface management (4) allowing researchers to develop a conflict management climate instrument which may prove useful in informing project managers about the socio psychological state of their employees with regard to conflict management and possible actions they might need to take to improve situation proactively, if required. In a bid to conceptualize this construct, this paper presents theoretical underpinning of the construct, characterization of the construct and a research agenda which may reflect on the potential of this newly conceptualized construct in the field of construction project management.

RATIONALE UNDERPINNING THE CONCEPTUALIZATION OF THIS CONSTRUCT

The concept of division of labour furthers the notion of specialization and provides ground to deal with challenges arising out of complex product designs and project architectures. However, this very same concept engenders fragmentation (Fellows and Liu, 2012) and consequently necessitates the creation of boundaries/interfaces between different entities challenging the free flow of information and ultimately threatening the achievement of project goals. Accordingly, Chua and Godinot (2006) notes that project success is contingent on the successful management of interfaces between different specialized work divisions. Construction project management literature has given extensive space to inter-organizational interface management since the publishing of Latham’s (1994) and Egan’s (1998) reports, but it is difficult to

find research on intra-organizational interfaces which have a potential of engendering improvements at operational level by reducing waste, delays and rework. General contractor's project organization that takes a responsibility of transforming drawings into reality faces enormous challenges with regard to intra-organizational interface management as there are multiple specialized teams working together to deliver project successfully. One of the great challenges is that of effective collaboration between different teams because due to different "thought worlds" (Dougherty, 1992), it is very likely that people from different functional teams get into conflict during the process of information sharing and decision making. The functional heterogeneity symbolizing different thought worlds in general contractor's project organization is reflected through fig.1 below. Katz and Kahn (1978) once observed that "every aspect of organizational life that creates order and coordination must overcome tendencies to action and in that fact lies the potentiality for conflict". At one side, where people contain themselves in "silo thinking" may get successful in avoiding conflict, however "silo thinking" doesn't allow alternative views and explanations which may create difficulties for the organization at the later stage in the form of delays, reworks and conflicts with other stakeholders (Ellegaard and Koch, 2014; Goh *et al.*, 2012). On the other side, where people take other teams' perspective to plan and execute may get into the trap of conflict owing to different "thought worlds" or functional heterogeneity.

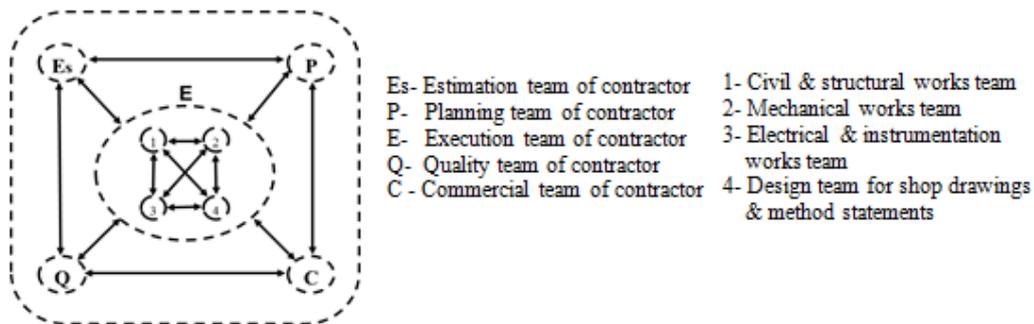


Fig.1 Graphical representation of functional differentiation in general contractor's project organization

This whole situation calls for a perspective which could explain theoretically as to how the individuals from different functional teams of an organization keep their dialogues constructive and benefit from the cross-fertilization of ideas and avoid getting into the abyss of dysfunctional conflict. A possible research question which then follows this discourse is: Is there any role of context in keeping the dialogue constructive? The research motivated to address this question of theoretical and practical importance, built on the long term perspective of conflict management (Thomas, 1992) which posits that structural parameters of a system influence thoughts and emotions which in turn determine the course of conflict management. Measuring structural parameters of a system to know whether they will engender collaborative conflict management is a challenge for empirical research purposes that has been overcome by bringing the notion of climate which deals with shared perceptions of people with regard to distinct phenomenon (Schneider *et al.*, 2013). Therefore, conflict management climate as a notion is conceptualized to act as a theoretical lens to explain the performance differentials between the project organizations with a climate for intra-organizational conflict management and those without.

LITERATURE REVIEW

Organizational conflict and its management is a crucial component of management research and has been part of the literature from at least five decades (e.g. March and Simon, 1958; Pondy, 1967; Walton and Dutton, 1969) . Conflict is an integral part of organizational life, as Pondy (1989) observed that conflict constitutes an integral part of organizational life, rather than occasional break down of cooperation. Theorists have proposed different normative and descriptive models (see, Lewicki *et al.*, 1992) to capture the antecedents , dynamics and consequences of conflicts. Among these models, researchers concerned with conflict management behaviours have tried to focus on dual concerns models (Thomas, 1976). However, these models have been criticized for being over simplistic as primarily only two variables seem to be determining the intentions of a conflict party. Also, the rationale reasoning in the models seem to be shaped only by the valence parties attach to the desired outcomes besides ignoring the impact of normative reasoning and emotions altogether (Thomas, 1992). Jehn's (1997) seminal work and De Dreu and Weingart's (2003) meta-analysis showed the importance of emotions during a conflict episode and the possible interplay between task conflict and relationship conflict, thus giving empirical validity to Thomas' (1992) argument that there are multiple forces that act on a conflict party and therefore a more complex model is needed to account for such forces rather than just relying on two variables. Furthermore, dual concerns models' emphasize on the dynamics of conflict and outcomes precluding the importance of context on dynamics and consequences of conflict. In his seminal article, Johns (2006) has built his case for the importance of context in shaping one's behaviour. Johns (2006) has defined context as "*situational opportunities and constraints that affect the occurrence and meaning of organizational behaviour as well as functional relationships between variables*". Similarly Cappelli and Sherer portrayal of context is synthesized by Johns (2006)in following words "*organizational characteristics as providing context for individual members and the external environment as providing context for organizations.*" Therefore, we note that omission of context from the models articulated to represent conflict behaviour is meaningful in a sense that it allows current researchers to understand the shortcomings of prevalent models of conflict and to look for other models which are more comprehensive rather than reductive.

Similarly, in the construction project management literature, dual concerns models have been used to predict different outcomes (e.g. negotiations outcomes). However, these are again used without accounting for context. Cheung *et al.* (2006) have done research in which they have just tried to find how different conflict management styles impact on different negotiation outcomes isolating research from its context. Similarly, Liu and Zhai (2011) have tried to find how personality affect the choice of conflict management styles without considering its interaction with organizational context as Johns (2006) note that context can interact with personal disposition ultimately having effects on behaviour. Tsai and Chi (2009) did try to find the relationship between culture and conflict management styles of dual concerns model, however, national culture alone does not convey a complete picture as organizational context being more proximal antecedent of behaviour holds more potential to explain variance in the behavioural outcome of individuals. These researches, although important, suffer from two main fundamental theoretical deficiencies: (1) The context reflective of situational opportunities and countervailing constraints and their additive effects on behaviour (Johns, 2006) is not taken as such and therefore is suspected to have cast doubts on the generalizability of findings (2) theoretical underpinning

behind the dual concerns models is not rich that could inform about how context could possibly shape a meaning. In view of the above limitations of the dual concerns model and the extant research employing these models, we submit that Thomas’ (1992) process model of conflict together with structural framework address these theoretical shortcomings and provide theoretical underpinning to conceptualize a notion that could capture context, account for multiplicity of forces acting on conflict party during a conflict episode, and allows one to achieve global optimum solution— the type of solution which is reached by parties through collaborative management of conflicts as it is reported to be associated with perceived fairness, decision quality, quality of working relationships and increased satisfaction of the parties (Thomas, 1992) — through long term conflict management perspective. Long term perspective of conflict management is reflective of an idea of pro-active management of conflicts to achieve synergistic solution by keeping in mind the long term benefits of collaborative conflict management rather than an idea which takes long on the time horizon of project to bear its fruit.

THEORETICAL UNDERPINNING OF THE NOTION

Owing to the influence of economics on conflict/negotiation literature, the underlying assumptions of conflict models tend to be rational which means that conflict parties choose behaviours depending on their likelihood of achieving desired outcomes (Thomas, 1992). This influence, however, has ignored normative reasoning and emotions that could have strong effects on the behaviour of conflict parties (ibid). Drawing heavily on Fishbein’s (1963) work, Thomas (1992) notes that behaviour results from intention and intention is shaped by the additive effects of two forms of reasoning i.e. rational/instrumental reasoning and normative reasoning. As emotions are regarded as an important feature of conflict phenomenon (e.g., Pondy, 1967) therefore, Thomas (1992) expanded the Fishbein’s central idea and posited that intentions are shaped by the additive effects of reasoning and emotions i.e. rationale /instrumental reasoning, normative reasoning, and emotions. Fig.2 depicts the importance of reasoning and emotions in determining the course of conflict management. The relevance of process model of conflict to the construction project settings could be ascertained from the fact that the process model of conflict is grounded in the Fishbein’s work on behaviour — the basics of which have been extensively tested in the form of theory of planned behaviour in variety of contexts including construction project management settings (cf. Zhang and Ng (2012); Teo and Lossemore (2001); Begum *et al.*, (2009)). As the basics of Fishbein’s work have withstood the test of time in various contexts including construction, quite plausibly the process model of conflict grounded in Fishbein’s work is expected to offer insights on the proactive management of conflicts in construction project settings.

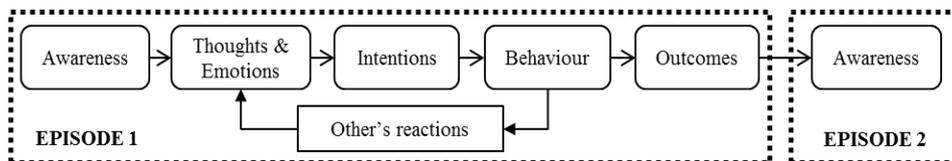


Fig.2 Process Model of Conflict (Thomas, 1992)

Depending on the goal of conflict management, Thomas (1992) proposed that conflict management can be either short term or long term. These both types of conflict management then could either be focused on addressing only one party’s concerns, or to look after the concerns of both parties or even to address the concerns of a larger system. As the short term perspective deals with the situations on “*here and now*”

basis it certainly is not of descriptive value for those who want conflicts to be managed through improvements in structural conditions (parameters) of the system. Short term conflict management perspective is essentially reactive in nature whereas long term conflict management professes the idea of proactive conflict management whereby structural parameters of a system shape one's reasoning to collaborate in a conflict situation. Both perspectives are of importance from their respective standpoints. Long term conflict management perspective is of value when the objective is to manage conflicts through collaboration whereas short term conflict management is appropriate when the principal parties expect to encounter conflict situations where the collaboration is not practical (Thomas, 1992). Intra-organizational interface management is benefited most when the conflicts are managed collaboratively. Also, the purpose of collaborative conflict management fits well with that of interface management as 28 CEOs of different companies have suggested that collaborative conflict management suits most when the objective is to learn; when it is desired to merge insights from people with different perspectives; and when the objective is to find integrative solutions (Thomas, 1992). This line of reasoning suggests that collaborative conflict management suits best to interface management and could systematically be achieved in an organization by the long term perspective of conflict management. Long term perspective of conflict management argues for structural changes in a system to enhance opportunities and reduce constraints to achieve more globally optimal set of solutions. Colloquially speaking, Thomas'(1992) 'long term conflict management' and Johns'(2006) 'context' are similar in nature as both see behaviour emanating from the force field (Lewin, 1951) characterized by enhancing opportunities and restraining constraints. Therefore, long term conflict management perspective provides opportunity to account for the context in the shape of structural variables and allows one to see how contextual variance impinges on the behavioural outcomes. Although the long term perspective of conflict management carries a lot of intuitive appeal, measuring structural conditions for empirical research purposes is a challenge. However, this challenge has been surmounted by bringing in the notion of climate that deals with shared perceptions of individuals with regard to particular phenomenon at certain level of analysis.

Organizational climate is defined as "*the shared perceptions of and the meaning attached to the policies, practices, and procedures employees experience and the behaviours they observe getting rewarded and that are supported and expected*" (Schneider *et al.*, 2013). Synthesizing Schneider and Reichers' (1983) etiology of climates, Naumann and Bennett (2000) note that climates develop from (1) social interaction giving rise to shared meanings (the symbolic interaction approach), (2) attraction/selection/attrition (ASA) giving rise to homogeneity (the ASA approach), and (3) mere exposure to the same policies, practices, and procedures (the structuralist approach). We submit that it is the structuralist and social interaction approach that offer insights into etiology of conflict management climate in contractor's project organization. Structural approach refers to the influence of characteristics of structural properties of an organization on individuals' attitudes, values and perceptions of organizational event in the organization. However, structuralist argument fails to provide insights as to how these organizational characteristics could influence perceptions homogeneously across different groups (Schneider and Reichers, 1983). Therefore structuralist argument could help in differentiating the climate of two different organizations but not within the same organization (*ibid*). This argument is complemented by social interaction view which argues that climates are created by the social interaction process. Social interactions allow individuals to understand the

meaning of various aspects of the work context and ultimately provides basis for development of homogenous perceptions across different groups working in the organization. Therefore, conflict management climate is expected to evolve through exposure of same policies, procedures and norms and the homogeneity in perceptions is linked to the social interaction of individuals from different functional teams.

CHARACTERIZATION OF THE NOTION

Drawing on the Thomas' (1992) structural framework for collaborative conflict management and the theory of climate, the proposed three dimensions of the construct are as under:

Rational reasoning climate

Drawing on the theory of climate and structural variables posited to foster rationale reasoning, the notion of rationale reasoning climate is defined as shared perceptions of the individuals with regard to structural variables— positive mutual regard, mutual trust, power parity, commitment to organization mission, organic climate and collaborative reward systems— that foster rationale reasoning necessary to achieve collaborative conflict management. Building on expectancy theory, Thomas (1992) has identified two distinct types of structural variables i.e. integrative incentives and feasibility conditions. Integrative incentives are those variables that contribute towards the valence of an intended outcome (in this case collaborative outcome), whereas feasibility conditions are those that contribute towards the expectancy that such an outcome is attainable. Therefore, rationale reasoning climate is construct that measures whether the individuals in the organization attach valence and expectancy in the attainment of integrated outcome.

Normative reasoning climate

Normative reasoning climate is defined as shared perceptions of the individuals about the structural variables that foster normative reasoning which in turn allows to achieve collaborative conflict management. Synthesizing Fishbein's model (1963), Thomas (1992) has noted that *"force of each normative system on the individuals' intention to collaborate is assumed to be a multiplicative product of (a) the degree to which that normative system prescribes collaboration and (b) the degree to which the party is motivated to comply with that normative system. These structural factors are referred to as "collaborative norms and precepts" and "acceptance/internalization factors," respectively"*. Therefore normative reasoning climate is a construct that measures the perceptions of individuals about the organizational norms, shared collaborative expectations, and organizational cohesiveness.

Emotional management

It is now well accepted notion that conflicts can only be productive if the emotions during the episode of conflict are positively channelized (De Dreu and Weingart, 2003). In line with the definition of collaborative conflict management that is concerned with confrontation and cooperation, the collaborative efforts requires reality centric handling of the conflict situation. (Thoits (1984)) has named this reality centric handling of conflict as *"problem-focused coping"* where party handles the conflict in a pragmatic way rather than depending on defensive mechanisms such as cognitive distortion — a process that constructs a psychological protection from the threat to self-concept (Thomas, 1992). Thomas (1992) has identified 'social support' as a variable that buffers between individuals and the effects of stressor. Thomas (1992) also notes that *"social support is also a major source of positive affect which,*

as discussed earlier, serves to block the expression of negative emotions and to provide a motivational force for cooperation". Thomas (1992) further notes that social support is not merely notion of providing comfort to individual rather research shows that colleagues also help individuals to steer them away from the distorted interpretations of events "*that generate inappropriate or maladaptive negative emotions*".

RESEARCH AGENDA

Conflict management climate as conceptualized in this paper provides understanding on how intra-organizational conflicts could be managed proactively. As conflicts are integral feature of organizational life, managing conflicts proactively can have productive ramifications on organizational performance. Therefore, this section delineates on the notions that could be explored well in connection with this newly conceptualized construct. However, the conceptual underpinning for the connections between conflict management climate and other notions is beyond the scope of this paper and may be presented elsewhere. Hence, the role of agenda here is to present the possible avenues for future research.

(1) Currently, in the main stream management literature, 'social capital' as a notion is being researched upon and many researches have shown its worth in the context of organizational performance. Some even have shown its influence on project success. However, not much is known as to how social capital can be developed in project organizations which are purposefully built and are of temporary nature. We believe that conflict management climate holds theoretical potential in explaining the development of social capital in project organizations. As conflict management climate epitomizes an environment of trust, normative norms, and social support, it may allow people from different functional teams to bridge and bond ultimately leading to the development of social capital.

(2) Organizational citizenship behaviour (OCB) — compliance with the company, altruism, conscientiousness, interpersonal harmony, and protecting company resources— as an extra role behaviour is known to have positive impact on project performance. We expect that conflict management climate reflecting the perceptions of trust, social support, commitment to organizational mission, social cohesiveness, may influence OCB. We further propose that psychological capital — hope, resilience, optimism, and efficacy — may play a mediating role between conflict management climate and OCB.

(3) We also submit that conflict management climate holds theoretical potential in explaining the variance in intra-organizational interface management. Interface management is believed to be linked to conflict management climate via collaborative conflict management because collaborative conflict management provides critical foundation to understand different perspectives and to reach to an integrative solution— the idea which is at the heart of interface management. Also, owing to uncertain environment of complex projects, iterative working practices are required to successfully complete a task at hand. Iterative working practices are to be benefited most by collaborative conflict management as people will tend to communicate and coordinate with each other without getting into task or relationship conflict.

CONCLUSION

The conceptualization presented in this paper marks a departure from the conceptualization that was advanced by the dominant paradigm of dual concerns

models. Where traditional paradigm of conflict management dominated by dual concerns models focus on short term conflict management, the notion of conflict management climate builds on long term perspective of conflict management and argues for pro-active conflict management by improving structural parameters of a system. This paper does not only contribute towards body of knowledge by presenting the conceptualization of this construct, it also has refreshed the process model of conflict which explains how rationale reasoning, normative reasoning and emotions play their part in determining the course of conflict management. It notes the importance of context in determining behavioural outcome and has therefore pointed out possible shortcomings in the extant literature of construction project management. By arguing that long term perspective of conflict management captures context, the conceptualization of conflict management climate is expected to produce empirical research whose findings will be more generalizable and attractive for practitioners. Finally, this paper has suggested a research agenda which we believe will provide a new perspective to look into other notions (e.g. social capital, organizational citizenship behaviour, psychological capital and interface management).

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DEVELOPING TEMPORARY MANUFACTURING FACILITIES FOR RESIDENTIAL BUILDING: A CASE OF THE MODERN FLYING FACTORY

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The building industry is often berated for its shortcomings in meeting up with the demand for the provision of new housing. Addressing the need for new housing stock is a challenge that has led to debates among professional bodies, the construction sector, housing industry and government. The introduction of new manufacturing technologies is often offered as a solution, but the challenges of increasing the amount of off-site construction in residential building are well known and well-rehearsed. The modern flying factory (MFF) is a concept that involves the manufacture of specific components or modules in temporary off- or near- site locations using relatively simple and quick to set up and dismantle technologies and processes. The aim is to produce short batches and hence achieve some of the benefits of off-site manufacture on a much smaller scale than in dedicated factory environments. A case study of a modern flying factory being set up to produce pre-assembled utility cupboards for a large residential development in London is presented, involving participant observation and informal interviews with key actors on the design and operationalising of the process. The case reveals that although there are costs, efficiency and health and safety benefits to using MFF approaches, there are also challenges to overcome over the time required to set up and establish the process for relatively short runs, and in evaluating whether the MFF or traditional site based production is most effective for particular aspects of projects.

Keywords: manufacturing, house building, flying factory.

INTRODUCTION

The topic of off-site, industrialised building or Modern Methods of Construction is one which has been debated considerably in construction. Work by scholars such as Gibb (1999), Goodier and Gibb (2007), Pan *et al* (2007) and many others have both rehearsed the benefits of off-site manufacture, and commented on the modest uptake of such processes in a UK context. Reduction of time and amount of activities on site (along with the health and safety advantages a factory environment brings) and improved quality are often cited as the benefits. But these are tensioned against issues such as the initial investments and economies of scale required (Boyd, 2012), the relative inflexibility of modular components versus bespoke design (Lawson, 2014) and a general perception that modular construction is more expensive than traditional are three of the main reasons given for this, even if some increase in use, especially in housing, has been found (Goodier and Gibb, 2007).

Alongside this is a growing problem in meeting demand for new housing, with the estimated 115,000 new homes per year being produced falling some way short of the

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estimated requirement of 260,000. There are an estimated 2.6 million 'concealed households' in the UK - defined as separately identifiable family units but which do not have separate facilities. The scale of the problem is continually growing with an increasing population and growing gap between supply and demand. Increasing the use and scale of off-site manufacture is heralded as one solution to address this, but despite its benefits, this remains a significant challenge.

This paper describes a case study piloting a form of off-site manufacture which realises some of the benefits of off-site but at a smaller scale, with more flexible and temporary facilities - the Modern Flying Factory. It is part of a Technology Strategy Board funded project led by Skanska UK, one of the UK's largest contracting organisations. Specifically, this case concerns the development and production of utility cupboards - pre-assembled units containing the electricity switch board, boiler, washing machine and related services which can be then installed on site in one go. The housing project is a large residential development in south London. The aim of the paper is to report on the instigation and development of this modern flying factory, and to shed light on the practical challenges that emerge from this process.

MODERN METHODS OF CONSTRUCTION (MMC)

There are a number of related and interconnected terms used to describe the production of building components or sections away from the building site. Pan *et al* (2007) describes how early discussions of 'prefabrication' have moved through 'off-site fabrication' to 'off-site manufacture' and most recently MMC. Although there are important variations in terms of types of MMC (for instance component or volumetric) for consistency we use MMC in this discussion.

Despite the attractiveness of offsite technologies, in term of process benefits and economic impact, both the nature and the scale of innovation in the UK house building sector are conservative in comparison with other countries (Hooper, 1998). The Barker report (Barker, 2004) specifically identifies increasing the use of off-site and addressing the barriers to the take up of MMC as vital to addressing the UK's housing shortage.

Modern Methods of Construction (MMC) as defined by Gibb (1999) is a process that incorporates prefabrication and pre-assembly. The process involves the design and manufacture of units or modules, usually remote from the work site, and their installation to form the permanent works at the building site. It is a project strategy that promises to change the orientation of the building process from construction to manufacture and installation. Benefits from using such technologies have been widely studied by (Gibb, 1999; Sparksman *et al.*, 1999; Housing Forum, 2002; Parry *et al.*, 2003; Venables *et al.*, 2004) and they include reductions in cost, time, defects, health and safety risks, environmental impact and a consequent increase in predictability, whole life performance and profits. MMC are:

“about better products and processes. They aim to improve business efficiency, quality, customer satisfaction, environmental performance, sustainability and the predictability of delivery timescales. Modern Methods of Construction are, therefore, more broadly based than a particular focus on product. They engage people to seek improvement, through better processes, in the delivery and performance of construction.” (Barker 33 Cross-Industry Group, 2006).

What makes MMC “*more broadly based*” than just prefabrication is the application of 'new production philosophies': an evolving set of methodologies, techniques and tools,

the genesis of which was in the Japanese JIT and TQC efforts in car manufacturing that have since been applied to construction (Koskela 1992). The core of the new production philosophy is in the recognition of two distinct aspects of all production systems; (a) conversions; value adding activities and (b) flow; non-value adding activities; inspection, waiting, moving etc. (Koskela, 1997). Managing these activities (by optimising conversions and eliminating flow) can contribute to significant improvements in construction processes in modular housebuilding as measured by cost, time and sustainability indicators (Nahmens and Ikuma, 2011).

THE MODERN FLYING FACTORY

The concept of the Modern Flying Factory (MFF) is positioned somewhere between full scale, permanent manufacturing facilities and traditional site based construction. It involves the use of a temporary, near site facility, which is used to manufacture or assemble components using relatively low-tech equipment, which are then taken to site. The first pilot for the project involved the manufacture of straw bale wall panels in a farm building for an extension to a school in Bristol which took place in the summer of 2013. The advantages of the MFF compared to a fixed prefabrication assembly are flexible short term leases on the space, low capital intensity in the production system, minimising transportation of volumetric components (and related energy reduction benefits), and the use of local materials and, where possible, labour. The main aim is to deliver the benefits of off-site factory assembly whilst overcoming the barriers of high capital investment and high transport costs. Skanska UK estimate this approach has the potential to deliver 30% shorter programmes, a 28% reduction in cost per square metre (as well as a more predictable build cost) and provide higher-quality. This is because the structure is built in controlled conditions, removing the potential effects of bad weather and other on-site hazards, and speeding up the assembly of the building on site.

The MFF is similar in concept to Martinez *et al* (2013) 'flexible field factory' which seeks to address the same niche in the construction production system but via a mobile automated assembly plant based on a shipping container. The difference between flexible field factory and MFF is that the former is oriented towards frequently repeated tasks and proposes a relatively high degree of capital-intensive automation for that task on the assumption that sufficient high-volume projects would be available to move the field factory between. It is also implicit that the field factory would be deployed on-site. MFF is a more open system potentially applicable to any components or sub-assemblies except those that require significant capital investment.

The project-specific nature of MFF puts it within the analytical scope of Gann and Salter's (2000) project-based project framework in which the MFF can be seen as an integrator within a network, mediating between material and component suppliers and the construction site. The project-specific MFF is likely therefore to share many of the characteristics of construction project organising that have been shown to be challenging to the adoption of lean manufacturing concepts in general (Vrijhoef and Koskela, 2005) and for industrialised housing in particular (Höök and Stehn, 2008). For instance, in Höök and Stehn's (2008) research, construction workers in an industrialised housing production system had low motivation to consider built-in quality, continuous improvement and consideration of flow which was attributed to the prevalent construction project culture.

The fact that the MFF is embedded within a 'loosely coupled' (Dubois and Gadde, 2002) production system defined by a construction project presents both 'upstream'

and 'downstream' challenges. For example, by removing some elements of on-site work the overall project process will require some reconfiguration or re-sequencing. Conversely, the typical project processes in which work packages are often awarded close to construction might limit the amount of pre-planning and optimisation of the specific MFF. The case study and analysis follows the set-up and operation of the MFF in order to investigate these challenges in a real environment.

METHOD

In line with calls for more connectivity between academic research and practice (e.g. Green and Harty, 2008; Stokes and Dainty, 2011) this case study involves collaborative co-production of both activities and data in a live setting. The research design is a longitudinal single case study overlapping with an ongoing action research programme (Brydon-Miller *et al*, 2003). The action research project consortium is led by Skanska UK and involves Modcell, the South West Manufacturing Advisory Service, the Building Research Establishment and the University of Reading. The findings reported here were developed primarily through the single case study. In that study the researcher spent time at the MFF during its set-up and during the manufacture of the utility cupboards. Non-participant observation of work processes, and the physical setting and products of the factory were supplemented by ongoing discussions and informal interviews with factory managers and staff and members of the action research team. Additionally the researcher performed a form of cross-case participant observation assisting action research team members with work study and also attended action research programme meetings and discussions. Overall, the case represents a detailed and finely grained account of the efforts involved in mobilising the modern flying factory.

CASE DESCRIPTION

Before Skanska UK set up the MFF, the project consortium established the following criteria for the delivery of the MFF and the utility cupboards: (1) the location for the MFF must be no more than a distance of 20-25 miles radius from the residential development in order to achieve the full potential of the off-site construction facility; (2) the utility cupboard must be fit for purpose; (3) there must be strict adherence to sustainability requirements; (4) it must be economical and being able to reduce the construction programme time for the project; (5) the MFF must produce reductions in carbon dioxide emissions; (6) the setup and operation of the MFF must be achieved at a reasonable cost; and, (7) the MFF must be able to contribute directly or indirectly to the resolution of the UK housing shortage.

A total number of 855 utility cupboards are required for the residential development's first phase - 535 units to be constructed in the factory and 320 units to be constructed in-situ. The need for in-situ construction is due to variation in the spaces available in some of the apartments in the development. It was anticipated at the start of the built-out (in the second quarter of 2014) that the MFF at full production capacity would produce 20 units per week.

Process of the start-up and operation of modern flying factory (MFF)

The initial findings identify two phases of set-up and operation. Each phase is described below.

Phase 1: Set up of the modern flying factory (MFF)

This first phase was to set up the MFF. The choice of a factory location / space was a warehouse space adjacent to the builder's off-site manufacturing factory in Slough. Further, the factory was located within 25 miles of the housing development site. The proximity to the residential development site would reduce the cost of transportation and also have a significant reduction in carbon dioxide emission from the trucks that would be involved with transporting the final products (the utility cupboard) to the construction site (an important sustainability factor).

Phase 2: Manufacturing / production of the utility cupboards

The second phase, the manufacturing / production of the utility cupboards consisted of two stages: constructing the cupboard, and installation and construction of the internal fixtures. Each stage is discussed in detail below.

1. Constructing the cupboard

The construction of the cupboard can be divided into six stages, including delivery of the metal frames to the factory (activity 1-1), fixing of boarding to the back of the metal frames (activity 1-2), boarding to the top and sides of metal frame (activity 1-3), plaster boarding (activity 4), plaster board fix to the front edges at the top and sides of the cupboard (activity 1-5), and taping and plastering of the cupboard (activity 1-6). Finally, a completed cupboard ready for the installation and construction of the internal fixtures.

2. Installation and construction of the internal fixtures

The installation and construction of the internal fixtures consisted of five sub-processes: fixing the electrical conduits (activity 2-1), installation of the water retainer and distributor with heat exchanger (HIU Unit) (activity 2-2), installation of the water pipes for the cold and hot water system (activity 2-3), fixing of the electrical switch board, electrical units and sockets, and heat reclamation unit (MVHR) to enable electrical installations (activity 2-4); and installation of telephone box, satellite box and the TV cable points (activity 2-5). Finally, a completed utility cupboard in the factory is ready for transportation to the site.

INTERIM FINDINGS

Key challenges of the set-up and operation of modern flying factory (MFF)

The initial findings indicate that there are a number of challenges to the setup of a modern flying factory (MFF) and the manufacturing / production process subsystems such as utility cupboards. These are less to do with internal processes within the factory itself, but more the interdependence between the MFF, supply chain and wider project activities. These key challenges are discussed in more detail below.

1. Material procurements to specification

Acquisition of materials and components to specification for utilisation in constructing the utility cupboards caused a number of specific problems as specification details were not adhered to by manufacturers and suppliers. The non-compliance to specification led to the following problems encountered during the manufacturing process.

First, the metal frames supplied for starting the process were painted in 'black' instead of the specified grey colour (activity 1-1). The rework of repainting the metal frame in black incurred extra person hours and led to a slow-down of the production speed. A further planned improvement is to move from metal to wooden frames which do not

require painting. Second, four 12 mm diameter holes at the base of the supplied metal frames were incorporated into the design to be used as the stabiliser and also to create space between the metal frame and the concrete floor during assembly (activity 1-3). These holes were either not in place, or they were incorrectly placed requiring rework and adaptation.

Third, the pre-drilled holes in the plywood boards supplied for the top of the cupboard were not correctly placed for installing pipes for the water retainer and distributor with heat exchanger (HIU unit) (activities 2-2 and 2-3) and the vents for the heat reclamation unit (MVHR unit) (activity 2-4). Finally, the plaster boards used were initially not cut to the correct dimensions. This occurred as a result of an error from the initial drawings and specification obtained from the consultants who did not take into consideration the thickness of the plywood board at the back of the cupboard would extend into the internal part of the metal frame. This thickness should have been deducted from the width of the plaster board during the initial drawings and preparation of the specifications and before ordering the plasterboard. On discovering this error, corrections could only be effected by reducing the plaster board after boarding the plaster board to the metal frame. Further, reducing the plaster board created a lot of health and safety issues from dust emissions into the factory. It was time consuming, as it slowed down production speed from the recruited 2 person gang fixing the boards.

What these examples show is the large number of small but significant details that need to be considered in order to achieve productive assembly in the MFF. The overall vision of the approach is to achieve manufacturing levels of productivity but in a temporary factory with low capital costs. These numerous examples of 'on-site' problem solving (although the site here is the MFF) highlight the conceptual issues of how to characterise the early phases of assembly of the cupboards. The process could be considered as an advanced form of site-work in which the repetition and the factory environment allows for quicker refinements of the product and process and the sharing of those refinements. From a manufacturing perspective, the phase of work described in the case study contains many examples that might be seen as inefficiency and waste in the process but might be more usefully be thought of as a prototyping phase to develop a new product, and solve these myriad small issues before full production.

Selecting the appropriate logic would have implications for the development of the MFF concept and the way it is embedded in the broader construction system. These examples also highlight the interconnectivity of the MFF and its reliance on a design and material supply chain that is unused to designing products for assembly or supplying materials and components to the required level of accuracy. From the perspective of the MFF and optimisation activities, this shows how the supposed discrete activities of the factory cannot be separated from the wider supply chain, and that optimisation is necessary across the supply chain. This is not inconsistent with the principles of lean production, but does re-introduce issues of how to bring about changes outside of the factory environment. This is perhaps a new requirement for the MFF process, and shows how concurrent adaptation is required throughout the supply chain to mobilise the MFF effectively.

2. Lack of storage space

It was found there was a lack of storage space for the materials procured for the production process and for the finished utility cupboards. It was found there is a much greater challenge with the emerging requirement for a 'holding space' for finished

utility cupboards that could not yet be taken to the residential project construction site. This was down to variations in the programme on site, and demonstrates the challenges of seamlessly connecting the MFF based production process, with the main construction activity on site.

In order to address this problem, a temporary space was created behind the builder's off-site manufacturing factory for storing the finished utility cupboards, supplied and unused metal frames, and most of the plywood and plaster boards. Storage is not a new issue for the builder but shows the need to develop ability to predict and model storage requirements in a number of scenarios. When faced with a choice of potential spaces, there is a need to balance the risk of over-crowding with the cost of spare capacity - in the case study, the location of the MFF is close to the construction site, in this case, not more than a distance within 20-25 miles radius from the construction site near to the builder off-site manufacturing factory was fortunate.

Whereas the discussion of material specification above showed the interdependence between the MFF and the supply chain, this shows similar connectivity between the factory and the construction site. Although technically the production of the utility cupboards off-site was compatible with the broader project requirements, delays on the project caused the factory to require storage, in lean terms a non-value adding flow.

3. Factory manufacturing space constraints

To reiterate, from the second quarter of 2014, production was anticipated to be at 20 units per week when the factory was at full running capacity. As of now (the beginning of the second quarter of 2015), production is at 15 units per week with a 17 person gang. It may be an unrealistic assumption to believe that the 20 units per week is achievable, because the factory manufacturing space is not large enough to accommodate more trades people and the factory is presently working extra hours including working most Saturdays and Sundays. This shows that there is exploratory work to be done to calculate the relationship between the process, available space in the temporary facility, and potential output levels, regardless of labour resources. This was an unanticipated problem when the 20 units per week were estimated.

Even this relatively simple process is reliant on numerous skilled trades in sequence, and this reveals two issues. The first is that the sequencing of skilled activities around a small component requires space as well as effective coordination. The second is that even a relatively simple process remains dependent on a range of skills, rather than being oriented to semi-skilled labour. This resonates with Höök and Stehn's (2008) assertion that a challenge for lean implementation is the existing pattern and landscape on on-site skills.

4. Lack of skilled personnel and skilled technicians

It was found that there was no skilled technical staff within the company near the MFF site that was conversant with the construction of the utility cupboard. As a consequence, sub-contracting firms were recruited for the boarding, taping and plastering of the cupboard. This was to ensure that there was strict adherence to specification details so that quality requirements were not compromised. However, getting these specially trained workmen when required at the factory was difficult to coordinate. Although this is by no means an unusual problem in site-based work, it does point to the need to consider the division of labour and sequencing of tasks carefully in a small-scale production process. Intermittent use of subcontracted trade operatives was necessary but prevents continuity in the process, and adds potential

delays, making it more difficult to develop a factory style continuous process rather than a more site oriented and disjointed set of activities.

The use of skilled trade operatives in the MFF is counter to the, sometimes implicit (Green and May, 2005), goals of de-skilling and multi-skilling for the workforce to reduce costs and increase flexibility. As in the spatial constraints', it also risks perpetuating the project culture and limiting the benefits that can be gained by the application of lean techniques as found by Höök and Stehn (2008). However, our observations also support their conclusion that the creativity and skill of construction trades workers represent a relatively untapped resource for continuous improvement if mobilised correctly.

DISCUSSION AND CONCLUSIONS

This paper defined the MFF with other related topics such as MMC and offsite manufacturing with a clear distinction of the additional benefits and aims of the MFF which is to deliver the benefits of off-site factory assembly, while overcoming the traditional barriers of high capital investment and high transport costs and while also reducing carbon dioxide emission (keeping the environment sustainable) and speeding up the assembly of the building on site by reducing time spent.

Overall, as a pilot the on-going MFF can be seen as a success - the process is now more refined, production is flowing and if anything, it is the variations in progress on-site to enable installations that are the major issues being experienced. But the case is also instructive in terms of developing the concept further, in thinking through the MFF as an area for lean improvement, and in instigating more use of MFFs. There was perhaps an under-estimation of the complexity of the task, and this led to a longer period between setting up and reaching a stage where production was in full swing. Some of the details around potential capability, for instance in terms of numbers of units per week would have been difficult to accurately predict until the assembly process was tested. The final figure of 17 units per week is the MFF operating at full capacity, and this suggests that there is a complex relationship between required output, the 'scope' of the process and the size of the factory. But perhaps above all, the delays for installation on site show that careful consideration of what kinds of activities can be extracted from site, and relocated to a MFF is required. Although technically, certain aspects of site-based activities can be relocated to a factory environment, it is impossible (or at least was in this case) to isolate the MFF from broader interdependencies in the network, whether the supply chain, or the site-based project.

Finally, there is an interesting mix of issues experienced here, some of which are more related to on-site construction and others to factory style production. For instance the subdivision and coordination of labour was an issue - not unusual for construction work and related to the construction of the utility cupboards being reliant on a range of skills, rather than an automated, unskilled or semi-skilled process. Similarly some of the quality issues with components coming into the site could be attributed to the supply chains lack of readiness to provide components with the exact specification and adaptations required for the MFF process. But also issues such as the need for (and lack of) storage space, and the adaptations to the process such as incorporating the stabilizers to enable the cupboard to be moved along the factory as it was assembled are 'classic' production issues. The MFF was set up to sit somewhere between the full scale fixed factory and the building site, and is experiencing some of both in terms of getting up to speed.

Returning to Gann and Salter's (2000) model, the MFF can be positioned as an integrator in a network mediating between material and component suppliers and the construction site (or project). This provides perhaps an unintuitive insight where the factory performs a similar role to any other project based organisation, rather than functioning as a different type of organisation. It is not surprising then, that many of the challenges stem from this mediating and integrating role, rather than the continuous improvement of the factory process itself. A question for further exploration is whether this can be another part of the explanation for the lack of off-site use in construction projects.

The MFF offers a novel way to bring some of the benefits of MMC at much lower economies of scale. There will always be some process improvement required for any new activities but those experienced in this case were straightforward to rectify. There are also some new requirements in terms of supply chain expectations and quality to enable a smoother transition to full operation. But as proof of concept, the case here shows that considerable benefits can be realised with the MFF.

ACKNOWLEDGEMENTS

The authors would like to thank our consortium partners for their involvement in this case, and especially Andrew Skinner and Sam Stacey of Skanska UK for their valuable input into the case study.

The research is part-funded by the Innovate UK's under the 'Rethinking the Building Process' programme: 'Near Site, Off Site - affordable near site assembly in Modern Flying Factories' (Project Reference: 101344).

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DISCRETE-EVENT SIMULATION MODEL FOR OFFSITE MANUFACTURING IN AUSTRALIA

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Offsite Manufacturing (OSM) has potential capabilities to enhance the Australian affordable housing supply. However, OSM supply chain requires effective management between two concurrent working sites: (1) offsite factory; and (2) building site. This means that information and material flows are necessary components for managing OSM supply chain. Nevertheless, the OSM supply chain is influenced by a number of major challenges such as broken junction between offsite and onsite, jumbled onsite process and vague customer demands. To overcome these challenges, this paper developed a Discrete-Event Simulation (DES) model for OSM in Australia. The Arena® software is designed to model manufacturing and construction processes to support a high level of analysis. Arena® provides advanced capabilities to mimic the behaviour of real system entities, layout and flow logic, as well as to produce data distributions and confidence intervals for the performance measures. The actual data was collected using interview with four OSM builders in Australia. The simulation model assist to evaluate three OSM scenarios (as-is, what-if I and what-if II) with different house order information intervention to the OSM supply chain. The simulation results indicated noteworthy improvements in the house completion time. Some limitations are acknowledged as the study reports on the findings using just limited interviews. Secondly, the model was developed and tested within Australia only; as such future studies could be employ case studies and further be conducted in other countries to enhance the generalisation of the findings. Currently, there are limited studies which seek to investigate the potential of DES within the housing supply chain management. In order to address this gap, this paper contributes by developing a DES for addressing challenges associated with the supply chain within the Australian housing sector.

Keywords: Arena® Simulation, discrete-event simulation, offsite manufacturing, modelling and simulation.

INTRODUCTION

The supply of affordable houses is an urgent concern for the housing market in developed countries (Demographia 2014). The Australian housing market is experiencing a severely unaffordable situation and the calls for affordable housing supply are increasing continuously. In such an environment, offsite manufacturing (OSM) has been suggested as one of the viable solutions to improve the housing affordability situation. OSM has the capability to meet the growing affordable housing demand by providing houses at reasonable price without compromising the quality (Mostafa *et al.* 2014a; NHSC 2013). OSM provides a factory controlled environment to fabricate house components (e.g. panels, pods, or modules). The house construction components are manufactured in the offsite factory then transferred to the building site for assembly and installation. The OSM practice accounts for 3%, with AUD 1.4 billion value of work, of the total construction sector in Australia (Schesinger 2014).

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Approximately, more than 54 corporations constitute the OSM industry in Australia working in non-volumetric and volumetric pre-assembly and modular building (Blismas and Wakefield 2009). OSM has been acquired a popularity from practitioners and researchers in Australia in recent years (Kenley *et al.* 2012; Mostafa *et al.* 2014b; Wynn *et al.* 2013). This is clearly from the establishment of PrefabAUS as the peak body for Australia's OSM industry in 2012. It comprises OSM manufacturers, suppliers, architects, engineers and research bodies whom are committed to innovation, productivity and quality in Australian built environment through an increased uptake of prefabricated building technologies (PrefabAUS 2015).

Simulation is a suitable tool for evaluating and analysing the dynamism of any system. It has been used in to model and evaluate different alternatives in complicated construction projects (AbouRizk 2010). Discrete event simulation (DES) is an effective technique to represent and study the operational processes of any construction system. In the UK, for example, Vidalakis *et al.* (2013) used DES to study the effects of varying demand of construction materials on logistics performance measures. In Australia, DES has been mainly used in specific areas of offsite supply chain including planning and scheduling of workers. Arashpour *et al.* (2015) applied DES to create multi-skilled resources in OSM through comparing cross-training strategies. Another study by Dalton *et al.* (2013) designed a simulation model for investigating relationship between day-to-day operational variations effect on the volume builders efficiency. The simulation model allowed explaining the behaviour of construction system used by the volume builders. At the same time, the extent of resource availability effect on house completion time was investigated by Fadjar *et al.* (2013). Their research showed that DES is an effective method to predict the effect of resource shortage on the house completion time.

Despite these research works, considering the entire OSM supply chain from receiving the house order until the completion of the house is insufficiently addressed. Most importantly, materials and information flows are important for an efficient OSM supply chain. This is because of the extended nature of OSM supply chain to manage two working locations concurrently and potential production process bottlenecks. Moreover, each house order has to run through many different processes once a builder received the order. Each OSM process is influenced by the availability of the resources and conditions at the building site. This leads to unpredictability of house completion time and delivery to clients. Therefore, this paper applied simulation to control the randomness of OSM processes and to evaluate different scenarios of house order interference within the OSM supply chain. The simulation model used was developed using Arena® simulation software.

RESEARCH METHODOLOGY

The objective of this research is to develop a conceptual model representing the entire OSM supply chain in Australia (As-is scenario), and suggest and test improvement scenarios (what-if) using simulation. The methodology in this research is based on discrete event simulation (DES) as suggested by Martinez (2010). The rationale and benefits for using DES over other simulation modelling techniques is well documented in literature as previously discussed in the preceding introductory section (AbouRizk, 2010; Vidalakis *et al.* 2013; Dalton *et al.* 2013; and Fadjar *et al.* 2013). Recent studies such as Moradi *et al.* (2015) further provide support to the appropriateness of DES by comparing it with systems dynamics across a number of criteria including problem scope and model components. Generally, DES has been applied at the operational level due to its capability to capture detailed information on

the resources (operational details including availability, processing time, and idle time) and flow of entities (logic, probability distribution, queue and waiting). Arena® simulation software was used to model and evaluate different scenarios of the OSM supply chain. The stages of the research methodology are to:

- 1 Identify the main processes and stakeholders in the whole OSM supply chain
- 2 Develop the conceptual model for the entire OSM
- 3 Suggest and evaluate scenarios of managing OSM using DES

For data collection, this study employed literature reviews and interviews with OSM experts in Australia. A review of the related literature on OSM in Australia assisted in establishing a base of the OSM. This includes the types of OSM, OSM main processes and builders. This facilitated designing the interview questions. The interview was conducted to identify the key processes and its operational data within the current practice of OSM supply chain of a single-storey detached house as mentioned in Blismas (2007) with average floor area of 241.1 square meters as indicated in the Australian Bureau of Statistics (ABS 2014). The average floor area represents the median value of the usable space in a house at the final stage of its construction across Australian States and Territories (ABS 2014). Teddlie and Tashakkori (2009) stated that semi structured interviews facilitate the gaining of an insight to the research topic. Therefore, this study used semi-structured interview to facilitate open discussions on the OSM processes. The interviewees' organisations and contact details were identified from the member directories of PrefabAUS as well as help from the PrefabAUS CEO and founding director. The interviewees were recruited based on their direct involvements and experience on OSM processes (design, manufacture and building site). The total number of invitations sent for interview participations were 24. However, only seven participants' were willing to participate but, three participants later declined due to work and time commitments. Therefore, a total of four interviews in two different Australian States were conducted via telephone following the suggestion of Hughes (2008). The telephone interview is widely recognised as cost effective when interviewing participants across geographically dispersed area. The interview lasted between 30 to 60 minutes. Because of the small number of the conducted interviews, the data was transcribed and classified manually. The data covered the OSM processes and its operational characteristics including process time, and resources which are required for the simulation modelling.

OSM CONCEPTUAL MODEL

Form the literature review and interview, approximately 25 critical OSM processes identified for developing the conceptual model. Figure 1 demonstrates the material and information flows including as well as stakeholders including clients, subcontractors, and material suppliers.

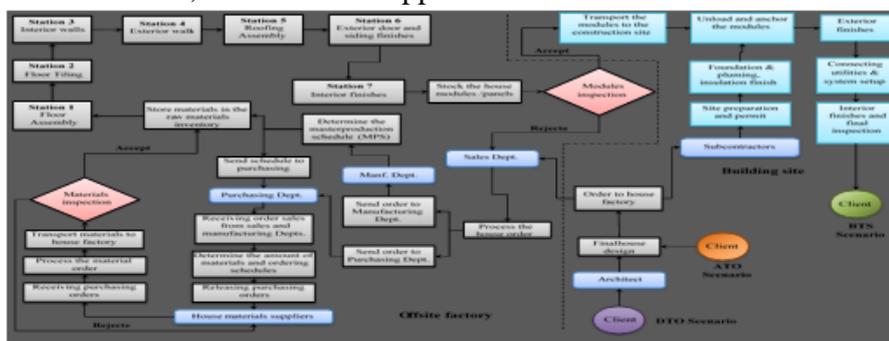


Figure 1: conceptual model and scenarios for OSM supply chain

The typical OSM information flow starts with the client-builder interaction to design the house. The potential client initiates the process by discussing the specifications of the house with the architect in order to finalise the house design. This is the current scenario (As-Is) of OSM in Australia and named design to order (DTO). When the design is approved by the client, the sales team prepare the house order and simultaneously communicates with the manufacturing supervisor for producing the components and the construction manager for preparing the building site. At the same time, the building permits are obtained from the housing council or developer. Then, the house order is sent to factory for production. In the factory, the manufacturing department defines the master production schedule (MPS) and what is required for purchasing. Accordingly, the house order is distributed to the floor, walls and roof production lines. The role of purchasing department in the offsite factory is to provide the necessary materials for house components manufacturing. This is done through preparing and releasing the materials orders to suppliers. Once the purchasing order received, the sales department employees inspect and store the materials in the raw materials inventory. When the house order components fabrication is finished, the components transported to the building site for installation. The components are uploaded and anchored on the building site once it arrived. Simultaneously with house components manufacturing, building site is prepared for installing and assembling the components. The preparation includes the excavation works, footer install, and foundation plumbing and insulation finishes. After the components are assembled, the first fix started with finalising the external finishes and joining the utilities. Subsequently, the second fix of internal finishes and final inspection are completed and then the order is ready to handover to the client.

ARENA SIMULATION MODEL DESCRIPTION

Model development

The conceptual model (Figure 1) was assured to represent the OSM supply chain. Then, the simulation model was developed to exhibit an overview of the current entire OSM supply chain and possibilities for efficiency improvements before implementation in the real world. This prevents a costly real world experiments. As the model is large and complex, the authors followed the suggestion of AbouRizk *et al.* (2011) by divide the model into four sub-models as demonstrated in Figure 2. These sub-models are: (1) finalising the house order; (2) preparation of the building site; (3) factory production of the house components; and (4) house installation.

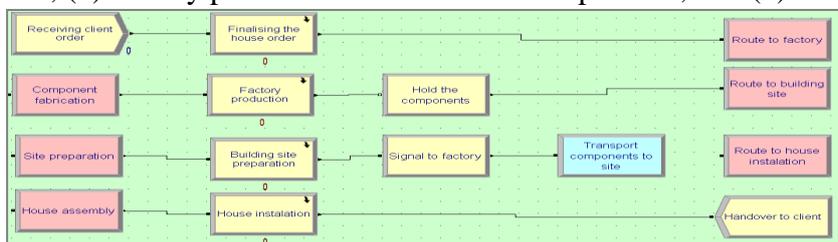


Figure 2: Arena simulation model of the OSM supply chain

The simulation model (see Figure 2) begins with the create module which is starting point for all entities in a simulation model in Arena® software (Kyu Choi and Kang 2013; Sadowski *et al.* 2007). The create module titled as receiving client order which makes an entity named as “Ent Client”. Consequently, the order goes through the four sub-models with different processes until they dispose at handover to client.

Simulation model assumption and runs

The model assumptions were determined by the real system operational conditions. In developing the simulation model using the Arena®, the following assumptions were used in this paper in the simulation of all four sub-models:

- The inter arrival time of client order in the first sub-model follow exponential distribution. It was assumed one order every five days and 2 entities per arrival with maximum 100 house order.
- The time probability distribution of the three sub-models was assumed to follow a triangular distribution. It is commonly used in situations where the minimum, maximum, and most likely values are available (Van der Aalst *et al.* 2010).
- Building materials were assumed to be available.

The simulation model was run over 36500 (356 days × 100 replications) working days. To approximate the number of required replications for the three scenarios, this paper followed the suggestion of Kelton *et al.* (2010). The first scenario, ATO, was simulated for an initial number of 20 replications. Then, the simulation runs for 100 replications which produced a 95% confidence interval. Each replication length was 365 calendar days with eight hours per day.

Model verification and validation

Model verification is done to ensure that the conceptual model is programmed correctly and does not contain errors or bugs while model validation ensures that the model meets represents the real system (Pace 2004; Shi 2002). In this paper, the authors considered the validity and verification of the conceptual and simulation models. The authors make sure that the conceptual model represents the real system of OSM through checking the model with the builders. Similarly, the Arena model has been verified through checking the logic and behaviour of the overall model and the four sub-models. Moreover, authors employed the independent verification and validation approach suggested by Sargent (2013). The authors contacted a third (independent) party to assess the model. The third party is a simulation consultant at the Simulation Modelling Services (SMS) Corporation in Australia. SMS is the certified partner of the Rockwell Automation (founder of Arena® Simulation) in Australasia. The simulation consultant reviewed the verification and validation of the simulation model developed. The consultant concluded that the model was an accurate demonstration of the OSM conceptual model.

RESULTS AND DISCUSSION

DTO (AS-IS) Scenario

This scenario covers most of the current practice of OSM in Australia. That is why the authors considered as-is scenario. In developing the simulation model, the authors identified the key performance measures that represent the OSM. The measures from a builder perspective are mainly related to the house completion time and number of orders they can achieved. House completion time is the total duration from receiving the house order until handover the house to a client. This time covers finalising the house order, components manufacturing time, building site preparation and components installation onsite. Therefore, all measures for these times and other such as record of house orders, finished houses in factory and completed house onsite were built in the Arena model using record module. This module continuously records the values for each measure over the whole simulation period (presented in Figure 3).

OSM Supply Chain Model				
Replications: 100		Time Units: Days		
User Specified				
Tally				
Between	Average	Half Width	Minimum Average	Maximum Average
Building site prep time	7.3335	0.02	6.0535	9.0775
Manufacturing time	14.3344	0.02	13.0439	16.2840
Record the completion time	26.3352	0.02	25.0567	28.2420
Counter				
Count	Average	Half Width	Minimum Average	Maximum Average
House orders in	67.7000	0.22	64.0000	71.0000
No of completed houses	53.1900	0.23	56.0000	63.0000
Record finished houses	63.6600	0.23	59.0000	67.0000

Figure 3: Arena simulation counter and tally results of the as-is scenario

It can be seen from Figure 3 that the house orders generated during the simulation time (almost 365 working days × 100 replications) were 71 orders. The finished manufacturing house orders were 67. This means that there are four house orders in the manufacturing process. The three time measures are also presented in Figure 3. The total duration from receiving the house order until client handover was approximately 29 days on maximum average. Moreover, the building site preparation time is nine days which included all site excavation, footers installation and foundation walls. At the same time, the manufacturing time of the house components was approximately 16 days. This consisted of all processes of the floor, roof and interior and exterior walls cutting and finishes.

What-if scenarios

The completion time is considered as one of the main factors of the housing undersupply situation in Australia (Dalton *et al.* 2013; Mostafa *et al.* 2014a). The house completion time can be shrink either by minimise the components manufacturing, the site preparation or house installation times. For this reason, this paper hypothesised and experimented two OSM (what-if) scenarios that highly contribute to house completion time reduction (presented in Figure 1). These scenarios are ATO and BTS. A brief description of each scenario is as following.

ATO (What-if I)

This scenario represents the situation where the client order interfere the OSM supply chain after the components have been produced (see Figure 1). The clients have flexibility to select from the builder's catalogue. The customers can add extra features to their own kitchen, bathrooms, external living area, as well as upgrade standard items such as windows and doors (Dalton *et al.* 2011). This scenario is suitable for most f detached house building in Australia. It requires using of standard components and builders to include variety of designs which can meet various demands. Theoretically, from client's perspective, the manufacturing time is zero as the components already produced and stored. However, there are time involved in terms of building site preparation and the house installation. These considerations were included in developing the simulation model of this scenario using Arena (Figure 4).

OSM Supply Chain Model				
Replications: 100		Time Units: Days		
User Specified				
Tally				
Between	Average	Half Width	Minimum Average	Maximum Average
Building site prep time	5.4752	0.06	3.8755	7.3445
Manufacturing time	7.3376	0.06	5.4961	10.2390
Record the completion time	13.2792	0.06	9.8884	16.3128
Counter				
Count	Average	Half Width	Minimum Average	Maximum Average
House orders in	151.50	3.55	115.00	200.00
No of completed houses	133.29	3.15	98.0000	173.00
Record finished houses	142.56	3.42	104.00	192.00

Figure 4: Arena simulation counter and tally results of the what-if I scenario

The house orders generated during the simulation were 200 orders. The finished manufacturing house orders were 192. This means that there are four house orders

need to be processed in the factory. In addition, the total duration from receiving the house order until client handover was about 17 days on maximum average. The building site preparation and the manufacturing times were around 8 and 16 days.

BTS (What-if scenario II)

BTS scenario refers to the intervention of the client order after installing the house components onsite. This scenario is convenient for volume house building projects such as social housing (e.g. affordable housing program, nursing homes and retirement housing (South Australian Government, 2014). This means private and public sectors could ensure their capacity for achieving large accommodation projects for low and medium income groups. BTS is also known as speculative house which means that the house built according to the builder design. This means that the finalising the design and the order are almost very minimal. This has been considered in the model development and simulating the model of this scenario.

OSM Supply Chain Model				
Replications: 100		Time Units: Days		
User Specified				
Tally				
Between	Average	Half Width	Minimum Average	Maximum Average
Building site prep time	4.5745	0.06	3.6545	6.4317
Manufacturing time	8.5454	0.06	6.7074	11.7006
Record the completion time	11.5775	0.06	9.3428	16.2415
Counter				
Count	Average	Half Width	Minimum Average	Maximum Average
No of completed houses	130.31	2.95	92.0000	159.00
Record finished houses	136.60	3.21	98.0000	174.00

Figure 5: Arena simulation counter and tally results of the what-if II scenario

The simulation results of all measures in the three scenarios are listed in Table 1. It is clear that the house completion time is decreased to about 17 days (What-if I scenario). Compared with the as-is scenario results, the decrease is approximately 9 days in completion time. This result shows a significant improvement. Clearly, there is a notable decrease in the difference between the manufacturing time and building site preparation time. In what-if II scenario, the difference is around 4 days, however, the difference is 7 days in the as-is scenario. The difference could represent the time gap between the two sites (offsite factory and building site). This leads to waiting time (non-productive) and inventory costs in the factory.

Table 1: Summary of simulation run results of the three OSM scenarios

Average value	DTO (as-is)	ATO (what-if I)	BTS (what-if II)
Build site prep time	7.3 days	5.6 days	4.6 days
Manufacturing time	14.3 days	7.3 days	8.5 days
House completion time	26 days	16.3 days	16.2 days
House orders received	67.7	136	151.51
No of houses manufactured	53.19	136.6	142.56
Completed houses	63.66	128.31	133.29

IMPLICATIONS

This research responds to the proposed action plan of Blismas (2007) for realisation of the potential capabilities of OSM in Australia. This research considered the entire OSM supply chain from receiving an order to completing the order and handover houses to clients. This is one of the first studies in Australia to our knowledge in exploring the entire OSM system dynamics using DES. Three different scenarios (as-is, what-if I and what-if II) have been developed based on altering information intervention of a client order within the OSM supply chain and tested using DES. The

simulation results (see Table 1) provide compelling evidence for practitioners for managing the OSM supply chain. Generally, the two what-if scenarios appear to be effective in reducing the house completion time and increasing the number of completed houses. Similarly, it demonstrates two configuration options for adjusting the OSM supply chain capacities in order to achieve high orders of completed houses. The conceptual and simulation models introduced in this study can give practitioners insights of redesigning OSM resources to match client demand with their capacity. Furthermore, DES using Arena® can help in evaluating different scenarios before real implementations with minimal expenditure. At the same time, Arena® as a DES platform can be used for training purposes in factories and building sites.

CONCLUSION

This study developed a discrete-event simulation model for the OSM supply chain in Australia using Arena® simulation software. The simulation model was constructed according to the conceptual model that represents the current practice (as-is) of OSM in Australia as demonstrated in Figure 1. The conceptual model shows the entire OSM supply chain (main processes and stakeholders) from receiving the house order until handover to the client. The conceptual model was developed and validated through interviewing four major OSM builders who are also members of PrefabAUS. As a result of this approach, it can be inferred that the model is an accurate representation of the actual OSM practice in Australia. Accordingly, the conceptual model was developed and programmed using Arena® interface software (see Figure 2). This has been done by using the basic process, advanced transfer and advanced transfer templates in Arena. The simulation model was verified and validated using independent verification and validation (IV&V) approach suggested by Sargent (2013). This approach involved a process where third party (Arena simulation consultant) reviewed the verification and validation of the simulation model to assure that it is a precise representation of the developed conceptual model. Therefore, three scenarios were simulated by modifying the client order information interference within the OSM supply chain. The as-is (DTO) scenario where the order received at the design process, while the what-if scenarios I and II (ATO and BTS) were based on receiving the order after manufacturing the house component offsite and after finishing installing the house respectively. The simulation results in term of the times measures and counting of orders received and completed were provided for each scenario (presented in Figures 3, 4 and 5).

The two what-if scenarios demonstrated in this study and their simulation results display the significance of the client order information in managing the OSM supply chain. Besides, the information flows amongst all stakeholders involved in delivering the house order. These scenarios showed noteworthy improvements in terms of building site preparation time, manufacturing time, and house completion time as well as the no of house orders completed. For affordable housing practitioners (OSM builders) and decision makers, the implication is that the discrete-event simulation model would enhance the supply of affordable housing, thereby contributing to the overall effectiveness of the offsite manufacturing process. Some limitations are acknowledged as the study reports on the findings using just limited interviews. The model was developed and tested within Australia OSM context (based on the assumptions mentioned earlier and for single-story detached house of 241.1 square meter floor area); as such future studies could employ case studies and further be conducted in other OSM contexts to enhance the generalisation of the findings. Moreover, other scenarios that focus on enhancing the OSM performance using the

model provided are suggested for future research. Furthermore, future works can expand this study to cover other processes in the modular/OSM industry such as integrating manufacturing concepts including lean, agile and six sigma.

ACKNOWLEDGMENTS

The authors would like to thank the anonymous reviewers for their constructive and encouraging comments on the submitted abstract. The authors also gratefully acknowledge the help provided by the PrefabAUS teams especially Mr Damien Crough and Mr Warren McGregor for providing the list and contact details of the OSM builders in Australia. Moreover, the authors are thankful to the builders' organisation (Hickory Group, Habitecsystems, TEKTUM and Fairweather homes) for participating in the interview. Furthermore, the authors are equally appreciative of the Arena simulation consultant for his time to review the simulated model.

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EXPLORING SWEDISH LOCAL PLANNING AUTHORITIES' PERCEPTIONS OF STANDARDIZED HOUSING CONSTRUCTION

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We explore how Swedish Local Planning Authorities perceive standardized housing construction and attempt to use an ideal type typology of institutional logics to describe how Local Planning Authorities make use of the multiple institutional logics available to them. Increased standardization in Swedish housing construction has been suggested as a means to meet the growing need for housing with reasonable rent levels. However, housing contractors that use standardization and repetition of processes and components claim that the variation of requirements set by Local Planning Authorities prevents them from taking full advantage of their standardization. A recent empirical study of standardized housing contractors' perceptions suggests that Local Requirement Setting, the requirement setting practices of Local Planning Authorities, are interpretational responses to a lack of familiarity with standardized housing construction. Yet, Local Planning Authorities' perceptions of standardized housing construction have never previously been explored. Empirical material for this on-going study was collected through in-depth exploratory interviews with local planning officers from three municipalities situated in Swedish population growth regions. Findings suggest that Local Planning Authorities perceive potential benefits with standardization, but ultimately expect standardized housing concepts to adapt to local standards for processes and products. In projects with high ambitions for architectural quality standardized housing concepts need to be highly flexible. Conversely, highly standardized housing concepts benefit from project ambitions that favour reasonable rent levels. Therefore, Local Requirement Setting is indicative of a mismatch between the Local Planning Authority's project ambitions and the standardized housing contractor's degree of product standardization.

Keywords: ideal type, institutional logics, local planning, local requirement setting, standardization.

INTRODUCTION

The Swedish government and construction sector agree that increased standardization of housing construction is necessary in order to meet demands for lower production costs, shorter time frames and higher production quality (SOU 2012:86, Statskontoret 2009). Standardization is frequently highlighted as a potential remedy the growing Swedish housing shortage, particularly to the shortage of housing with reasonable rent levels; by reasonable we mean a level of rent that an average Swedish household can afford. Gibb and Isack (2001) define standardization as:

'Standardization is the extensive use of processes or procedures, products or components, in which there is regularity, repetition and a record of successful practice

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[...] Suppliers produce standard items or customised items with standard components through standard procedures [...] Process standardization may vary from absolutely standard documentation and procedures at the detailed level, to a more strategic approach of a standard framework or approach.'

In literature standardization is frequently connected to a discussion in terms of pre-fabricated construction, offsite production or construction, and industrialised building systems as a means to move some of the effort that goes into the construction process, into a controlled environment (Goulding *et al.* 2015). This discussion takes its standpoint from how to control the means of production. However, as early as 2001 Gibb and Isack (2001) pointed out that standardization has changed over the years with efforts now being made to meet clients' needs and produce customised individual buildings, yet still using standard components and employing standard processes to ensure success. An increased level of standardization must be weighed against the reduced variety for the customer. Using definitions from production-systems and resource based perspectives Jansson *et al.* (2014) view standardization as the strategic idea of housing contractors to control and create a predictable and stable supply chain through the notion of platforms. In their platform definition of standardization Jansson *et al.* (2014) include a variety (continuum) in the component platform between certain levels of standardization for housing contractors utilizing the off-site production technologies volumetric preassembly and/or modular building categorized by Gibb and Isack (2003). For the scope of this paper it is interesting to recognize that there are primarily two types of standardization a client meets: process or product standardization and that both types offered by a standardized housing contractor may be designed (as a company strategic choice on how to control the means of production) in ranging levels.

According to the Swedish Planning and Building Act (PBA) it is mandated to the local authority to plan the use of Swedish land and water to ensure the quality of the built environment. The concept of 'quality' in architecture and urban design is theoretically complex and subject to a wide range of interpretations (Rönn 2010). However, among practitioners the term 'architectural quality' is commonly associated with building proportions, façade materials and the design of particular features such as the ground floor, roofs and eaves and 'urban design quality' is more closely associated with city block structures, street spaces and the specifics of the site surroundings such as noise pollution. The two terms do somewhat overlap, but generally speaking urban design quality deal with the proposed building in relation to its surroundings whereas architectural quality deal with the proposed building in relation to its end users.

To fulfil this mandate local planning authorities (LPAs) are allowed to set requirements for local construction projects, either through regulations in detailed development plans (DDPs) or in development agreements. DDPs can be either flexible or project-specific (Kalbro *et al.* 2012). The PBA is based on the assumption that all DDPs are flexible, i.e. are developed without a specific project in mind, and as such contain only the bare minimum of regulations that is necessary in order to ensure the purpose of the plan. However, developers that initiate DDPs want to be involved during the planning process in order to optimise the DDPs for specific projects (Kalbro *et al.* 2013).

Local requirement setting, the municipal practice of setting requirements that vary greatly in extent and scope between one LPA and the next, has been questioned on the basis that the large variance is detrimental to housing construction in general (SOU

2012:86) and to standardized approaches in particular (Stehn *et al.* 2013). The conclusions made by SOU 2012:86 that the intentional setting of local requirements disregards standardized housing contractors' needs for transparency and predictability has led to the implementation of legislative changes that forbid LPAs from formulating intentional local requirements. In the wake of these changes some LPAs are now struggling to find new ways of ensuring the quality of the built environment.

Although the relation between standardized housing contractors and external project conditions stemming from client decisions have been previously explored in the construction management literature, i.e. as client barriers to adopting technical innovations (Hedgren and Stehn 2014), requirements originating from local authorities remains an under-developed research topic. Viking and Lidelöw (2015) identified that in addition to intentional local requirement setting there is also interpretive local requirement setting which results from a lack of familiarity with standardized housing construction, yet there are no studies that address how standardization is perceived by LPAs.

Viking and Lidelöw (2015), using Thornton *et al.*'s (2012) institutional logics perspective, suggested that when confronted with standardized housing construction planning officers respond by making use of a number of different institutional logics. By exploring LPA's perceptions of standardized housing construction we aim to use a model of Friedland and Alford's (1991) inter-institutional system constructed from a typology of ideal types (Weber [1922] 1978) to describe how LPAs make use of the multiple institutional logics available to them.

Empirical material for this on-going study was collected through exploratory interviews with respondent from the LPA of three Swedish municipalities situated in regions of population growth. Our analysis reveals that we are at present not able to use institutional logics to conclusively describe the actions of LPAs in relation to standardized housing construction.

AN IDEAL TYPE TYPOLOGY OF INSTITUTIONAL LOGICS

Institutional theory advocates non-rational, cultural socially constructed explanations of societal order and change. Friedland and Alford (1991:243) define institutions as:

'Institutions are supraorganizational patterns of activity by which individuals and organizations produce, and reproduce their material substance and organize time and space. They are also symbolic systems, ways of ordering reality, thereby rendering experience of time and space meaningful.'

Friedland and Alford (1991) conceptualised the world as an inter-institutional system comprised of the major institutional orders in society, each associated with its own central institutional logic. They argued that individuals, organizations and society constitute three nested levels, specifying progressively higher levels of opportunities and constraint for action. Thornton (2004) following Doty and Glick (1994) argues that Friedland and Alford's (1991) inter-institutional system can be viewed as a typology of ideal types (Weber [1904] 1949).

An ideal type is a pure analytical model of the typical features of a phenomenon that have been abstracted from the empirical reality. The ideal type never seek to claim its validity in terms of reproduction or correspondence with reality, but through terms of adequacy (Weber [1904] 1949). As such the ideal type is a tool for interpreting cultural meanings into their logically pure components and understanding the meaning that actors invest their actions with (Swedberg 2005).

In its most recent update (Thornton *et al.* 2012:73) the ideal type typology of the inter-institutional system consists of seven institutional orders: family, state, market, profession, corporation (Friedland and Alford 1991), religion (Thornton 2004) and community (Greenwood *et al.* 2010), each constructed by a set of nine categorical ideal types: root metaphor, sources of legitimacy, sources of authority, sources of identity, basis of norms, basis of strategy, informal control mechanism and economic system. Friedland and Alford (1991:250) note that institutional logics are 'mutually interdependent and yet contradictory'. During later years the study of institutional complexity, how individuals and organizations respond to encounters with incompatible prescriptions from multiple institutional logics (Greenwood *et al.* 2011), have become a rapidly growing stream within institutional logics research. The literature on institutional complexity details a number of strategies that individuals and organizations may use to respond to interdependencies and contradictions between different institutional logics (Pache and Santos 2010, Kraatz and Block 2008).

RESEARCH DESIGN AND METHODS

Empirical material for this on-going work was collected during December 2014 – April 2015. The material was collected through the use of explorative interviews with respondents from the LPAs of three Swedish municipalities. Municipalities A, B and C are situated in Swedish population growth regions and as such housing construction volumes in all three municipalities are high compared to the national average.

Municipality A was chosen because of its extreme need for housing with reasonable rent levels coupled with very high ambitions for architectural quality. Municipality B distinguished itself by a large number of completed standardized housing construction projects. Municipality C were very strongly opposed to the legislative changes to forbid intentional local requirement setting, but still carries an interest for standardization due to a perceived potential for environmental improvements. From each municipality interviews were conducted with two respondents, one detailed development planner (A1, B1 and C1) and one respondent who works with development agreements (A2, B2 and C2).

Due to the exploratory nature of the study the interview questions were revised with each new interview, and as such none of the respondents were asked an identical set of questions. However, the following question areas were recurrent throughout all of the interviews: (1) what were the LPA's requirement setting prior to the legislative changes and how have they changed since their implementation, (2) what did the respondents think standardized housing construction is and what associations they made upon hearing the term, (3) what were the respondents previous experiences with standardized housing construction, and (4) what did the respondents think should be standardized, to what degree, and by who so as not to conflict with their local standards for products and processes.

All interviews were made in situ, so as not to deprive the researcher of informal, nonverbal communication. The interviews lasted 45-90 minutes each and were all recorded and subsequently transcribed. The empirical material was analysed using thematic coding (Miles and Huberman 1994) in which thematic codes from a predefined list were applied to transcribed sections of text. Superfluous codes were removed and overly represented codes were subdivided, redefined and reapplied in an iterative manner until the researcher determined that the remaining themes corresponded well to the empirical material at large. The remaining themes were then

abstracted into the terms of the ideal type typology of the inter-institutional system. Only 9 out of the 63 ideal types were found useful to make these abstractions so due to space limitations only those 9 ideal types are depicted in the analytical model (Table 1) below. This also approach allowed us to identify empirical material where ideal types from multiple institutional logics were used simultaneously.

Table 1: Analytical model adapted from Thornton et al. (2012:73)

	State logic	Market logic	Profession logic
Source of legitimacy	Democratic participation	Share price	Personal expertise
Source(s) of identity	Social and economic class	Faceless	Association with quality of craft Personal reputation
Basis for strategy	Increase community good	Increase efficiency profit	Increase personal reputation

THE MUNICIPAL PERSPECTIVE ON STANDARDIZATION

All the respondents agreed that the term 'standardized construction' transmits many negative associations. Most of them immediately thought about failed business ventures involving standardized housing construction or of projects from the Swedish Million Homes Programme during the 1960s and 70s, infamous for its overly rational approach that resulted in extremely monotone environments. However, many of the respondents were also adamant that standardized construction has come a long way since then and they believed that the approach carries with it lots of benefits over traditional approaches construction. In fact, most were convinced that standardization is an important, perhaps even necessary, factor for tackling the current Swedish housing shortage.

Municipality A

Municipality A is among the biggest municipalities in Sweden, both in terms of population growth and in housing construction. Even so the housing deficit is massive and coupled with extremely high construction costs, the shortage of small lease-hold apartments, is a particularly growing concern; so great that the LPA has is instructed to pay particular attention to the ability to produce housing with reasonable rent levels when considering housing developers for development agreements for construction on municipal land. The LPA stressed that rent level is a much more important variable than construction cost, because if the housing is sold or leased at market value the earnings from low construction costs will not benefit the end-users at all. The LPA employs project-specific DDPs, as the PBA directs them to carefully describe the consequences of plans to the public; conducting public consultations for one building yet granting building permit for another would be to trick the public.

Urban planning is an issue of great importance to the local politicians and, despite a frequently shifting political majority, there is a broad political consensus in this particular area. Municipality A feels that it can afford to have extremely high ambitions for architectural quality as the central location assures that there will never be a shortage of willing housing developers regardless. One planning officer elaborated that while architectural quality may seem subjective to the untrained in actuality it is not:

“Architectural quality is like musical quality. Regardless of whether you like it or not, if you are well versed, you can determine what is good quality and what is not.” - A1

With regards to standardization, the planning officers felt that they have never been opposed to it; that while reasonable rent levels is secondary to high architectural quality, the interests are not by nature antagonistic. On the contrary, they found the prospect of standardized leasehold apartments with reasonable rent levels and high architectural quality to be a very attractive proposition. However, they felt that standardized housing concepts need to be quite flexible in order to be applicable, because in highly urbanised areas adaption to the surroundings is an important factor that will exclude the usage of housing concepts with too high degrees of product standardization. They also felt that in order to avoid many complications it would be beneficial to standardized housing contractors to consider architectural quality to a greater extent in their product standardization, perhaps by incorporating a flexible interface for the façade to an otherwise standardized product.

Municipality B

Municipality B is among the ten largest Swedish municipalities in terms of population and also boasts a very large number of standardized housing construction projects relative to their size as well as a wide range of different standardized housing contractors. The LPA employs flexible DDPs with few requirements and local design programmes that describe desired qualities rather than prescribe detailed solutions. One planning officer explained that their approach focuses more on urban design quality than architectural quality:

‘We often focus on the logic of the space: how will people act around it, how will they use the proposed building. That is more important than whether the facade is red or black or what type of roof it has.’ - B2

The flexible approach is motivated not only by the content of the PBA, but also because the practice saves the LPA from having to redo the DDP if the project falls through as would be the case for a more project-specific DDP. The planning officers believed that this in combination with their more collaborative approach to development agreements is the key to enabling standardized construction.

Municipality B did previously use local requirements for energy, as this was mandated by the local politicians, but the planning officers claim that they felt that they lacked the proper legitimacy required to enforce a deviation from the building code and were almost relieved when the legislative changes were implemented that now prevent them from setting such requirements. It seemed, however, that the local politicians were keenly aware that there are conflicting interests related to housing construction. One planning officer elaborated:

“On the one hand they want to quickly enable the construction of housing – affordable housing, but at the other hand they do not want to lower the level of quality ambition either.” - B1

The planning officers said that despite the uncertainty of the local politicians, the long-standing overarching goal is the construction of a sufficient quantity of affordable housing. However, they were still not convinced that standardized housing construction necessarily leads to reasonable rent levels. In particular, they felt that standardized housing concepts with high degrees of product standardization are difficult because they lack the level of flexibility necessary to adapt to most project surroundings, e.g. noise pollution. Instead, they felt that standardized housing

contractors should focus on developing their process standardization or a product standardization that enables more diversity.

Municipality C

Municipality C is smaller than A and B, but with a positive population growth and a sizable housing deficit. The local politicians strive to develop an environmentally friendly profile. In particular, municipality C was among the most vocal in the public debate about local requirement setting, claiming that the national building code was out of sync with time. Municipality C has a strong interest in the forest industry and wood as a construction material. The local public housing developer was recently ordered to drastically increase its production share of timber-frame housing. According to the LPA, setting challenges and forcing actors to think outside the box is the best way to drive a development process forward.

The municipality is eager to try anything that drives the development forwards; they want to experiment, to learn together with other actors, and for this purpose they have designated an area that they stipulate will only be used for pilot projects using timber frames. The LPA felt that learning and developing is a teamwork effort that requires the cooperation of a chain of actors: sawmills to deliver the raw materials, politicians to create the right conditions, planning officers to create the plans and surfaces, architects to deliver ideas and the construction industry to deliver the finished product. This approach has allowed the local public housing developer to work continuously with a number of local contractors that together have been able to drive the production costs down to a level that is among the lowest in the entire country.

Municipality C employ flexible DDPs, as they believe that if there is an opportunity for development advancements, then the DDP should not stand in their way. They were very critical towards LPAs that regulate architectural quality in the DDP, claiming that it should be reserved for regulating the urban design quality. One planning officer elaborated on their view of different municipalities setting different requirements for similar projects:

“It is not reasonable. It is not wrong for municipalities to set requirements, but there has to be rules so that everyone knows what is going on.” – C1

The planning officers of municipality C have had previous exposure to standardized housing construction in the shape of standardized glulam timber frames and prefabricated concrete components, but not with fully modular construction which they admit may be influencing their perspective. In general, they believed that the construction industry is the weakest link in their chain and that anything that could possibly drive the development of the industry forward is a good thing. However, they felt that standardized housing contractors should focus on process standardization and limit their product standardization to the supporting structure, installations and other cost driving components. This standardized core could then be modularised and configured according to the architect’s visions in order to achieve product diversity. One planner explained why it is important that each actor in the chain does their own job and not someone else’s:

“No matter how much we draw we cannot do this without the input from the building industry, but also vice versa. We should not create utopian plans or houses that cannot be implemented, but they should not produce houses that no one wants.” – C1

ANALYTICAL IMPLICATIONS

The analysis of the empirical material reveals that for all three municipalities the main source of legitimacy was 'personal expertise', the main source of identity was 'association with quality of craft' and the main basis of strategy was 'increase of community good'. Given the limited extent of the empirical material it any claim for analytical conclusions would be premature, however there are a number of analytical implications that we can identify from the analysis.

The first implication is that LPAs to an extent do seem to employ strategies to handle interdependent and contradictory logics. For instance the claims of respondents from municipality A that detailed development plans should be project-specific is based on an argument that their source of legitimacy consists of both 'personal expertise' and 'democratic participation', thus combining elements profession logics with elements of state logic.

The second implication is that some of the ideal types, such as 'personal expertise', 'association with quality of craft' and 'increase of community good' are somewhat ambiguous. Respondents from municipality A considered the primary cause of 'increase of community good' to be high architectural quality, whereas respondents from municipality B considered it to be reasonable rent levels and respondents from municipality C considered it to be a combination of reasonable rent levels and urban design qualities. These different considerations result in the three municipalities having different ways of relating 'increase of community good'(state logic) to 'increase of efficiency profit' (market logic). As respondents from municipality A consider architectural quality potentially contradictory to standardized housing construction state logics is also considered contradictory to and given primacy over market logic. For respondents from municipality B the two logics are instead complementary and for respondents from municipality C they are simultaneously both complementary and contradictory. Although we acknowledge that these differences may be caused by the combinations of multiple institutional logics, which may be possible to study by using institutional complexity, we have at present not been able to identify which these combinations may be.

A third implication is that by using the analytical model we were not able to fully describe all aspects of the empirical material; some unexplained themes remained. One such theme was the insistence of some LPA on furthering their own politically motivated local standards for housing construction. Municipality A would be willing to accept standardized housing construction only on the condition that it adapts to the local standards for architectural quality and municipality C only accepts standardized housing contractors on the condition that they are willing to engage in collaborative experimentation. Another related theme was the tendency of these LPAs to insist that adaptation is strictly voluntary for standardized housing contractors; that if they are not interested they can always go somewhere else. This insistence is based on the assumption that other municipalities do not have local standards of their own. These two themes in particular were difficult to describe using the ideal type typology analytical model.

In summary, implication one is encouraging; it seems possible to some extent to explain LPA's perceptions of standardized housing construction using an ideal type typology of institutional logics. Implications two and three are less encouraging; there are themes that are not properly described and the elements of the analytical model may result in different interpretations from one respondent to the next. However, let

us stress again the exploratory and early character of our research, which is based on a very small amount of empirical material. While at present it is implied that some of the ideal types are ambiguous, it may be because the limited extent of empirical material prevented the discovery of abstractions to other combinations of ideal types that would better describe the observed empirical differences. A similar case can be made for the non-described themes, that more empirical material may enable discoveries and abstractions that at present are impossible to make.

The answer to the question whether or not LPAs' perceptions of standardized housing construction can be described using an ideal type typology of institutional logics remains unanswered. We see three possible avenues for advancement. The first would be to go out and collect more empirical material and thereby being able to draw more precise conclusions. The second avenue would be to redo the analysis, focusing more intently on the institutional complexity in the hopes that this would bring about new realisation and insights. A third possibility is to accept that the ideal type typology approach can only hope to be successful to a certain degree and that in order to provide a more complete description of the empirical material the current theoretical perspective may need to be complemented by an additional theoretical perspective.

CONCLUSIONS

This paper contributes empirically by identifying that the degree of product standardization that is possible to use depends on the Local Planning Authority's project ambitions. In projects where ambitions for architectural quality are high standardized housing concepts need to be more flexible. Highly standardized housing concepts instead benefit from project ambitions that favour reasonable rent levels. Therefore, the presence of Local Requirement Setting is indicative of a mismatch between the Local Planning Authority's project ambitions and the standardized housing contractor's degree of product standardization.

We also identify that although Swedish local planning authorities see potential benefits in using standardized housing construction, they ultimately expect standardized housing concepts to adapt to the local standards for processes and products that each Local Planning Authorities itself champions. Although local requirements can no longer be set through formal directives municipalities seem to be finding new, less formal ways, to regulate the built environment.

Finally, we contribute to the small body construction management papers based on institutional theories by attempting to describe our empirical material using an ideal type typology of institutional logics, thereby making three analytical implications.

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ETHNICITY OF HOUSEHOLDS AND CROWDING LEVELS IN PUBLIC HOUSING MULTIFAMILY APARTMENTS IN LAGOS, NIGERIA

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Crowded housing is one of the housing stresses that bother policy-makers and housing authorities in Lagos, Nigeria. At the core of the argument is the anthropology of proper and acceptable sleeping arrangements, particularly as it applies to households' ethnic and cultural group. It is claimed that more than 250 ethnic nationalities in Nigeria are represented in Lagos. This study examines the crowding levels among persons of different ethnic and cultural origins occupying Lagos State Development and Property Corporation (LSDPC)'s apartments. Four housing estates were purposively selected among LSDPC's multifamily categories, comprising 7,764 apartments. A sample of 7.5% was chosen using stratification and systematic random techniques. A pretested questionnaire instrument was used to collect the relevant demographic data of occupants. The ethnic group of the household head was taken as a measure of the ethnicity and cultural background of the household. Apartment occupants were grouped into three: households that harboured 1-2 occupants; households that harboured 3-5 occupants; and households that harboured six or more occupants. Non-parametric statistical techniques were applied to analyse and compare data obtained from questionnaire. The result shows that four ethnic groups of Yoruba, Igbo, Edo and Hausa-Fulani constitute 91.4% of the total number of respondents. The policy implication is that housing provision should be targeted at meeting the harmonized needs of these four ethnic groups. Only 14 ethnic groups were represented among household heads who responded to the questionnaire, contrary to widespread speculation that Nigeria consists of over 250 ethnic nationalities. Households that harbour 3-5 occupants were dominant and no one ethnic group consistently maintained higher or lower crowding level across apartments. Hence, household head's ethnicity had no significant effect on apartment crowding. This result contrasts with findings from earlier researches in some countries which claim that household crowding varies considerably according to ethnic groups.

Keywords: crowding, ethnicity, multifamily apartment, public housing.

INTRODUCTION

There is no single point of agreement concerning the exact number of ethnic groups in Nigeria. However, some earlier researchers contend that Nigeria is made up of not less than 250 ethnic groups (Odumosu 1999; Oduwaye 2008; Iweka 2012). The ethnic groups are broad groupings or collections of sub-groups. For example, the Yoruba sub-group consists of the Aworis, the Eguns, the Ijebus, and the Egbas. Unlike in New Zealand where people can belong to more than one ethnic group (Statistics New Zealand 2012); ethnicity in Nigeria is indicative of cultural affiliation.

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Historically, the city of Lagos has served as the political and commercial nerve centre of Nigeria. In its modern form Lagos continues to attract Nigerians from across the federation as well as peoples from other parts of Africa and beyond. Infact, Odumosu (1999) and Oduwaye (2008) claim that over 300 ethnic groups in Nigeria are resident in Lagos State alone. However, the reality on ground does not seem to support this.

Household crowding experiences of people from various ethnic backgrounds are considered a big challenge for policy-makers and housing authorities who are saddled with the task of public housing delivery in Lagos. This can be substantially attributed to the recognition that different ethnic and cultural groups may not share the same beliefs, attitudes, and norms regarding acceptable crowding experiences. Earlier analyses by Statistics New Zealand (2012) point out that household size and living arrangements vary considerably by ethnic group. The delivery of public housing by the Lagos State Government has been largely done through its agency, the Lagos State Development and Property Corporation (LSDPC). It is pertinent to note that there is no evidence of ethnic-based differentiation or bias on access to the prototype apartment units produced by LSDPC. The apartments are usually balloted for based on socio-economic grouping of low, medium and high income class, irrespective of other criteria like ethnic structure, extended family groups, regions or religion. People in any of these three socio-economic categories can apply for any apartment type in any preferred estate. Thus the outcome can appear skewed in favour of certain ethnic groups with high social network, and who may wish to cluster together in certain areas.

Room norms which specify how many people can share an apartment may vary among people of different ethnic cleavages. Understanding the variability among ethnic groups is therefore important for policy makers wanting to interpret crowding in LSDPC apartments. This study seeks to investigate how the composition of crowded households varies by ethnicity. Specifically, the study examines the relationship between LSDPC apartments and household crowding within and between ethnic nationalities. Understanding these ethnic and cultural differences is especially important in segmenting apartment users into more homogeneous subgroups in LSDPC's estates. This is currently lacking in the planning and management framework of LSDPC's estates.

LITERATURE REVIEW

Household crowding

Crowding and space are critical factors taken into consideration in determining the risk faced by occupants. There is no single definition or measure of crowding. Some countries such as Canada define crowding as a situation where one or more additional bedrooms are needed to meet the sleeping requirements of household residents. Statistics New Zealand (2012) explains that crowding occurs when a dwelling is too small to accommodate the number of people in a household. A few decades ago authors like Newman and Hagan (1981) saw crowding as a perceived phenomenon or the subjective feeling of having too many people around.

Obviously, there are ambiguities and contradictions because crowding and overcrowding tend to be intertwined, while the link between crowding and density appears indistinct among researchers. Those who discuss crowding alongside overcrowding see crowding as objective measure and overcrowding as subjective (Baldassare 1979; Warah 2003). In this perspective crowding is technically an

indicator (or, an objective measure) of the number of persons per room in a housing unit. Overcrowding on the other hand gives an expression of a normative judgement concerning the degree of crowding that manifests on the scale. Warah (2003) concluded that the crowding indicator is objective but the adoption of a particular number of persons per room as an overcrowding standard is a subjective evaluation.

Conversely, researchers who associate crowding with density see crowding as subjective while density is an objective quantitative and neutral term that has no positive or negative connotations (Newman and Hogan 1981; Churchman 1999; Kaya and Erkip 2001; Pader 2002). Density is therefore an objective measure and refers to the number of people in any given space, e.g. per square metre, per room, per dwelling or per hectare while crowding is the subjective evaluation that a given density is too high or negative. According to Newman and Hogan (1981), such a level of density varies across cultures, the number of interacting individuals, their tasks and roles, their relationship to each other, and their psychological states. Churchman (1999) also cautions that the level of density that is regarded as optimal varies between nations, cultures, socio-economic classes, contexts, and at different stages of development.

Most bureaucratic institutions around the globe have persisted in calculating crowding by using density measures of number of persons per room in a housing unit (Memcott, Birdsall-Jones and Greenop 2012). This density model of predicting crowding is based on sleeping and living norms in a British nuclear family culture. The model is embedded in Canadian National Occupancy Standards (CNOS) and has been adopted by several countries. In Lagos Nigeria, LSDPC apartments' family units are essentially nuclear (Iweka 2013). This is in tandem with the British model. Hence, this density orthodoxy is considered useful and applicable for understanding crowding in LSDPC estates.

In the present study, crowding is interpreted as an objective measure of spaces, available for each person (Baldassare 1979; Warah 2003). OPDM (2004) states that the threshold whereby a household is deemed to be overcrowded varies among researchers. It is seen as a complex housing problem that involves household structure, racial and ethnic diversity, housing availability, gender and age factors. These issues have attracted research attention over the years.

The Canadian National Occupancy Standards (CNOS) was adopted in this study as there is no evidence of a model of household crowding specifically for Nigeria. The CNOS is based on the number, sex, age, and inter-relationships of household members and identifies the number of bedrooms that are required but lacking, based on the number of occupants, their age and the gender of siblings. The CNOS is regarded as a standard measure for housing utilization. The specifications of CNOS that were applied in this research include: (a) there should be no more than two persons per bedroom, (b) Couples and parents should have a separate bedroom, (c) Children under 5 years either of the same sex or opposite sex may share a bedroom, (d) Children five years of age or over of opposite sexes should not share a bedroom, (e) Children less than 18 years of age and of the same sex may reasonably share a bedroom, (f) Single household members aged 18 years or over, and any unpaired children require a separate bedroom. (Australian Bureau of Statistics year book 2008; Memcott, Birdsall-Jones and Greenop 2012).

Households living in apartments where this standard cannot be met are considered to be overcrowded. The Canadian occupancy standard follows the argument that household size defines only a minimum dwelling size (that is, a threshold of need) that

if exceeded will no longer be considered important in a household's choice of dwelling. The sleeping norms considered in CNOS are applicable to Nigeria, particularly in terms of separation of sexes. Furthermore, LSDPC housing stock under investigation was presumably designed for nuclear households typical of what obtains in countries where CNOS thresholds are applicable. The CNOS specifications provided a basis for establishing the number of occupants in an apartment. Thus, the total number or combinations of persons permitted by CNOS to inhabit a room is regarded as "*one adult*" or "*one occupant*".

Ethnicity and household crowding

Bulmer (1996) quoted in Llangco (2013) defined an ethnic group as a collectivity within a larger population having real or putative common ancestry, memories of a shared historical past and a cultural focus upon one or more symbolic elements which define its identity such as kinship, religious affiliation, language, shared territory, nationality, physical contiguity or any combination of these. Ethnicity is an individual characteristic that may also be tied to the native language spoken and the respondent's local government area of origin. The relationship between household's ethnic background and crowding has attracted the attention of several researchers (Moller, Johnson, and Dardia 2002; Statistics New Zealand 2012; Gillis, Richard and Hagan 1986; Ministry of Health 2014; Fuller, Edwards Vorakitphokatorn, Sermisri 1993; Pader 2002).

There seems to be a general consensus that crowding and attitude to crowding vary between ethnic and cultural groups. In a study of crowding level in California, Moller, Johnson and Dardia (2002) found that Hispanics were 26 times more likely to be crowded than those headed by native whites. Also, Latinos and Asians have substantially higher average household sizes than Blacks and Whites. An earlier investigation by Gillis, Richard and Hagan (1986) equally remarked that Asians were more adaptable to high density living and were more able to cope with crowding than North Americans and the British.

In Australia, a study by Ministry of Health (2014) shows that 40% of Pacific peoples live in crowded apartments compared to 20% for Maori; 18% for Asians and 4% for Europeans. Fuller, Edwards, Vorakitphokatorn and Sermisri (1993) also carried out a study on household crowding and family-relations in Bangkok. It was found that the normative tolerance for crowding in Bangkok was high compared to North American standard. The researchers argued that this could be due to some ameliorating cultural factors. The Thais were acknowledged as people who place higher value on social interaction and less value on privacy. This is largely in contrast with the situation in the United States. Thus space and time appear to be crucial in comparing and validating researches on ethnicity undertaken by different authors.

METHODOLOGY

This research investigated household ethnicity and crowding level in public housing multifamily apartments in urban Lagos. Housing estates belonging to Lagos State Development and Property Cooperation (LSPDC) were purposively chosen as a case study. A survey research component was incorporated to provide the data on the research variables that cannot be obtained through observation or direct physical measurement.

Illesanmi (2005) and Iweka (2012) justified the use of case study approach in this type of research on the grounds that the study focuses on information specific to a

particular context of LSPDC. Furthermore, it permits the researcher to concentrate on an in-depth investigation of a specific issue, ethnicity and crowding levels of residents. Different ways of categorizing case studies have been suggested by a number of previous researchers (Jensen and Rodgers 2001; Yin 1994; Gerring 2007; Stake 1995). The single institutional context of LSDPC qualifies it to be classified as a single unit entity, or single case with several embedded units for in-depth examination.

It has been established that LSPDC has 40 residential estates, with a total of 20,572 apartments (Fatoye and Odusanmi 2009; Jiboye 2009; 2010). However, the current research focused on low and medium income estates containing multifamily apartments. Twelve estates with a total of 17,679 apartments fell into these categories and hence constitute the study population. These are made up of nine estates with 15,950 apartments in the low income group and three estates with 1,729 apartments in the medium income group. Three low income estates and one medium income estate were purposively selected as cases for in-depth study. The three selected low income estate were Abesan (4,272 apartments), Iba (2,388 apartments) and Dolphin II (576 apartments). They constitute 65% of the nine Low income estates that form part of the study population. Also, one medium income estate, Ebute-Metta (528 apartments) was purposively chosen as a case for in-depth study. The 528 apartments in Ebute-Metta constitute 40% of all the three middle medium income apartments. Essentially, the sample frame of this study was the 7,764 apartments in the four selected estates. In the low income category, there are two apartment prototypes at Abesan, one prototype at Iba and two prototypes at Dolphin II. The medium income estate at Ebute-Metta contains only one prototype apartment.

Sampling

In all a 75% (582) sample of all the apartments in the four selected estates was chosen. The apartment types available in each estate were classified and stratified according to number of bedrooms and the proportion in each estate. The 582 apartments that were ultimately picked for detailed survey were selected using systematic random technique, after the first apartment was chosen at random. This research adopted the approach of some previous studies which used the ethnicity of the eldest person in the household to assign ethnicity to a household (Iweka 2012; Statistics New Zealand 2012). This method was developed by the Otago University Wellington school of Medicine and is acclaimed to mitigate field research difficulties and minimize biases by ensuring consistency. It is, however, necessary to point out that the ethnicity of the oldest person in a household may not truly reflect the rest of the household.

A structured survey questionnaire instrument was used to obtain data on number of household members, number of rooms, ethnicity of household heads, persons-per-room by age, sex and marital status. The density model of number of persons per apartment was observed as an objective measure of household crowding since it is unconnected to attitudes and feelings and is not subjected to bias. Data obtained were applied to CNOS to extrapolate the total number of adults or their equivalent living in an apartment, which indicates the crowding level in the household.

Measurement of ethnicity

The response categories for this research were limited to the nine biggest ethnic groups in Nigeria that constitute 95% of the languages. Among these, the Yoruba, Hausa-Fulani and Igbo constitute 68% of the country's population. At the same time, the Ijaw, Edo, Ibibio, Kanuri, Tiv and Epira-Nupe account for 27%. The other

minority groups comprise the rest 5%. Since all household members were grouped and assigned the same ethnic identity as the head of household, it was not possible to identify specific combinations. As a consequence, the existence and extent of multiple ethnic identities within households were ignored.

RESULTS AND DISCUSSION

The distribution of the respondents shows that the Yoruba ethnic race constitutes the largest number 59.4%. Other respondents were Igbo - 21.1%; Edo - 5.7%; Hausa Fulani - 5.1%; Ibibio - 1.2%; Ijaw - 1.2%; Kanuri - 1.2%; Tiv - 1.2% and Ebera Nupe - 0.6%. The large number of Yoruba respondents was probably because the study area was in the South Western Nigeria, where the natives are predominantly Yoruba.

The location information relating to the four estates selected for this study was matched with the different categories of apartments found there. This was used to group the apartments into Type One (2-bedroom) Abesan, Type Two (2-bedroom) Dolphin, Type Three (3-bedroom) Abesan, Type Four (3-bedroom) Iba, Type Five (3-bedroom) Dolphin and Type Six (4 bedroom) Ebute-Metta, for the purpose of analyses - Table 1.0. Therefore there are four locations of interest: Abesan estate, Dolphin II estate, Iba estate and Ebute-Metta estate.

Group measure was adopted in interpreting the crowding levels of occupants belonging to different ethnic identities in each of these apartment types. This was achieved by grouping all the apartment occupants in each of the ethnic groups into three categories: (a) households that contain one or two occupants; (b) households that contain three to five occupants and (c) households that contain six or more occupants. The occupants are interpreted as total number of adults or its equivalent entitled to sleep in one room. This is extracted by reconciling the questionnaire data with CNOS specifications.

ABESAN ESTATE: As revealed in Table 1.0, 100% of all respondents in Type One (2-bedroom) apartments are Yoruba. Among the households investigated 77.79% harbour 3-5 occupants. Also, 16.67% of the households contain 1-2 occupants while 5.56% are occupied by six or more residents. The Yoruba group constitutes 76.26% of all the residents of Type Three (3-bedroom) apartments, Abesan. Six other ethnic groups found in this apartment type are Hausa-Fulani (2.99%), Igbo (10.40%), Edo (4.48%), Ibibio (1.49%). Of all these apartments, those containing 1-2 occupants were found among the Yoruba (23.88%) and Kanuri (1.49%). Similarly, households containing six or more occupants were more likely to be found among the Yoruba's (7.46%) and the Igbo's (1.49%). Apartments that harbour 3-5 occupants are the dominant situation among six out of the seven ethnic groups in Type Three (3-bedroom) category.

DOLPHIN II ESTATE: Table 1.0 also indicates that Type Two (2-bedroom) in this estate is inhabited mainly by the Yoruba (53.35%), Hausa-Fulani (13.33%), Igbo (20.00%) and Edo (6.67%). Of the four ethnic groups in this apartment type, households containing 1-2 occupants were all Yoruba and constituted 6.67%. Similarly households containing six or more occupants were found among the Yoruba (20.01%) and Igbo (6.67%). On the contrary, respondents in apartments that harbour 3-5 occupants were found in all the four ethnic categories that occupy this apartment type. Moreover, this occupancy of 3-5 persons represents the highest for each of the four ethnic groups. Yoruba has the highest occupancy of 26.67%. Hausa-Fulani and Igbo have 13.33% each while Edo has 6.67%. The Type Five (3-bedroom) at Dolphin

harbours eight ethnic groups and this represents the highest number in all the six apartment types investigated in this research, the ethnic groups found in this apartment type are Yoruba (56%), Edo (8%), Hausa-Fulani (8%), Igbo (4%), Ijaw (4%), Ibibio (4%), Kanuri (4%) and Tiv (4%).

Table 1.0: Grouped measures of crowding level based on household ethnicity

Apartment type	Ethnicity of household	1 – 2 Occupants (%)	3 – 5 Occupants (%)	6 occupants & above (%)	Total (%)
Type One	Yoruba	16.67	77.77	5.56	100.00
2-bedroom	TOTAL	16.67	77.77	5.56	100.00
Abesan					
Type Two	Yoruba	6.67	26.67	20.01	53.35
2-bedroom	Hausa Fulani	-	13.33	-	13.33
	Igbo	-	13.33	6.67	20.00
Dolphin	Edo	-	6.67	-	6.67
	Others	-	6.67	-	6.67
	TOTAL	6.67	66.70	26.68	100.00
Type Three	Yoruba	23.88	44.78	7.46	76.26
3-bedroom	Hausa Fulani	-	2.99	-	2.99
	Igbo	-	8.96	1.49	10.40
Abesan	Edo	-	4.48	-	4.48
	Ibibio	-	1.49	-	1.49
	Kanuri	1.49	-	-	1.49
	Ebira-Nupe	-	1.49	-	1.49
	Others	-	1.49	-	1.49
	TOTAL	25.37	65.68	8.95	100.00
Type Four	Yoruba	-	13.33	6.67	20.00
3-bedroom	Igbo	20.00	40.00	13.33	73.33
	Edo	6.67	-	-	6.67
Iba	TOTAL	26.67	53.33	20.00	100.00
Type Five	Yoruba	8.00	32.00	16.00	56.00
3-bedroom	Hausa Fulani	-	8.00	-	8.00
	Igbo	-	4.00	-	4.00
Dolphin	Ijaw	-	4.00	-	4.00
	Edo	-	4.00	4.00	8.00
	Ibibio	4.00	-	-	4.00
	Kanuri	-	4.00	-	4.00
	Tiv	-	4.00	-	4.00
	Others	-	8.00	-	8.00
	TOTAL	12.00	68.00	20.00	100.00
Type Six	Yoruba	2.86	22.88	2.86	28.60
4 bedroom	Hausa Fulani	2.86	5.72	-	8.58
	Igbo	14.30	25.74	2.86	2.86
Ebute-Metta	Ijaw	2.86	-	-	2.86
	Edo	2.86	5.72	-	8.58
	Tiv	-	2.86	-	2.86
	Others	-	2.86	2.86	5.72
	TOTAL	25.74	65.78	8.58	100.00

A similar level of crowding experience was found in both Type Two (2-bedroom) and Type Five (3-bedroom). Households containing 1-2 occupants are very scanty and likely to be among the Yoruba (8%) and Ibibio (4%). Also, households of six or more

occupants are more likely to be found among the Yoruba (16%) and the Edo (4%). The highest proportion of residents belonging to each of the eight ethnic groups in this apartment type harbour households with 3-5 occupants.

IBA ESTATE: All the respondents from this estate belong to three ethnic groups namely Yoruba (20%), Igbo (73.33%) and Edo (6.67%) – Table 1.0. This is the only apartment type in which people of Yoruba ethnic background were not found among households containing 1-2 occupants. Instead the Igbo (20%) and Edo (6.67%) dominate this household crowding level. The study shows that the Edo are not found among the households harbouring 3-5 occupants and six or more occupants. These occupancy levels are found among the Yoruba and Igbo. However, among the Igbo, households containing 3-5 occupants constitute 40% while households of six or more occupants constitute 13.33%.

EBUTE-METTA ESTATE: Table 1.0 shows that the respondents in this estate were Yoruba (8.58%), Igbo (2.86%), Ijaw (2.86%), Edo (8.58%), Tiv (2.86%). The Ijaws were only found in households containing 1-2 occupants, while the Tivs were only found in households containing 3-5 occupants. The Yoruba and Igbo were found among the three measures of crowding level, while Hausa-Fulani and Edo ethnic groups are most likely to be found in households containing 1-2 occupants and households containing 3-5 occupants. Overall, households that harbour 3-5 occupants were highest among the six ethnic groups covered in Type Six (4- bedroom) apartment in Ebute-Metta.

Statistical validation of effect of ethnicity on household's crowding level

The effect of ethnicity on crowding level among residents of the six apartments investigated was tested using chi-square technique. The results are shown in Table 2.0. The statistical level of significance for acceptance or rejection was set at 95% confidence interval. Thus P-Value (that is, T tabulated) represents the effect of ethnicity on crowding level. The decision rule is that at the same degree of freedom, if the P-Value is less than 0.05, the effect of ethnicity on dwelling density is classified as “*significant*”. This implies that at the same degree of freedom, if the P-Value is higher than 0.05, the effect of ethnicity on dwelling density is classified as “*not significant*”. The table reveals that ethnicity had no significant effect on household’s crowding level, at 95% confidence level.

Table 2.0: Effect of ethnicity on household’s crowding

Apartment type	Chi-square Value X ²	D.F.	P-Value (T- tabulated)	Remark
Type one (2-bedroom), Abesan	Constant			Ethnicity has
Type two (2-bedroom), Dolphin II	3.344	8	0.911	no significant
Type three (3-bedroom), Abesan;	10.678	14	0.711	effect on crowding
Type four (3-bedroom), Iba	3.939	4	0.414	level in all apartment
Type five (3-bedroom), Dolphin	13.151	16	0.662	types
Type six (4-bedroom), Ebute-	10.427	12	0.579	

CONCLUSIONS

The research results indicate that four ethnic groups of Yoruba, Igbo, Edo and Hausa Fulani constitute 91.4% of the total number of respondents. Therefore the cultural traits and life styles that are common and acceptable to these four dominant groups should capture the attention of public housing providers in Lagos. The widespread speculation that Nigeria is made up of over 250 ethnic nationalities was not supported

by the data from this study. Only 14 ethnic groups were represented among the 176 household heads who responded to questionnaire. Disaggregating across groups reveals that no one ethnic group consistently maintained higher or lower crowding level over the other groups across apartments. A chi-square test further reveals that ethnicity of household head did not have any significant effect on apartment crowding, at 95% confidence level. Overall, an occupancy level of 3-5 persons per household represents the most occurring experience among the ethnic groups in all the apartments investigated. This result contrasts with findings from earlier researchers which highlighted differences among ethnic groups in their apparent acceptance of higher levels of crowding (Moller, Johnson, and Dardia 2002; Statistics New Zealand 2013; Gillis, Richard and Hagan 1986; Ministry of Health 2014; Fuller, Edwards Vorakitphokatorn, Sermsri 1993).

Two postulations can be adduced. (1) LSDPC tends to propagate an ideology of one-size-fits-all compact prototype apartments for nuclear households, (2) earlier finding that the dominant pattern of LSDPC's apartments was inclined towards Eurocentric lifestyles of nuclear family arrangement with not more than five adult-equivalent occupants (Iweka 2013). Over all, the design of LSDPC apartments should target meeting the spatial needs of persons from Yoruba, Edo, Ibo and Hausa-Fulani ethnic origin. Apartment types which cater for these ethnic groups should be deliberately mixed to meet their varying home space needs, while striving to achieve ethnic and social integration. However, further research is required to validate these results before applying them to settlements in Lagos that are outside public housing estates.

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DETECTING DEFECTS IN THE UK NEW-BUILD HOUSING SECTOR: A LEARNING PERSPECTIVE

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House builders play a key role in controlling the quality of new homes in the UK. The UK house building sector is, however, currently facing pressures to expand supply as well as conform to tougher low carbon planning and Building Regulation requirements; primarily in the areas of sustainability. There is growing evidence that the pressure the UK house building industry is currently under may be eroding build quality and causing an increase in defects. It is found that the prevailing defect literature is limited to the causes, pathology and statistical analysis of defects (and failures). The literature does not extend to examine how house builders individually and collectively, in practice, collect and learn from defects experience in order to reduce the prevalence of defects in future homes. The theoretical lens for the research is organisational learning. This paper contributes to our understanding of organisational learning in construction through a synthesis of current literature. Further, a suitable organisational learning model is adopted. The paper concludes by reporting the research design of an ongoing collaborative action research project with the National House Building Council (NHBC), focused on developing a better understanding of house builders' localised defects analysis procedures and learning processes.

Keywords: action research, defects, house builders, new homes, organisational learning.

INTRODUCTION

The delivery of high quality homes in the United Kingdom (UK) rests predominantly with the house builder (e.g. Sommerville and McCosh, 2006). The house building sector is under pressure to deliver 240,000 homes per year to meet demand (e.g. Holmans, 2013). It is argued that the one of the principal reasons for the decline in house building in the UK is local councils withdrawing from production from the late 1970s onwards (e.g. KPMG and Shelter, 2014). The withdrawal of local council housing supply has placed further pressure on private house builders to bridge the gap. Private house builders have responded to the need for more homes by rapidly up-scaling supply, with a 23% increase in new housing starts for the year 2013-14 compared to 2012-13 (DCLG, 2014). At the same time as increasing housing supply the UK house building industry is also under a further pressure to meet new requirements, such as the target for all new houses to be 'zero carbon standard' from 2016 (UK Government, 2012). The zero carbon standard agenda has resulted in the introduction of tougher Building Regulations, for example, changes to part L

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'Conservation of Fuel and Power' (DCLG, 2013), which has resulted in house builders incorporating new technologies to achieve compliance (e.g. Lees and Sexton, 2014).

A review of current literature has highlighted that the pressures the UK house building industry is currently under may be having a negative impact on build quality, causing an increase in defects (e.g. Hopkin *et al.*, 2014). There is growing evidence that the inclusion of new technologies can adversely impact new-home quality (e.g. Gill *et al.*, 2010). Moreover, it has long been advocated that an increase in housing supply can reduce build quality as tightened delivery dates cause supply chains, skills and site management to become over stretched (e.g. Sommerville *et al.*, 2004). The strain caused by an increase in supply is evident with the UK house building sector currently reporting materials, skills and workforce shortages (e.g. HBS, 2013). Further evidence of the increase new housing defects is in the Home Builders Federation survey results (HBF, 2015), which show that in 2015, 93% of home owners reported defects within their new-build house, the second year in a row that this figure has increased.

A review of UK new-build housing defect literature has identified that learning from defects experience is a potentially useful approach for house builders to reduce defects in new homes. The extant literature is, however, silent on how house builders actually learn and make improvements based upon past defect experience. This paper presents the theoretical framework used to guide the ongoing collaborative action research project with the National House Building Council (NHBC) which is focused on developing a better understanding of how UK house builders learn from defects.

LITERATURE REVIEW

Research into new-build housing defects in the UK is limited when compared to the wider construction sector (e.g. Love and Li, 2000), non-new-build housing (e.g. Page and Murray, 1996), and international new-build housing (e.g. Macarulla *et al.*, 2013). Hopkin *et al.* (2014) provided a review of the UK new-build housing defect literature, identifying that research into new housing defects in the UK can be generally grouped into three aspects: the stage in which the housing project is studied; the level of analysis; and, the findings, and how the findings are used. Building upon this review, this paper will further explore the recommendations being made within the literature.

Recommendations within the UK new-build housing defect literature

A number of recommendations to reduce defects have also been given within the literature, including: training for trades, standardised processes and products, predefined quality criteria, and learning from defects. Each will be discussed in turn.

Training for trades

It is argued that a mandatory training requirement resulting in the granting of a licence to carry out building works would improve the levels of skill and knowledge, and increase the ability for trades to achieve the desired levels of workmanship and ultimately reduce defects (e.g. Baiche *et al.*, 2006). For example, gas engineers in the UK are required to be qualified and on a register to legally work on boilers, fires and all other gas appliances (e.g. Gas Safe, 2015). Despite the mandatory qualification and registration requirements for gas engineers, Craig (2007) extracted a number of defects related to gas installations from a leading snagging company's database, for example, boilers and flues. The defects identified suggest that a licence to carry out building work is unlikely to eradicate defects on its own.

Standardised processes and products

The adoption of standardised processes and products in the building process has been argued as a potential solution to reduce defects. Baiche *et al.* (2006), for example, point out that the adoption of standard details would reduce complexity within the building process and increase familiarity from one site to the next, and ultimately would achieve defect reductions within the current construction environment. Lees and Sexton (2014) have established that house builders currently utilise standardised design and production plans and practices which are repeated from development to development. The combination of standardisation and repetition currently employed within the house building industry and high defect levels suggests that standardised processes and products may not be a viable solution to eradicating defects.

Predefined quality criteria

It has been recommended that house builders should establish a set of quality criteria to deliver to their customers on a consistent basis. Customers should be made aware of these criteria, and as such they can judge the finished product, the home, against that predefined criteria. This approach is argued to reduce the level of subjectivity with regards to defects and ultimately reduce their incidence (e.g. Auchterlounie, 2009). Under the terms of most new home warranties, the house builder is required to build to the warranty provider's requirements. Any deviation from the warranty provider's predefined criteria would constitute a defect (e.g. NHBC, 2012) [Note: NHBC provide a warranty on 80% of UK new homes]. As circa 95% of new homes in the UK will be covered by a warranty (e.g. Sommerville and McCosh, 2006; DCLG, 2014; NHBC, 2013) the majority of new homes are already being constructed to a prescribed set of quality criteria, which the home buyer will be able to access. Despite the "predefined" quality criteria in place there are still high numbers of defects in new homes.

Learning from defects

Learning from defects is considered as a means for solving the persistent defect problems in the new-build housing sector nationally and internationally. In the international context, Macarulla *et al.* (2013) for example, argue that if house builders analyse their defect performance they can gain an understanding of the nature of defects occurring and develop strategies to reduce them in Spain. In the UK context, Auchterlounie (2009) states that the UK house building industry should implement a feedback system to enable the builders to assess their current systems and their outputs. Roy *et al.* (2005) emphasise that re-examining and modifying working practices has the potential to reduce quality failures. Baiche *et al.* (2006) conclude the above ideas by arguing continuous review, research and feedback as a means of reducing housing defects in the UK. Davey *et al.* (2006) further advise that sharing good practice and the developments of others has the potential to improve processes to aid defect reduction. A number of government and industrial reports have been published to guide how house builders can improve their new-build housing performance. The 'Home building' report, published by the National Audit Office (NAO, 2007) suggests that by tracking and measuring the performance of different construction techniques and processes year on year, house builders can compare one technique against another in order to make improvements in performance. The NAO (2007) further recommend that a house's quality performance assessment should include analysing the number of warranty claims and number of defects within the property. The 'Management of post-completion repairs' report, published by the NHBC Foundation (2011), advocates an approach of: recording and analysing defect data, feeding the outcomes of the analysis in to the design and construction of a home

to amend procedures and ultimately make improvements based upon what has been learnt. Together these ideas suggest that the 'learning perspective' has been recognised as a means of reducing defects in new homes. The extant new-build housing defect literature, however, is silent on how house builders actually learn and make improvements based upon past experience (Hopkin *et al.*, 2014).

Organisational Learning (OL)

Organisational learning (OL) has been recognised as a source of company competitive advantage and is a term frequently utilised within the general management literature. Argyris (1977) argues OL to be a process of detecting and correcting error. Fiol and Lyles (1985) develop the concept to go beyond detecting and correcting errors arguing that OL considers organisations to be cognitive units which contain cognitive systems and memories, capable of observing their actions, investigating to discover the effects of alternative actions, and modifying their actions to improve performance. The definition is further expanded by Neilson (1997) who adds a requirement for producing higher level assets by arguing OL to be the continuous process of creating, acquiring, and transferring knowledge accompanied by a modification of behaviour to reflect new knowledge and insight; and produce higher level assets.

The construction literature relating to OL tends to draw upon the general literature as the basis of their OL definitional discussions. For example, Opoku and Fortune (2011) adopt Lopez's *et al.* (2005) definition describing OL as a dynamic process of creation, acquisition and integration of knowledge aimed at the development of resources and capabilities that contribute to organisational performance. The suitability of OL in a construction setting has, however, often been questioned due to the largely project-based nature of the construction industry. Gann and Salter (2000) assert that project-based methods of production in construction create a strong requirement to understand knowledge flows to help facilitate the integration of experiences from an organisation's projects in to its continuous business processes. Winch (1998), however, argues that most construction project problem-solving techniques are adapted using tacit knowledge and applied to a situation to meet specific client needs, and therefore it is difficult for them to be learned, codified and applied to future projects. Furthermore, the way in which many construction firms acquire and make use of knowledge is often poorly developed, resulting in firms gaining experience at an individual level, yet are unable to translate that to an organisational level (Barlow and Jashapara, 1998). Barlow and Jashapara (1998) go on to argue that those involved in construction projects are not afforded sufficient opportunity to feed experience they have gained from previous projects in to future ones. It is suggested that existing feedback systems in place within the construction industry are unstructured and informal, and as a result, ineffective (e.g. Scott and Harris, 1998). In order to provide structured and formal knowledge sharing mechanisms to enable previous experiences of the project co-workers to be exchanged and assist in enabling OL, Knauseder *et al.* (2007) argue that construction companies should look for opportunities to bridge project boundaries and enhance the tacit knowledge base of the workforce (and organisation) to promote learning and organisational memory (OM). OM is defined as "*the means by which knowledge from the past is brought to bear on present activities*" (Stein and Zwass, 1995:89). Huber (1991:107) further stresses the critical role of OM as "*the basic processes that contribute the occurrence, breadth, and depth of organisational learning.*" OM may be stored in a range of repositories, both human and artefact (Robbey *et al.*, 2000). For example, OM may consist of computer-based OM for storing and retrieval of information by individuals (e.g. Huber, 1991). OM can

also be held and updated through codifying modifications within company processes in order to enable the transmission of the new routines (e.g. Berkhout *et al.*, 2006). Ozorhon *et al.* (2005) further stress the need for construction firms to develop the necessary skills and systems to ensure that explicit knowledge is formed and committed to OM.

The potential for OL to achieve defect reduction in construction is further evidenced through its application to successfully detect and reduce errors in a number of project-based industries, such as: reducing surgical errors in the health sector (e.g. Vashdi *et al.*, 2007) and reducing errors in aircraft maintenance in the aviation industry (e.g. Federal Aviation Administration, 2009).

In the construction literature, a number of OL models have been presented. For example, Chan *et al.* (2005) propose a multi-facet conceptual model of OL to help understand OL challenges at the construction project level. This model is made up of five facets. First, 'contextual facets' are the external factors that management have either indirect control or no control over. Second, 'policy facets' distinguish formal and informal steps taken by senior management to promote OL. Third, 'psychological facets' are the shared beliefs that a team is safe for interpersonal risk taking and the commitment to an organisation. Fourth, 'cultural facets' are the norms that are likely to create valid information and the commitment to take corrective action. Finally, 'structural facets' are the organisations learning mechanisms. This model however has not been empirically tested. Knauseder *et al.* (2007) move away from offering a conceptual model and take a broader approach to demonstrate evidence of different learning approaches based on quantitative empirical data drawn from 51 construction projects. Three learning approaches for enhancing OL are identified. First, 'organising for learning' to enable the exchange of experiences to expand individual knowledge bases. Second, 'experimenting' with new materials and working styles. Finally, 'networking' for sharing experiences between others to bridge boundaries and enhance learning. Berkhout *et al.* (2006) propose that OL can be seen as a cycle that can be modelled from four constructs: (see Figure 1). First, 'signal recognition and interpretation' is where an occurrence is recognised as a novel situation which indicates that existing organisational routines are inappropriate or ineffective. It is argued that organisations are more likely to recognise a signal as a need for change the more frequent, clear and relevant it is to the organisation. Second, 'experimentation and search' is the process of initiating adaptation of organisational routines. Adaptation typically occurs in two forms: trial and error to modify existing actions and observe their impact on a small scale, and searching internal and external sources for relevant experience and knowledge that can be applied to the given situation. Third, 'knowledge articulation and codification' is the process of exposing potential adaption options to an evaluation process in order to select the option most suitable to the organisation. Upon selection of an appropriate option the modified routines are codified in company documentation, processes, software, targets etc. in order to transmit the new routine throughout the organisation. Fourth, 'feedback' from experience will be sought to validate that the proposed alternative routine remains viable, finally returning to the beginning of a new cycle by way of a new stimulus.

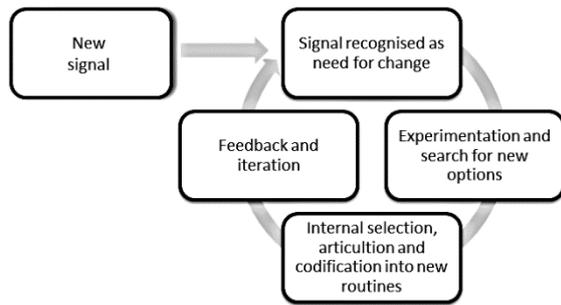


Figure 1: Organisation learning (adopted from Berkhout *et al.*, 2006)

As this project seeks to understand how house builders individually and collectively, in practice, collect and learn from defects experience in order to reduce the prevalence of defects in future homes (see ‘research aims and objectives’ section) Berkhout’s *et al.* (2006) OL model has been identified as the most suitable. The justifications for this model’s adoption are as follows. First, the adopted OL model has previously been tested within a construction environment, more specifically, to guide and analyse interviews from a range of functional departments within two housing associations and three house builders. Moreover, the model has been shown to be successful in determining how the housing industry responds to climate change impacts that are recognised as significant, for example to analyse a house builders technical innovation in response to persistent problems. Second, for OL to begin a signal needs to be recognised as a novel situation which indicates a need for change to existing organisational routines (e.g. Berkhout *et al.*, 2006). The starting point of this model is to identify a signal as significant. Third, it has been argued that there are a lack of structures, incentives and opportunities for project members to communicate and share knowledge and experience (e.g. Barlow and Jashapara, 1998; Scott and Harris, 1998; Knauseder *et al.*, 2007), the second stage of the adopted OL model involves internal and external scanning for relevant experience and knowledge to respond to a novel situation. Finally, the need for the storage of, and access to, OM by construction firms is highlighted (e.g. Ozorhon *et al.*, 2005). The adopted model identifies a clear logic for codifying new routines in organisational documentation, and transmitting the new information/knowledge throughout the organisation.

RESEARCH AIM AND OBJECTIVES

The overall aim of this action research project is to better understand how UK house builders’ individually and collectively, in practice, collect and learn from defects experience in order to reduce the prevalence of defects in future homes. In order to achieve the stated aim a number of objectives will need to be satisfied:

1. Understand house builders’ localised defects analysis procedures, and their current knowledge feedback loops to inform future practice.
2. Establish the impact of individual defects on key stakeholders in the defect detection and remediation process for house building.
3. Design and test action research interventions to develop a new defects assessment tool kit and learning systems to reduce targeted defects.

This paper has identified OL as a theoretical concept which can help on developing a better understanding of how UK house builders learn from defects. The next section presents the research methodology used to address the research aims/objectives.

RESEARCH METHODOLOGY

Research Approach

An action research (AR) approach is considered appropriate for this research as this research aims to empirically investigate how house builders learn from defects experience in general; and, more specially, to induce change (new defect assessment tools and learning systems) in a social setting (a house builder) in order to reduce targeted defects. AR is understood to be an approach which “*simultaneously assists in practical problem solving and expands scientific knowledge, as well as enhances the competencies of the respective actors, being performed collaboratively in an immediate situation using data feedback in a cyclical process aiming at an increased understanding of a given social situation, primarily applicable for the understanding of change processes in social systems and undertaken within a mutually acceptable ethical framework*” (Hult and Lennung, 1980:247). A cyclical process view of AR is resonated by Susman and Evered (1978) in the general literature and by Lu and Sexton (2009) in the construction literature who further differentiate the five-phase process of: problem/opportunity diagnosis, action planning, action taking, evaluating and specifying learning. First, the ‘problem diagnosis’ phase involves identifying an improvement opportunity. Second, the ‘action planning’ phase specifies the organisational actions to advance the intervention. Third, the ‘action taking’ phase is the implementation of the action plan. Fourth, the action evaluation phase is an activity to determine whether the applied interventions have been successful, in comparison to the criteria set out in the action planning stage. The final phase, ‘specifying learning’ is to reflect on the gained knowledge from the action research.

Research Design

This section presents the overall design for the research (Figure 2).

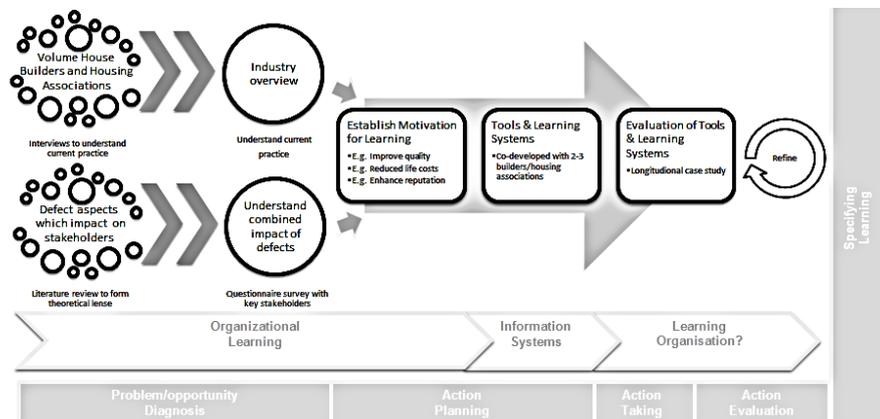


Figure 2: Overall research design

This research project is currently in the diagnosis phase of the AR cycle. There are two tasks being carried out in the diagnosis phase. The first task is to ‘understand house builders’ localised defects analysis procedures, and their current knowledge feedback loops to inform future practice’ (objective 1). Data collection for task one will involve semi-structured interviews with senior management and customer care departments of five volume house builders and housing associations, in order to understand their current processes and therefore identify the problem/improvement opportunity. The house builders and housing associations are targeted on an output basis (volume of properties built). Customer care departments have been selected due to their involvement in the post-completion defect remediation process while senior

management for their anticipated level of influence within the organisation. The second task is to 'better understand the impact of defects on key stakeholders within the new house building defect detection and remediation process' (objective 2). Data collection for task two was through an electronic questionnaire survey targeted at the four key stakeholders in the house building detection and remediation process: home occupant, house builder, warranty provider and building inspector. The aim of the survey was to establish what impacts of defects are the most important to the four stakeholder groups by asking the respondents to prioritise a number of pre-determined impact factors on a scale of 1 (Not a priority) to 5 (Essential). The survey was distributed via a web link with a covering email which set out the purpose of the survey and research ethics safeguards. The survey was distributed to 2003 people drawn from the NHBC's database, including 817 home occupants who have had a defect rectified under their NHBC warranty during the financial year 2013-14; 161 members of the same warranty provider's staff; 209 building inspectors from the UK's largest approved independent building inspection service, and 816 active house builders on the NHBC's register. The duration of the survey was one month with three follow-up email reminders. The overall response rate was 15% with a total of 292 responses (18% of home occupants; 6% of house builders, 34% of warranty provider; and 21% of building inspectors). The interview and survey phases contribute towards to the first two research objectives. In addition, the two phases will inform objective three 'Design and test action research interventions to develop new defect assessment tools and learning systems to reduce targeted defects.'

DISCUSSION AND CONCLUSION

What has become clear from a further review of the UK new-build housing defect literature is that a number of commentators have made consistent recommendations to reduce defect prevalence. The recommendations, in particular, for the training of trades, standardised processes and products, and predefined quality criteria are an on-going priority for the UK house building industry, yet the persistent problem of defects remains. It was found that the one remaining recommendation 'learning from defects', in this case, the process of how house builders currently learn from defects, remains under-researched. Learning at an organisational level (i.e. organisational learning) is often argued as a means of enabling organisations to produce higher level assets and gain competitive advantage. The translation of OL principles have, however, not been fully achieved in the new-build housing sector. The potentiality of OL to provide a framework for house builders to learn from and reduce defects is under-developed area. The review of literature relating to the suitability of OL in a construction setting has identified a suitable model for the theoretical basis of the upcoming interview process of the ongoing collaborative action research project with the NHBC to better understand house builders' defects analysis procedures and learning processes to reduce defects.

ACKNOWLEDGEMENTS

The authors would like to thank NHBC and the Engineering and Physical Sciences Research Council (EPSRC)-funded Industrial Doctorate Centre: Technologies for Sustainable Built Environments (EP/G037787/1) for their funding and support.

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RENEWING RENOVATION: LOOKING AT RENOVATION OF OWNERS OCCUPIED HOUSES WITH SOCIO-MATERIALITY LENSES

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Owner occupied houses built in Sweden before 1980 are in need of renovation to achieve the 2020 energy performance directives. Despite political pressure, these renovations are far from been realised. To explain this slow take off, studies have mostly focused on the necessity to better bridge new technical solutions with the needs and behaviours of the users. We propose to enlarge this analysis to a broader set of actors including the craftsmen in charge of the physical work and the houses themselves with their specific features and characteristics. To do so we build our contribution on the concept of socio-materiality. This perspective argues that technological artefacts are socially constructed but recognises a role to materiality; it describes the social and the material as becoming constitutively entangled. Drawing on the case studies of 18 small craftsman companies and their customers, our method includes interviews, workshops and ethnographic work. The results show many differentiated representations of the renovation process at stake. Norms and experts are portraying the house as a holistic system which parts need to be in balance; the various craftsmen relying on their own trade have a rather fragmented view regarding the interventions they carry out; the owners are mainly interested in comfort, aesthetic and economic considerations; the house itself besides its original material features often displays unique characteristics as the result of diverse modifications executed since the days of its construction. All these positions need to be understood and somewhat aligned in order to achieve successful implementations

Keywords: energy renovation, socio-materiality, single family house owners.

INTRODUCTION

Sweden has formulated ambitious national policies regarding energy consumption and sustainability, but is challenged when facing implementation of solutions to reach these climate targets. Buildings represent 30% of the total energy consumption in Sweden (Boverket 2010). Energy renovation is therefore one of the most significant contributions to decrease energy usage. However if renovation of large housing development is taken care of by large contractor companies, the renovation of single family houses is lacking behind. In particular houses built between 1950 and 1975, representing 43% (Boverket 2005, SCB 2014) of the Swedish dwelling are in need of renovation. Houses of this period see many of their features such as ventilation, bathrooms, laundry, drainage, windows or roofing coming to end of their lifetime expectancies. However, many owners carry renovation and redecoration without including energy efficiency interventions. The situation seems to be similar in other

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European countries, where energy renovation has still not become a “*practice*” (Bartiaux *et al.* 2014).

In the present paper, we contribute to the study on the lack of retrofit initiatives when houses built between 1950-1975 need to be renovated. We use the term retrofit when the renovation process includes energy consumption concerns and renovation when energy saving is not included in the process. Building on the concept of socio-materiality, we include among the actors in presence during the renovation, the house itself with its specific features and history as well as the diverse documents helping the decision process. We focus on the performative role of material elements and the actors' different representations at the time when the scope of the renovation project is shaped. The concept of socio materiality understands technological artefacts as socially constructed but recognises a role to materiality; it describes the social and the material as becoming constitutively entangled. Drawing on the case studies of 18 small craftsman companies and their customers' engagement in renovation processes our method includes interviews, workshops and ethnographic field work.

The remainder of the paper opens with a short presentation of recent studies of single family houses followed by a theoretical frame presenting the concept of socio-materiality and the method section. The next section presents findings, discussions and conclusion.

RETROFIT (OR LACK OF IT) FOR SINGLE FAMILY HOUSES

The high cost associated to retrofit along with the difficulty to obtain distinct energy savings have often been used to explain the lack of success that retrofit meets with single family house owners. These cross benefit types of analysis have been criticized for having a too narrow view on energy investments.

More recent studies have focused on the actors and the decision processes prevailing in the choices of interventions, retrofit, renovation or decoration of houses (Vlasova Gram-Hanssen 2014, Archtnicht and Madelner 2014, Haines and Mitchell 2014). The actors usually identified in these processes include: the house owners, the craftsmen, the policy and regulation and sometimes the technical experts. The lack of energy saving initiatives for the renovation project is differently attributed following the actors.

For the house owners, one of the main barriers identified is the lack of information and technical knowledge regarding retrofit. (Mortensen *et al.* 2014). In addition, house owners address their investments to other forms of renovation triggered by comfort, lifestyle and esthetical aspirations (Risholt and Berker 2013). However these studies also show that successful retrofits are clearly associated with proactive house owners (Risholt and Berker 2013, Galvin and Sunikka-Blank, 2014).

The craftsmen are said to be insufficiently equipped to develop and adapt new solutions to their current practices, they lack the full set of skills and resources to deal with but also to benefit from the upcoming increase of opportunities (Mokhlesian and Holmen 2012). Under pressure to deliver within tight time frames, they tend to offer and repeat standardized solutions to their customers (Archtnicht and Madelner 2014).

Policy and regulations should foster and support changes in actual practices by developing new building and operation standards (Directive 2010/31/EU). Economic and information policy instruments may be more useful than regulatory instruments to influence owners of existing houses to adopt building envelope measures (Mokhlesian and Holmen 2012). Without their actions, the energy targets seem to be difficult to

realize (ibidem 2012). However, as the retrofit strategies presented are not addressing their lifestyle and aspiration, house owners may not find these recommendations helpful or practical enough to follow them as in the Danish case described by Christensen *et al.* (2014).

Energy experts and energy consultants as private or public servants are helping house owners by informing about concrete possibilities of reducing houses energy consumption or producing new energy. Their role has been recognized in supporting retrofit projects (Vlasova and Garm-Hanssen, 2014). In Sweden these experts' advices seem to be followed by the house owners when consulted, the problem is that only few of the owners are actually seeking their expertise (Mahapatra *et al.* 2011).

However, the retrofit market is not only depending on the four actors, large do-it-yourself chains and magazines are also participating by assisting clients to carry jobs themselves (Buser and Carlsson, 2014). If house owners have opted for having a craftsman to carry the renovation, they usually follow their neighbours' advices both in term of technical solutions and companies choices. There is a preference to contact and hire local small and medium sized enterprises (SMEs) (Doona and Jarlbro 2009). Yet, the possibility among other provided by internet, for customers to access advices and services increases their ability to opt for energy efficient solutions and to require specific products (Risholt and Berker 2013). This also puts pressure on the SMEs not only to innovate and increase their portfolio of solutions but also to be able to advocate and argue for their choices when meeting their clients.

THEORETICAL FRAME

To analyse the interactions of the different actors in the renovation process, we build on the concept of socio-materiality (Carlile *et al.* 2012). The scholars engaged in the socio-materiality discussion aim at bringing back “*matter*”, “*thing*”, in a field where most of the interactions between people and technology have been claimed to be socially constructed. They argue that the emphasis of the role of language, “*the language turn*” taking place in the beginning of the 80ies, has eclipsed and marginalised objects from researchers' views. Building on the strands of science and technology studies, which analyse the social aspects of production of science and technologies (Latour 2005, Bijker 1995, Knorr Cetina 1999) and the strands of practice studies which recognise that the activities performed in organisations are not only mental activities but are also inscribed and enacted in body and materiality (Nicolini *et al.* 2003, Carlile *et al.* 2013), the socio materiality stream is interested in studying the “*constitutive entanglement of the social and the material in everyday organisational life*” (Orlikowski 2007). In this context, objects have emergent and relational qualities rather than being considered as fixed things (Clegg and al. 2013). This position confers a role to objects in organisational life. The capacity of the nonhuman entities to act without the support of human intervention is called material agency (Leonardi, 2012). This agency is performed trough the things humans cannot completely or directly control (Leonardi 2012). However, material agency can only be activated as humans approach these entities. It is inseparable from the network of social practice it is part of (Suchman 2000). Through practice as they are ‘performed’, human actors attribute meaning and uses to the materiality and these representations are neither fixed nor stable but emerging: “*Representations, then, are not passive representations but active, constitutive features of (socio-material) practice*” (Monteiro *et al.* 2012).

Paraphrasing Suchman describing a bridge (2009:316) we argue that like an organisation, a house “*can be viewed as an arrangement of more or less effectively stabilised material and social relations...the stability of the house is a matter of materiality, based on architecture, builders and inhabitants practices. This materiality though is inseparable from the network of social practice that must be put in to place to maintain and renovate this artefact over time. More specifically to discuss material agency in renovation process integrating or not energy saving measures, we focus on the performative features of houses and the actors’ representations as engaged in this process*”.

The group of scholars gathered under the concept of socio-materiality is not unified. There are tensions within the socio-materiality stream regarding the independency of agency for both human and material. Where for Orlikowski and Yates any “*distinction between humans and technologies is only analytical and can only be done with the recognition that these entities necessarily entails each other practice*” (2008: 256); others see agency for both human and materiality as separate elements whose interactions can be traced and analysed (Leonardi 2013, Mutch 2013).

A brief browse in the literature specific to the construction sector shows that studies building on socio-materiality are rather rare. However, the relation between humans and non-human actors (Latour 2005) has been described by several authors using other concepts such as boundary object (Harty 2008) and Actor Network Theory (Tryggstad *et al* 2013, Sage *et al.* 2014).

METHOD

The method is multidisciplinary and employs an interpretive approach to discuss the empirical material (Burrell and Morgan 1979, Bryman and Bell 2011). The frame of understanding is based on a selective literature review drawing on organisational theories on socio-materiality.

The empirical material for this paper has two sources: the first and main contribution is an ongoing PhD (2013-2016) conducted by one of the author. Her focus is to document and analyse the integration of new energy saving solutions for the renovation of single family houses with a particular attention to the relation between the house owners and the craftsmen engaged to carry the work. This longitudinal study includes so far 13 interviews with craftsmen and enterprise representatives; nine interviews with customers: 5 at the customers’ homes at the end of the craftsmen’s initial visits and four on the phone after the visit; and six observations of initial encounters between craftsmen and customers to design and decide the scope of the renovation. To these have to be added 14 workshops with a total of 18 craftsmen’s companies to discuss and develop the potential of new energy saving solutions for their customers, and including twice the presence of technical experts.

The second source which complements the first one is an example auto-ethnography (Alvesson, 2008). Auto-ethnography can be described as, “*a form or method of research that involves self-observation and reflexive investigation in the context of ethnographic field work and writing*” (Maréchal 2010:43). The second author has been engaged in the process of finding a new house in the region of Gothenburg, (between 2012 -2014). She has visited more than 100 houses and read almost as many technical reports, before finally being able to buy a property in need of renovation last October. She has since been confronted to the choices, advices and works of experts and craftsmen. For this paper, the material included the description and technical

reports from 20 of the visited houses, as well as notes taken after the meetings with the expert, the real estate agent, the former owner and the neighbours.

FINDINGS

Context of renovation in the region of Gothenburg

All renovation projects used as cases for this study have been initiated by the house owner. So far, we have identified four situations at the beginning of the renovation process: the sale of a property; the buying of an existing property; the need for repair; the comfort upgrade to meet lifestyle aspirations or/and energy savings.

As the situation of the second author may have suggested, the region of Gothenburg is under heavy pressure regarding access to residence, for both acquisition and renting of apartment and houses. With few objects on the market, a large amount of buyers and a system of auction similar to the one in Scotland, the prices of housing have increased of 19% for the last 12 months. This situation often pushes buyers to overrun their initial budget. Several of the interviewed craftsmen incriminate this situation to account for the lack of retrofit and large renovation initiatives as the *“buyers are broke once they enter their new property”*.

When selling a property, the Swedish law requires the publication of a technical report describing the physical state of the building and if needed the improvements required for its maintenances. This technical report is a PDF document listing the different parts of the house and indicates which elements need to be taken care of, with a grading system of the seriousness of the failure. Since 2008-2009, the seller has also to provide an energy declaration of the actual consumption of the building as well as solutions and associated costs to reach the new energy standards. Besides the buyer is compelled to organise his or her own technical expertise of the property and make its own assessment, this is often organised by the real estate agent with the same technical expert as the seller used.

The selling of property is not seen by our interviewees as an opportunity to engage in neither large technical retrofits nor renovations. Among the work performed we have one investment in a new heating option. The owners rather invest in cosmetic intervention, like painting and trendy furniture. The business of redecorating houses is booming in Gothenburg giving a uniform look to the properties on sale. This trend is strongly supported by magazines and TV programmes defining what a stylish and attractable house should look like. These lifestyle trends also support the renovation for comfort or energy savings as valorisation mean for the house owner, following an *“eco-chic”* fashion. Though the narratives about retrofit usually include economic rationality and potential savings.

Scope, choices and decision

To help to make a decision about the scope of renovation, the house owners have at disposition a lot of different sources for inspiration: neighbours, media (magazines, internet, TV programmes), do-it-yourself shops, technical reports.

They can also contact the professional actors: craftsmen, public or private energy experts, architects. But the choices of what competences and which professionals to involve can be seen as a burden. As described in a previous study, (authors selves references, 2014), Internet is not very helpful to find and select a specific craftsman. The preferred source of information to engage a professional is often personal contact and network; as described by a house-owner: *“My husband knew the owner since*

before we wanted to renovate, that is how we decided to hire him. Regarding the other craftsmen, we got to know people during the renovation process and through people you can find out who is good and who is not depending on what needs to be done, and from this information we add on new craftsmen in the process”.

In our panel, is it not so much what the house owners want to achieve which is an issue but more the matching between the goals they have in mind, the people to carry the work and the physical characteristics of their property. When contacting professionals, house owners expect them to bridge their expected improvements with the features of their own house. However, house owners knowledge about their property is not always up to date as underlined by one the craftsmen: *“Most of the house-owners are not aware of the bad condition of their houses, how the lifespan of some of the materials is long gone and that these desperately need to be replaced to fulfil its purpose... so when they find out, they have to change priority”.*

But knowledge of the craftsmen may also be challenged as here by one of the energy expert: *“I have heard craftsmen saying that we should not change the house and its settings because these old houses have never had any problems! And I usually say then that it is amazing that we do not have more problems considering how the houses were constructed before....”*

The house owner may give up his own intention and follow the opinion of the expert as in this observation: a customer comments the solution of solar panels installed by his neighbour and asks the craftsman if this might be something that he too should invest in. However, the craftsman advises against it, claiming that it is not a solution he would recommend as it would not cover the house's specific needs; he then continues to sell his own solution of geothermal heating. Paradoxically, the house owner may be surprised if the professional is not coming with challenging ideas on how to carry the renovation. One of the house owners was disappointed by the craftsman accepting their suggestions of what needed to be done without discussing the solutions she and her husband had proposed.

The different sources of expertise may also be contradicting: old double glass windows have been sealed to their frame by the painting of previous house owner's. The technical report indicates that these old windows may have low insulation efficiency so shifting them could be a good investment. When the new owner informs the expert during the technical visit that she intends to do so, he replies back: *“Why would you like to do that, these windows are fitting with this type of house. Bah, there is no need for that. It is not worth it, it won't pay back”.* Actually all her initiatives to increase energy efficiency, like: new roof, heat pump or extended insulation are turned down. She is instead instructed to use only part of the ventilation system and as often as possible let the door of the bathroom in the cellar be open to balance humidity levels, as *“these old houses are working quite nicely”* (expert).

If craftsmen appear to show confidence in their own trade, they may dismiss the competences of others. Competition between professionals is also appearing during the workshops when the craftsmen are gathered to discuss new possible energy solutions: *“There are big risks of moisture problems in houses, however, there are also a lot of myths in the field. I have collaborated with several different carpenters during my years and they can have very different opinions of what can and should be done and how it should be performed, 20 different carpenters can have 20 different ideas”* (craftsman).

Another craftsman claims that *“Even if customers want to insulate their houses it is not for everybody to have.”* This position of the craftsman though should not be read as simple resistance to changes. The punctual energy saving interventions of the houses may have unattended consequences which may carry the need for further interventions. Tightening the windows modifies the former ventilation process of the house and increases the risk of keeping moisture in the house. Introducing geothermal heating requires changes in the chimney pipes and its aeration. Changing from oil tank to district heating may increase the humidity of the cellar. The craftsmen interviewed claim that they rather avoid the domino effects of such changes to minimize the risk of mould problems or speed up the decay of materials.

Facing numerous choices when engaging in a renovation process: *“there is a kind of relief in trusting professionals as it takes from your shoulders the weight of having to make your own decisions, even if you have doubt about the quality of their solutions”* (house owner).

DISCUSSION

The concept of socio materiality allows to conceptualise how humans and non-humans are participating to create choices and scope of the energy renovation process. A house is not only a passive object which should be expected to be continuously shaped by humans. The conditions and the materials which have contributed to the building of the house as well as the successive interventions which have been conducted create a specific situation which escapes from readymade or generic solutions. The house influences and participates to the renovation process by its features and limits the possibilities of intervention, and consequently exhibits its performing role.

Moreover the representations associated to the house by the actors both human and non-human mobilised in the process also participate in the shaping of the renovation project.

The following chart resumes the characteristics and roles of the actors, human and non-human, their representations respectively of the house, and of the renovation project when the scope of renovation is defined. These representations are neither stable nor fixed and may contain contradictory statements for the same actor. They show the diversity of interests, positions and goals that the renovation project may mobilise. Their interactions are multiple and complex and we present here a simplified version of this complexity. (Chart should be here)

Agency is a relational process, where some objects are mobilised to empower some of the dominant actors, in this study the experts and the professionals, and disempower their challengers (Clegg *et al.* 2013). The house owners have the difficult task to be project manager for the renovation project. They have to organise professionals who appear to be more knowledgeable not only about the renovation possibilities but also about their own houses. The representations of experts, craftsmen and house owners are often challenging each other as they are built on different meanings and practices related to the houses. In the projects we have looked at, the house owners tend to follow the craftsman they have hired even if his decisions may be contradictory to their own aspiration. The expertise and professional competences mobilised are valorised higher than the house owners' own interpretations.

CONCLUSION

Researches on renovation have usually considered the house as a passive element which can be configured at will. Using socio-material lenses to understand the slow take off of the retrofit of single-family houses in the region of Gothenburg underlines the performative role of the house in the process. Both its material features and the social practices to which the house is associated actively shape the decision processes and may limit the scope of the project. If most of the analyses done by other scholars on the barriers to retrofits are confirmed by our empirical case, our contribution shows that the houses themselves play a role in the shaping of the renovation processes. So socio materiality helps us to renew renovation.

Table 1 The socio-materiality of renovation process of single house owner

Actors	Characteristics and role	Representations of the house	Representation of the renovation
House (1950-75)	Original technical features Aging and ware out of material Add on: new bathroom, extension Professional and non-professional interventions	Broken Not functioning properly Not functioning ultimately	Improve the function of the system Repair Maintain Embellish
House owner	Owner, initiator, project manager Individual, couple, family, pets Customer client	Privacy, comfort, identity, emotions, aspirations, aesthetics, cost,	Improve comfort, self-image, value, own economy Impress the neighbours Comply to social order
Craftsmen	Translate the technical features of the house to the owner Define the possibilities and the scope Co-design the scope of the renovation Carry the work Expertise	Focus on materiality and things that need to be fixed Fragmented view related to his own trade Give judgment on the quality of the house Stereotypic understanding of what the owner want and can	Jobs Budget both time and cost Craftsmanship Service Workload Organisation complexity
Experts	Provide expertise Provide new solutions Translate the technical features of the house to the owner	A system	Jobs Sell technical solutions (depends on experts) Make sure laws and policies are followed Make sure improvements works as a whole?
Legislation	Mathematic formula and report between space and energy	Goals to be achieved	Justification of the renovation
Technical reports	Paper or electronic, text, photos, measures pictograms	House fragmented in a succession of elements Hierarchy of the problems - benign to acute Users friendly	Identify (possible) work to be done
Energy report	Paper or electronic, list of items and statistics, figures, formula, very little text, costs	See the house as a system which needs to be balanced Technical features	Propose cost efficient solution to balance or reduce the energy consumption

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AN APPROACH TO SUSTAINABLE REFURBISHMENT OF EXISTING BUILDING

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The climate change challenge in built environment is complex as on one side there is a pressure to reduce carbon emissions from energy consumption, on the other side energy consumption trends are moving upwards and performance of the existing housing stock is degrading. As the majority of the existing housing stock will still be standing in 2050 there is need to address its energy consumption if CO₂ targets are to be met. This challenge forms the basis refurbishment, offers a huge potential to improve the performance of existing housing to the meet climate change and sustainability. Although the technical approaches to low carbon refurbishment are well known; deep retrofit uptake is currently very low. Through a review of literature, review of theoretical areas under which social landlord operate this paper will explore possible reasons for the low uptake and present a theoretical model of the key decision points that influence the refurbishment process in social housing in UK. The paper will identify the importance of economic and social drivers alongside technical solutions in designing effective refurbishment interventions. The paper will present the model in the form of a decision tree which will help built environmental professionals better understand the refurbishment process and develop effective business models that contribute towards sustainability by reduced energy consumption, improved thermal comfort. The study will help closing the performance gap by balancing the adaptation and mitigation measuring impacts.

Keywords: decision tree, energy efficiency, refurbishment, sustainability, social housing.

INTRODUCTION

Energy efficiency and climate change are topical issues over the world. The building sector accounts a significant percentage of national energy consumption: 37% for EU, 39% for the UK (Perez-Lombard *et al*, 2008). With the Climate Change Act in 2009, the UK has committed itself to an 80% reduction in all greenhouse gases by 2050 over 1990 levels (H M Government, 2008). The scale of the challenge, to achieve at least 80% cut in carbon emissions by 2050, is somewhat daunting. Paul King, chief executive of the UK Green Building Council said: “We drastically need to cut emissions from all sectors, but the built environment offers the best cost effective opportunity to do that. We have the technology and the know-how in the industry, but we haven’t managed to mainstream these yet. So the drive to cut carbon emission, quest for sustainability has put new challenges to engineers (i.e. doing more with less).

From 1994 to 2004 building energy consumption in UK and North America has increased at a rate of 1.5 to 1.9% per annum respectively (Perez-Lombard, 2008). The high level of building energy consumption, the steady increase in building energy

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demand and the legislative obligation to cut carbon emission necessitate low energy houses either by newly built or refurbishing existing building. The rate of new buildings that are being added to the current housing stock is nearly 1% per year (Power, 2010). At this rate it will take several ages to get a significant percentage of new houses of the total stock. Demolishing housing, taking the debris to the site, preparing the site for the new build involves high embodied energy. At this rate of new built and demolition, about 70% to 87% of the current existing stock will still be standing in 2050 (National Statistics, 2012). Therefore, refurbishing offers the most potential in making the existing building stock energy efficient.

Although a wide range of software tools and retrofit technologies are readily available, methods to identify the most cost-effective retrofit measures are still a major technical challenge. There is still a lack of implementing quality and performance management techniques. Through literature review, review of theoretical areas under which social landlord operate this paper describes the business cases and theoretical model for refurbishment and a decision tree for alternative measures to be identified through multi-criteria decision technique for a more rational and realistic assessment of technical, economical, social, and environmental issues. Findings of the ongoing research will help formulating a framework that asset managers can use to evaluate and plan technical interventions over a 10 years timespan from the many available to a build (or stock) depending on the building archetypes, future climates, socio economic conditions and occupant's preference.

WHY REFURBISHING?

According to BSI (1993) "*refurbishment is a combination of any actions required to retain an item in, or restore it to an acceptable condition*". The above mentioned definition is solely true for physical condition of the building or its elements under the current refurbishment practices. But a building's functional performance is different from physical state, which can be improved to more than its original state. In Jones's (2007) model, refurbishment as an activity can be partial or total. Repeated partial refurbishment cycles are carried out until the point at which a building fails to satisfy the occupier's demands. Even after full refurbishment some residual obsolescence may remain and grow over repeated refurbishment cycles. Obsolescence means a building no longer meeting its requirements, which could occur for a number of reasons. Details of refurbishments are available in Jones and Sharp (2007).

The basic question of undertaking refurbishment can be simplified as when to refurbish and how to refurbish. Different buildings will have different business cases to instigate refurbishment. Householders can be motivated to refurbishment for physical, functional or both requirements.

Physical requirement includes space – extending the house to make more space, provide privacy, security from intruders, better use of existing space, easy access, kid's room; technology integration – integration of innovative technology such as green roof, led light, heat pump; repairs – damaged features of the home such as floor, walls, roofs, windows, leaning, corrosion of fixing, mould growth.

Functional requirement includes discomfort –draughts, overheating, noise attenuation, visual comfort; efficiency – improving heating systems or insulation to reduce energy consumption, CO₂; indoor environment quality- provide fresh air, light, remove odour, reduce NO_x and VOCs (volatile organic components). Functional requirement also includes economic consideration- low maintenance cost, increase asset value, avoid

void period, long lifecycle; intrinsic factors – personal satisfaction, gaining a sense of achievement or relaxation, pride in restoration and a high standard of workmanship; social dimension - alleviate fuel poverty, stop anti-social behaviour, crime, environmental dimension - care for environment and wild life, less burden on fossil fuel, improved health; optimal use of resources –water, land, minerals, reduction of waste, less dependency of fossil fuel, exploitation of renewable energy; waste minimization – use less water, energy, produces less waste, use recycled product more; and overcome obsolescence – political, technical, aesthetic, societal changes, environmental aspect, climate change. Mostly these are microenvironment drivers. Though it is said micro-environment but it is hard to separate many issues from macro to micro environment as they are inter-related to each other. For the larger society of macro environment the drivers are low NHS cost, improved health condition, tree planting and beautification, low carbon society, increasing social equity, creating employment, and increasing energy security. So there are many business cases that drive refurbishment but under current refurbishment practices little emphasis is put on to improve the sustainability performance profile.

CURRENT REFURBISHMENT PRACTICE

The current refurbishment practice in social housing in UK is governed by stock condition survey putting physical condition, service life of the building or building component, and weatherproofing at its core taking into consideration of budgets, legislation and a time frame for a service life of generally 20 to 30 years for social housing. It also depends on the economic status and their attitude such as refurbishment is sometimes treated as a burden and waste of money (Moua and Russel, 2001) in the organization. In the past social housing refurbishment was carried out to meet the targets imposed by the local or central government under different schemes such as warm front, decent housing schemes etc. The social housing management was busy in meeting those targets only (eg. replace kitchen older than 20 years, replace inefficient boilers). So, effectiveness and efficiency of the refurbishment under previous approach was questioned as it did not do more than it was asked to. It is good that under current amendment social housing have been given the power to develop their own targets and act accordingly – a shift from regulatory prescribed housing management to a proactive style of asset management. It means that they have now more freedom to include sustainability at micro and macro level in their asset management strategy. Nevertheless, uptake of refurbishment is very slow.

THE BARRIERS AND CHALLENGE OF REFURBISHMENT

One of the most challenges of refurbishment as opposed to new built is the high cost, higher tax on refurbishment and lack of incentives. Though there are some incentives available under the schemes of green deal or renewable heat incentives, they are split by nature. Moreover the framework has its own problem. Another big challenge is the lack of enough information and uncertainty in the building structure to be refurbished (Azlan-Shah., 2010) such as physical condition of load bearing members, cracks, infiltration, or uncertainty in the whole construction project which may cause contingency cost allocation (Rayers and Mansfield, 2001). The drive to increase new housing also minimises the fund needed for refurbishment. Though cost is a big factor for refurbishment, social housing sector is less impacted by it as it is met through revenue budgets which are largely derived from rental income (Housing Corporation, 2008). Moreover public ownership under social housing allows a greater degree of

control, making it easier to coordinate and carry out refurbishment (Waide, *et al.*, 2006).

Barriers within the asset management are - lack of top level commitment, skilled person to take the lead with regards to sustainability, lack of co-operation between departments and support from external organisations. Building Regulation in UK is less strict than Scandinavian countries (Balaras, *et al.*, 2005). The Passivhaus standard of Germany is even almost three times stricter than the current Regulations in UK. Construction industry only meets the standard in force at the time of construction; they never go beyond building Regulation whereas the standard gets stricter day by day. Social housing sometimes lack in consistent stock condition data as stock condition data varies due to subjectivity, poor links to business cases.

Social housing works in partnership with third parties who are mostly SMEs (small, medium enterprises). In cases, SMEs lack knowledge in best measures; present poor quality of work. Sometimes the supply chain within SMEs is fractured and the holistic concept of sustainability is not known to them. Critical components for refurbishment are even often shipped from overseas increasing embodied energy. Sometimes installers don't like to take the risk with innovative solutions as complexities might arise later. Measures such as solid wall insulation are viewed as unattractive as outside appearance of the house is changed and disruption is involved. Housing stock with Hard to treat (HTT) or Hard to heat (HTH) may not be suitable for refurbishments at all. Though renewable energy can play a vital role to decouple HTT or HTH housing stock from the fossil fuel and minimize carbon emission, renewable energy is unpredictable, costly and pay back periods are sometimes very long.

Barriers at the downstream are age of tenants (particularly if elderly), habitual aspects- occupants do not understand how to operate most efficiently. Due to rebound or take back effect no improvement in energy saving might be seen from refurbishment. Obsolescence is less observed in dwellings or social housing but it is clear that if tenants don't accept changes due to the refurbishment, their preference is ignored, holistic approach to sustainability is not taken; expected performance will not be achieved. It becomes complex while integrating broad contextual issues in a holistic approach.

CONTEXTUAL FACTORS OF REFURBISHMENT

Before attempting to describe the context of refurbishment it is important to define "*Healthy housing*". A healthy housing means a quality housing itself which necessarily need not to be designed with special care in residential setting but meets the occupants preference and expectation. According to World Health Organization, (2010) housing will have four characteristics- physical entity, provide facilities and feeling of home to occupants, its surrounding environment, a feeling of neighbourhood. The above issues are correlated and have serious impact on physical and mental growth of an occupant. The contextual factors affecting the social house refurbishment in UK has been described below and shown in the conceptual sustainable refurbishment model of figure -1.

Technologies: Based on supply and demand the refurbishment technologies providing facilities can be categorised into three groups -supply side, demand side and change of energy consumption patterns, i.e. human factors. The supply side refurbishment technologies include solar PV, gas, electricity, biomass, oil, solar hot water, heat pump or other efficient sources of energy. Technologies for demand side include

strategies to reduce building heating and cooling demand (insulation, heat recovery, windows, shading, etc.), the use of energy efficient equipment and, low energy or zero carbon (LZC) technologies. Human factor can be managed by the application of controls, sensors or by habits. Mitigating climate change effect will require innovation in sustainability, technology, procurement and industry capacity in energy constrained world. However, the procurement and penetration of LZC in market is slow.

Environment or ecology: There are five major areas in which the built environment can interact with the environment. They are in the form of land fill, release to air in the form of gas (CO₂, CO, CH₄, NO_x and VOCs), release to water (waste generation), use of natural resources (water, fuel, metal, wood), use and release of energy (electricity and gas consumption, light, bulbs, ventilation fan, noise, heat). So, be it existing or new building it has its impact on the environment. Details of impact on environment can be found in introduction section and also in Michaityte, *et al.*, 2008. According to the National commission of the Environment (1993, pg 2) sustainable development mandates that the present generation must not narrow the choices of the future generation but must strive to expand them by passing on an environment and an accumulation of resources that will allow its children to at least as well as, preferably better than the people today. Unfortunately in practice, only energy and CO₂ reduction target is considered in refurbishment decision.

Social: The refurbishment does two important tasks. On the one hand, it preserves the design qualities and socio-cultural values of a building, a street atmosphere, or a neighbourhood. On the other hand, after experience with architectural ideals and urban concepts, today's planners are able to revise older concepts and repair mistakes of previous generations. For example, poorly designed urban surroundings, vacancy, which often occurs when buildings do not fulfil the current demands, and misuse of properties lead to a lack of acceptance by neighbours, vandalism and social problems. Furthermore, technical decay in the estates is connected with social decay. Groups of users with socio-economic strength leave the estate and weaker groups replace them. This mechanism often results in high turnover, vacancy, lack of control, and in general in "*unfavourable*" living conditions. Hence, social drivers such as education, awareness, culture, labour market can reverse this problematic social environment. However, social aspect is hardly considered for refurbishment in decision making.

Political: The setting of carbon reduction targets, although informed by the scientific research on climate change, is undoubtedly also a political process which is poorly aligned to sustainability. Political issues are likely to have a direct influence on social landlords through either Regulation or Government legislation affecting the housing sector. Different political government introduced many programmes such as warm front, decent homes, CERT (carbon emission reduction target), CESP (community energy saving programs) Housing Health and Safety Regulation, EPC (energy performance certificate) and SAP rating to bring the households to a certain standards and alleviate fuel poverty. More details on the changes of policy and its impact of on housing refurbishment can be found in Baek and Park (2012).

Stakeholders: Stakeholders are those people or organisations who influence, or are impacted by the business of the organisation, its programmes or projects (Jensen, 2001). For social house refurbishment the stakeholders are Government, local authority, tenant services authority (TSA), occupants, other social landlords and support networks. According to Jones and White (2008) "*stakeholder's satisfaction is central to effective asset management*". Project type, duration, budget and type of

technology to be used are shaped by preferences and expectations of stakeholders. Government plays an important role in social house refurbishment through Regulations and incentives. Occupants reflect current emerging issues of refurbishment. Local authorities influence carbon reduction interventions through devising and implementing spatial planning rules (DECC, 2009; GLA, 2007). SMEs play an important role by sourcing workers and materials from the local areas, using materials with less embodied energy and using innovative construction technology.

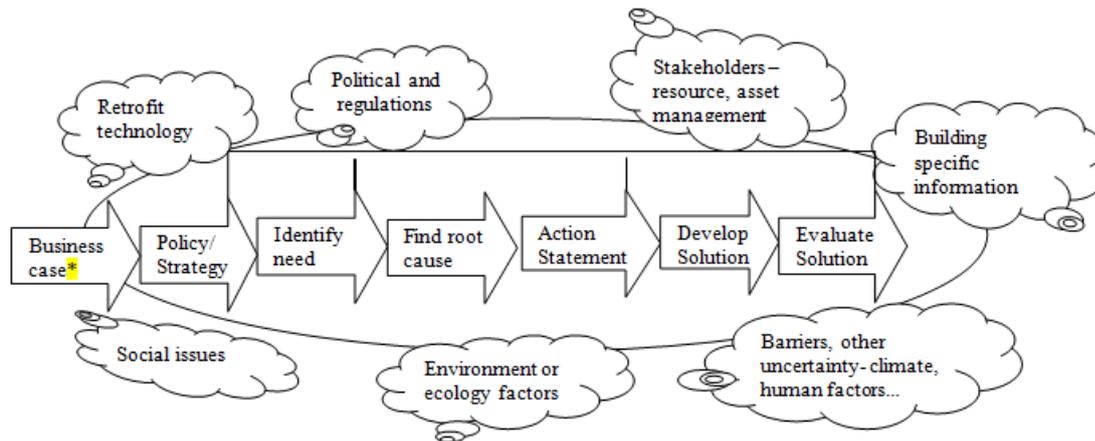


Figure 1: Contextual factors impacting building refurbishment (adapted from Jones and Sharp, 2006; Ma, et al., 2012)

Asset management: Refurbishment in social housing is carried out by social landlord under specific asset management strategy. The culture and attitude nurtured within an asset management is very important. Willingness of all operational, non-asset managers, stakeholders to achieve the service needed, standards to be set, priorities to be given and external and internal context (often termed environment) (Capon, 2000) to be considered is critical for a successful refurbishment.

Organisational strategy, approach: Refurbishment is also influenced by change in organisational strategy. According to Elrod II and Tippett, (2002) “*planned approach*” works on three phases. - firstly, unfreezing current behaviour to welcome new changes; secondly, roll on the modified strategy and get used to and, finally refreeze the modified new strategy. The limitation of this approach is, it does not unfreeze and accept any changes required in the last stage. So, an alternative approach was developed called ‘emergent approach’ to overcome the problem. Emergent approach assumes that rapid change might be needed due to change in internal or external issues, and it gets complicated if needed to manage from the top down approach. Rather it allows a buffer mechanism to adjust any change from top down or bottom up approach, and treats it as a process of learning. However, little use of planned and emergent approach is observed to keep in pace with the new situations in refurbishment.

It is understood, issues such as the variability of the climate, habitual aspects of people, unmeasured construction constraints (e.g. size and distribution of enclosure openings); design and construction deficiencies (thermal bridge, improper work); the unpredictable nature of renewable energy can influence refurbishment but they are outside the scope of this research. So by literature view and theories in contextual issues it is obvious that the cause of slow uptake of refurbishment are a loop of barriers, the poor business cases that fail to map the contextual factors influencing

sustainable refurbishment model and to convey and bring forward the social, economic and environmental benefits. The following section describes a strategy in a decision tree for refurbishment which can be used to integrate social, economic and environmental issues in decision making.

DECISION TREE FOR REFURBISHMENT

Decision-making tools can be defined as tools, which help decision makers to make (or even propose a decision for the user) on the basis of data about the alternatives to be selected from the multiple conflicting criteria (Leitch, *et al.*, 1992). The main advantage of the decision making tool is, it breaks the whole complex process in simple phases, minimize risks in advance and establish a balance between the expectation and achievement. The decision tree shown in figure 2 has been built on performance based built asset maintenance process model developed by Jones and Sharp (2007) under participatory research in UK, following a series of development and review cycles. It is adapted but seeks to address the weakness that is prevalent under current approach (physical condition based refurbishment). The steps are

Identify need:

Through this phase detailed information about the problems in the building, building component, building system or surround environment to be resolved are obtained. The problems might be high energy consumption, thermal discomfort, physical deterioration, failing to satisfy user's need. Through this phase information about priority, values, aspirations, budget and resources for the project are also collected. The information is collected by diagnosis, survey and questionnaires.

Find root cause:

Problems reported through above phase might be due to a single cause or a number of issues related to them. As an example, a building is not getting warm, does not mean that there is a problem in the heating system. It could be due to occupant's behaviour, draught, leaky building fabric or others. Auditing and survey can be used to find the cause of the problem under this phase. Data collected for modelling are building type, layout, physical status- leaky, single glazing, presence of insulation, status of building system, subsystem (Boiler, PV) and so on. Both of these phases are iterative and cyclical.

Action statement:

In the literature concerning multi-criteria decision- "*criteria*" can be called key point indicators (KPI) or key success indicators (KSI) that represent the social, economic, environmental and whole contextual factors in construction industry. Designers can decide the KPIs through several meetings or with the help of tools such as Design Quality Indicator, Housing Quality Indicator. KPIs vary from one case to another, one measure to another. Based on the root cause, action statement should be made through the use of KPIs.

Develop solution:

KPIs are organised in a hierarchical tree structured model where the aim gets the top, criteria and sub-criteria are represented in branches and sub-branches until it captures the whole view of the refurbishment. To form a comparison matrix quantitative KPIs such as energy consumption, CO₂ emission reduction from different refurbishment measures are scaled through energy simulation and modelling; and qualitative KPIs are scaled by survey or questionnaire. To simultaneously quantify the weight of qualitative and quantitative KPIs, a number of methods exist - Analytical Hierarchy

Process, Analytical Network Process and so on. The more alternative measures are investigated before making a final decision, the greater the possibility to achieve a more rational end result.

Evaluate solution and implementation:

Once multi criteria optimization is done, the cost benefit analysis should be carried out. A variety of economic analysis can be carried out- simple payback period; benefit cost ratio (BCR) based on tax, maintenance cost, insurance, consultancy fees. If value for money is expected to be achieved, depending on the situation partial or full refurbishment strategy can be developed and implemented. Otherwise, it should be demolished or called for auditing, survey again. At the end, commissioning and post occupancy evaluation is needed to ensure it operates as it is intended to, and justify the overall satisfaction of the occupants which gives room for improvement that can be implied for next refurbishment.

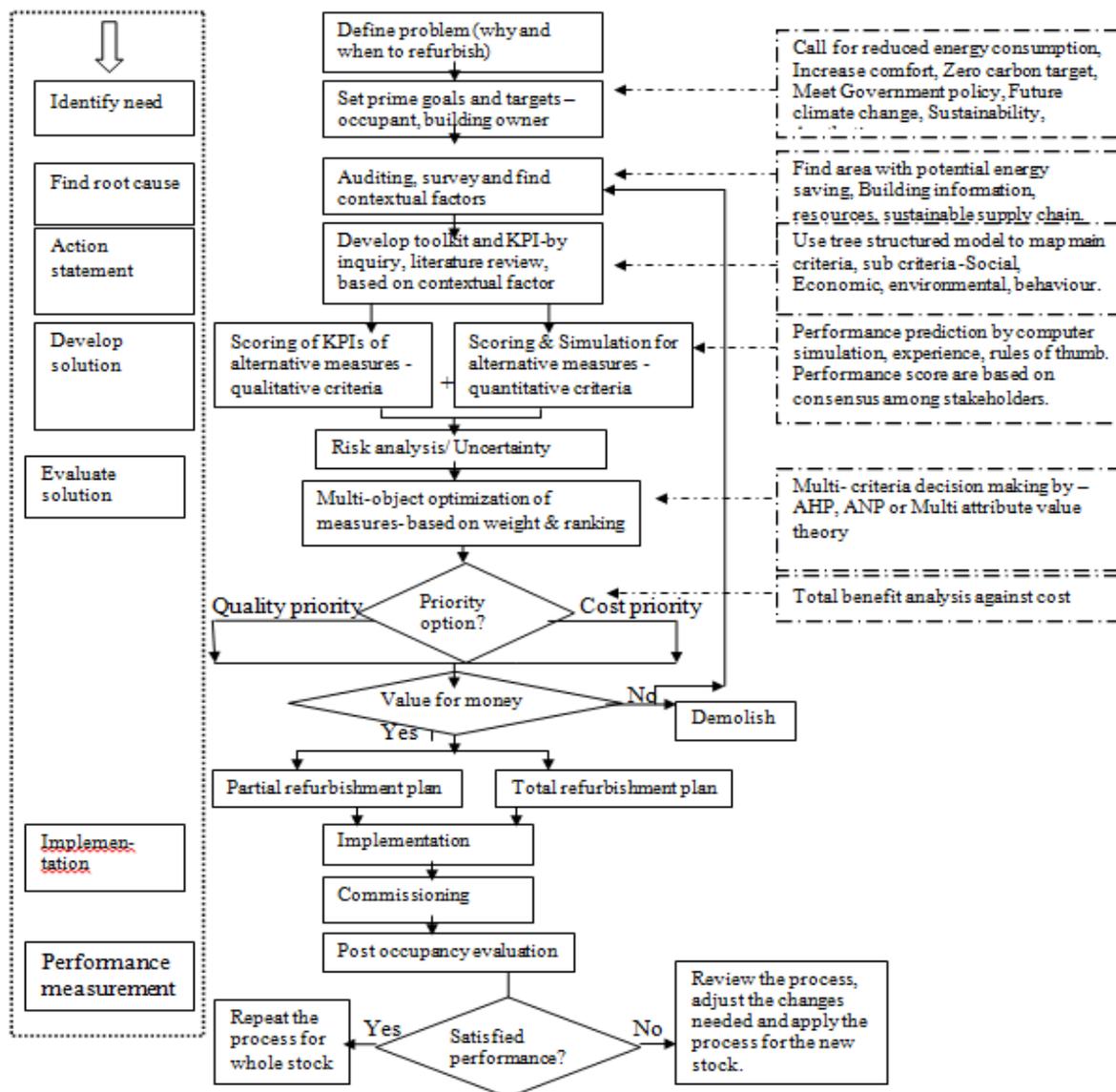


Figure 2: Decision tree for social house refurbishment (adapted from Jones and Sharp, 2007)

CONCLUSIONS

The paper presented theoretical conceptual model of sustainable refurbishment and factors that influence the refurbishment. Through literature review and review of

theoretical areas under which social landlords operate this paper identified the poor business cases as the reasons of slow uptake of building refurbishment. To overcome the weakness a decision tree was developed from the literature that is based on business cases. It integrates physical and functional performance of a building- a shift from a traditional condition based to performance based refurbishment. Quantifying the weight of the KPIs for different refurbishment measures and optimising the measures against cost, optimal measures for different house archetypes can be derived from the decision tree. Identification of the order of best retrofit measures by the decision tree can be used and extrapolated by asset managers to refurbish their whole housing stock to meet zero carbon targets, climate change issues and improve sustainability performance profile. Further research is needed to select the KPIs wisely that are specific, attainable, measurable and reflects the business cases properly.

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NEW WAYS OF ORGANISING CONSTRUCTION DUE TO USER DEMANDS

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This paper investigates how client demands affect organisational renewal in construction, more specifically how the combining of technical and organisational resources are directly and indirectly affected by demands from the user. We adopt an industrial network perspective and focus on inter-organisational interaction between the actors involved in two specific healthcare construction projects in Sweden. The findings show that user demands affect organisational renewal with regard to both onsite and off-site operations and that effects due to user demands can be spread outside the ‘temporary’ network to the ‘permanent’ network. Hence, user demands create direct and indirect effects on both the combining of organisational and technical resources across individual projects and organisational boundaries. These findings imply that in order to understand innovation in construction it is necessary to study how technical and organisational resources are combined across organisational boundaries and across projects.

Keywords: industrial networks, innovation, interaction, organising construction, resources, client demands.

INTRODUCTION

Several studies state that the construction industry suffers from low efficiency (Vrijhoef and Koskela 2000), and it has been suggested that structural changes are needed (Egan 1998). In particular, the industry faces challenges in the improvement of performance through innovation (Slaughter 1998). Nevertheless, there are many empirical examples of how the industry innovates in various ways, and the most relevant type of renewal appears to lie in the organisation of actors, resources and activities within and across projects (Slaughter 2000). For that reason, it is highly interesting to investigate drivers of organisational renewal within construction, and in this paper we do so by focusing on the role of the client. As the client places direct, as well as indirect, demands on the project and the final product, this actor is often identified as one of the most important drivers of construction innovation (Håkansson and Ingemansson 2013). We focus on how the demands of the client can influence new ways of organising projects in relation to how technical and organisational resources are combined in new ways, and the direct and indirect effects this has on project activities and actors. Due to the features of the construction industry, including

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for example its fragmentation, project-based character, and focus on arms-length relationships, we find an inter-organisational and interactive approach suitable for an analysis of how and why organisational renewal appears in the construction industry. Thus, we apply the industrial network approach (Håkansson *et al.* 2009), which views the single firm and its resources and activities as embedded in an interdependent business network of other firms' resources and activities. According to this view, firms are dependent on the network for their routine operations, development and innovation (Håkansson and Waluszewski 2002). Therefore, the most central activity of the firm is to interact with other firms, which enables access to resources such as knowledge and technology. More specifically, it is the combining of resources across firm boundaries that creates value for firms and enables them to find new valuable combinations, but at the same time it also locks them into specific investment and operation patterns. For the investigation of what makes construction actors organise in specific ways and how these ways may change, we find this perspective a highly useful theoretical and methodological approach. By the use of two in-depth case studies demonstrating different types of client demands, we investigate how clients can enforce new ways of organising construction projects.

THEORY

An industrial network perspective on construction

By adopting the industrial network perspective the emphasis is on inter-organisational interaction (Sundquist 2014) in which firms are viewed not only as relating occasionally through separate transactions, but also through continuous interaction processes in which resources and activities are adjusted in relation to each other (Håkansson *et al.* 2009). Through the interaction processes, the network of resources and activities of the single firm becomes embedded in a larger business network of other actors, resources and activities. This has implications for how firms are assumed to be able to use its resources as well as to develop new ones. More specifically, by interacting, existing resources (such as organisational knowledge, routines, production equipment etc.) can obtain new features depending on which other resources they are combined with (Håkansson and Waluszewski 2002). Many studies using an industrial network perspective have pointed to the construction industry as a “*special case*” (Håkansson and Ingemansson 2013). The project-based character hinders long-term commitment and inter-firm collaboration which differs from for instance the manufacturing industry. Analysing the effects that a project-based industry has on the couplings between firms Dubois and Gadde (2002) suggested that construction actors relate to ‘temporary’ and ‘permanent’ networks. The temporary networks refer to the inter-organisational interaction taking place within projects, which can be intense. The permanent networks refer to the interaction that takes place between or across projects, which generally is characterised by ‘loose couplings’ and little inter-firm collaboration.² It has been suggested that this has direct implications for how innovation can (or cannot) occur, and hence most adaptations take place within projects. Consequently, change and innovation is often project-related (Gann and Salter 2000), which makes the driving forces of change within projects highly interesting. Earlier studies have shown that within projects, changes need to be negotiated among the project actors (Winch 2003) and thus involve interaction

² There are however exceptions, showing how construction actors, when possible interact intensively across several projects resulting in both technological and organisational innovation (e.g. Crespin-Mazet and Ghauri, 2007; Crespin-Mazet *et al.*, forthcoming 2015).

processes. This paper investigates interaction in projects, and the following section outlines our theoretical perspective to do so.

The effects of combining resources

A well-used tool within the industrial network approach to study inter-organisational interactions and the effects thereof is the ARA model (see Håkansson and Waluszewski, 2002). This model outlines three different but highly interconnected layers of business networks, Actors-Resources-Activities. Resources are defined as being technological (e.g. products and production facilities) or organisational (e.g. knowledge, routines and relationships). One of the basic assumptions is that resources are heterogeneous and thus obtain specific features depending on which other resources they are combined with (ibid.). Thus, depending on how resources are combined across firm boundaries as firms interact, they obtain specific features and values. This can be expressed as it is the combination of resources that determines the use and services of resources (Ingemansson 2010). For instance, a product can result in one type of use and value for one client while for another client it results in another type of use and value depending on the specific set of resources and activities of the respective actors. Another basic assumption of the effects of resource interaction is that the interaction that takes place between technical and organisational resources affects how they can be changed, i.e. what is possible to change depends on how technical and organisational resources can be (re-) combined. Consequently, new ways of organising often depend on and/or affect technological solutions, and technological innovation often requires and/or results in organisational change (Håkansson and Waluszewski 2002). Due to the centrality of organisation in construction, in this paper we take particular interest in new resource combinations and how this relates to organisational renewal. More specifically we want to show how clients intentionally and/or unintentionally put certain demands on the construction which creates direct and/or indirect effects on the involved construction actors in combining resources in new ways.

METHOD

In the paper we focus on healthcare construction projects as they involve active clients with specific demands in order to provide efficient healthcare. Hence, healthcare is a suitable empirical arena when investigating user demands and their effects on organising construction. The paper is a multiple case study, involving two healthcare projects in Sweden; the university hospital in Linköping and the Skandion Clinic in Uppsala. Case studies are particularly useful for studying a contemporary phenomenon (Yin 1984) and for studies of complex systems, and events where broad conceptual frameworks are used (Dubois and Gadde 2014). The university hospital in Linköping is a refurbishment project of an existing hospital offering all kind of healthcare services, while the Skandion Clinic is a new clinic offering specialised cancer treatment with proton radiation. In both cases the construction projects are organised and directed by user demands. The Linköping case reveals user demands related to ongoing healthcare operations while the Skandion case reveals user demands related to future healthcare services. The cases complement each other by illustrating different kinds of demands. For each case three specific examples on how user demands create direct and indirect effects on organising construction are presented. To identify user demands' effects on organising construction we need to investigate the network of actors related to the construction projects. The main data of the paper is based on interviews with a variety of actors involved in the two projects,

such as the client, the main contractor, subcontractors, engineering companies and architects. A total of 20 interviews along with site visits including two guided tours were conducted in the Skandion Clinic case. In the Linköping University Hospital case, 10 interviews have been performed with actors such as the main contractor, subcontractors, the logistics specialist, the project manager and suppliers related to the project. This study also includes three on-site visits covering logistics and construction operations.

EMPIRICAL PRESENTATION

Case 1: Linköping University Hospital

The FUS-project involves new buildings and refurbishment of existing buildings at the university hospital in Linköping, Sweden. The total budget is 3850 million SEK and the project phases stretching from 2011-2019. The FUS-project involves new construction of nursing wards, emergency entrance, delivery ward, helipad, teaching facilities, and a psychiatric clinic. In addition, a major part of the main building is reconstructed to create a new entrance and reception area as well as various services such as pharmacy etc. The project also involves a new parking facility and new infrastructure to separate ambulance traffic from other traffic. The client, Östergötland County Council (ÖCC), had specific requirements regarding the organisation of the project owing to the fact that the hospital is fully operative during the construction project. Consequently, high demands were set on the coordination among construction processes and ongoing hospital operations, which include large amount of health care personnel, patients and visitors. By no means should health care provision be jeopardised by the construction processes.

Example 1.1: A logistics specialist appointed - securing onsite logistics

In order to handle the complex situation described above ÖCC emphasised a need for a sophisticated on-site logistics solution as to secure hospital operations. Conditions at the site are challenging, for instance, in the construction of two new buildings the entrance to the construction site is located next to the emergency entrance with ambulance traffic. Thus, ÖCC demanded in the tendering phase that a logistics specialist should be appointed, and Svensk Bygglogistik (SB), specialising in onsite logistic operations, was selected. Positioned under the main contractor, NCC, SB is responsible for the planning and monitoring of all deliveries to the site; for materials handling from the point of arrival to the site and to the assembly point on the site, and the organising of resources such as cranes, elevators and scaffolds, including updates of site disposition plans. This set-up was hence decided early on by ÖCC and clearly stated in the procurement process, thereby known to all contractors entering the project. Before the first delivery to the FUS-project each subcontractor needs to take part in an introduction arranged by SB concerning the logistics aspects of the project as the main contractor and all subcontractors are required to use SB for all logistics and materials handling operations. This arrangement was new to these actors, and required them to adapt their operations in several ways.

SB has a team of people stationed at the site. This team works regular working hours. The actual materials handling takes place after regular working hours (between 4 p.m. and midnight) by SB personnel to minimise disturbances of production flows and enable efficient use of cranes and elevators for construction work during daytime. Contractors pay a fee per unit materials handled by SB depending on the size and weight of the goods. Preferably, goods should be delivered on pallets that can be

handled by pallet lifts and transported in elevators rather than using the tower crane, to allow for more efficient materials handling at the site.

This logistical arrangement creates several effects both on-site and off-site. On site, the contractors' construction workers are no longer involved in materials handling and can focus on construction operations, which improves efficiency. At the same time, construction workers must plan ahead to a greater extent as they can no longer themselves bring in additional materials on short notice. Construction workers and managers thus interact more intensively regarding progress of work and requirements of deliveries of materials. This, in turn, results in increased planning by managers towards suppliers and call-offs of materials to the site. Also, managers tend to plan for excess delivery of materials to avoid a situation where workers are out of materials. Off-site the material suppliers, such as distributors, have to adapt their operations to be able to deliver off-hours. In one case a distributor and a carrier, who supply three subcontractors in the project, had to set up an intermediate storage facility some kilometres from the construction site from where off-hours deliveries could be made. For the material manufacturers, this way of working generated stricter rules for delivery times, and requirements on keeping the order together, not allowing residue deliveries.

Example 1.2: Required side-contractor partnering agreements: increased interaction to improve construction processes

The client ÖCC also had requirements on how the project should be organised with regard to collaboration forms and ÖCC demanded that for the frame complement the project should be permeated with cooperation among contractors and subcontractors in the formation of groups. Thus, for frame complement the project organisation consists of three side-contractor groups (each including a construction contractor, plumbing contractor, electricity contractor, and ventilation contractor) who took part in the tendering process as a group and work tightly together in the construction process. To support this work ÖCC sets up standards for formal meetings on various levels but also many informal meetings take place. Also, a common project office was set up by ÖCC where all cooperating firms within each side-contractor group have their working space in close proximity to one another.

The requirements of side-contractor groups created a more thorough recruitment process with regard to individuals that had to apply with an extensive cv, and also personally meet with the human resource function. Before the project started there was a three day long team building course with the respective side-contractor group, representatives from ÖCC and construction engineers. This was initiated and paid for by ÖCC. For the involved subcontractors, the arrangement created new management effects. Commonly, the building contractor manages and controls to a large extent all work and adapts this to its operations, and subcontractors have to adapt. In the case with side-contracting all involved actors in the group plan together to decide upon 'when to do what' to obtain the best result in all operations and avoid sub-optimisation.

Example 1.3: LogNet - a web portal for coordination of deliveries to site

LogNet is a web portal for deliveries to the site and is developed by SB and used in all projects in which SB is involved. Contractors have to book all material deliveries at least five days in advance in LogNet. Available time slots are visible for the contractors when planning for the deliveries. Deliveries are scheduled in LogNet in time slots of 30 minutes. Required resources for materials handling, e.g. cranes, are

also booked in LogNet. Personnel at SB confirm or deny the requested time slot and the required resources. All deliveries must pass through a “*checkpoint*” located at the entrance of the hospital area in order to get the delivery to the site approved. The area for unloading at the site is very small and only has room for one truck at the time. Trucks cannot wait outside the gate as this area has to be cleared for ambulances.

The use of LogNet has implications for the contractors as well as for their partners. Contractors get goods in neatly packed pallets delivered to the correct assembly area marked ‘house X, floor, Y, coordinates ZW. As no materials are stored outdoors at the site waste is reduced. However, it requires deliveries to the site to be booked at least five days in advance in LogNet, thus, contractors must apply more advance planning of deliveries to the site and ordering in comparison to what they are used to. This planning takes place in two steps: first a request is sent to LogNet, and second, after approval, the contractor sends the confirmation to the supplier.

Case 2: The Skandion Clinic

The Skandion Clinic is the first clinic in Northern Europe specialized on cancer treatment by using proton radiation. The construction started in June 2011 and the first treatment is planned to October 2015. The cost of the clinic is estimated to around 1 billion SEK (cost for construction: 500 MSEK, cost for medical tech: 500 MSEK). The client of Skandion Clinic, Kommunalförbundet Avancerad Strålbehandling (KAS), is an organisation established in 2006 with the aim to run and manage proton therapy at the clinic. KAS is a national organisation set up by seven Swedish county councils.³ As a client KAS has special requirements in relation to how the working areas in the clinic will be organised along with special requirements concerning the use of medical technology. KAS is the main user of the clinic but rent the clinic from the owner and property manager, Akademiska Hus (AH). Hence, it was AH that contracted a construction company, NCC Construction to set up the clinic, while KAS is the tenant.

Example 2:1: The partnering agreement between Akademiska Hus and NCC - increased interaction and spread to other projects

When KAS issued a contractor inquiry for construction and management of the Skandion Clinic, AH realised that in order to manage the construction of this unique building outside of its core business (normally the company manages buildings for higher education such as auditoriums, laboratories and offices) a capable collaboration partner was needed. Therefore, the company contacted NCC Construction, a construction company that they have worked with extensively in the Uppsala region for the past 20 years and asked if they would send in a joint partnering bid for the construction of the clinic. NCC accepted and this was the first partnering agreement between the two parties. The partnering agreement affected the whole construction process. To begin with, the parties organised procurement in another way compared to traditional contracting. AH decided to jointly manage the procurement process. As a consequence, more time was put on identifying suitable suppliers. Central suppliers of both parties were used along with new suppliers. In order to make the partnering agreement work this required increased interaction between the parties, hence more meetings and workshops were initiated during the Skandion Clinic project. For instance, a new type of meeting was introduced, the NAV-meeting, a meeting forum mainly used to facilitate the information and communication between the planning and the production of the clinic. Since the Skandion Clinic was the first partnering

³ All Councils with university hospitals

agreement between the two parties the project required investments in increased interaction, however in the subsequent project, the Uadm-project, the parties once again used the same type of partnering contract and NCC supplies a similar project organisation with partly the same managers. Once again, joint procurement along with the same meeting forums was used including some developments such as including more participants in workshops throughout the project.

Example 2.2: BIM as a coordination tool during the construction process - resulting in a manual and in new processes

A new technical resource, Building Information Modelling (BIM), was introduced in handling the construction of the Skandion Clinic. BIM is a software technology that can be used to manage the design, production and maintenance of the building. The reason for implementing BIM was due to the complexity of the building, especially due to the complexity of canalisations and installations that needed to be integrated in walls and ceilings. When awaiting the decision by KAS in which med-tech supplier to use, AH decided with the support from the partnering entrepreneur, NCC, to use the Skandion Clinic as a pilot project for BIM. The intention was to use BIM more as a coordinated work process stretching planning, production and maintenance. This meant that engineering firms in charge of supplying drawings needed to have BIM-experience. The planning coordinator, Sweco, instructed all consultants to connect the drawings to one BIM-model. This model could be used for coordinating planning meetings and visualise the building while planning. Therefore installation collisions could be identified early on, especially important for a building that contains extreme amount of canalisations and installations. Moreover, in production NCC used the model to extract quantities of materials needed and thereby minimise time on measuring quantities and hence facilitate planning and ordering of materials. New type of meetings between several of the actors using the model were also initiated. In order to be able to work in relation to the BIM-model, AH appointed an architect firm, Link, to coordinate and update the BIM-model continuously throughout the project. The use of the BIM model thus resulted in organisational and processual changes; new ways of handling the coordination among actors across the construction process were put in effect. Working with BIM in the Skandion Clinic project also resulted in a technical resource, a BIM-manual that AH could use for future projects. The manual can be seen as a technical resource since it is a new physical resource with codified information on how to manage BIM in projects. The BIM-manual is also used for the second partnering project between AH and NCC, the Uadm-project.

Example 2.3: Medical technology - setting the agenda for construction

As a user of the Skandion Clinic, KAS is in charge of the treatment of patients but this organisation also handle the procurement of medical equipment used for proton radiation treatment. This specific medical technology put specific requirements in relation to the construction process of the clinic, and it meant that KAS had to be approved to perform radiation treatment by the SSM (The Authority for Radiation Safety). In addition, the building needed to be approved as “radiation safe”. KAS started the search for suitable technologies already in 2007 but realised that the technique they wanted, 2nd generation proton therapy (spot-scanning), was not available for purchase. Thus, KAS waited two years for the technique to be developed. However, an actual procurement agreement with a supplier was not realised until April 2011 due to two public appeals regarding the public procurement process. Finally, the Belgium med-tech company, IBA, won the bid and was allowed to supply the cyclotron needed to generate the proton beam for treatment of patients.

The choice by KAS to buy equipment from IBA meant that the construction process needed to adhere to specific demands from IBA and especially the integrated building document (IBD), a technical specification from IBA including 30-40 drawings and a 100 page document with detailed instructions of how to construct the rooms used for treatment down to nut and bolts. The IBD secured the quality and the function of the equipment. For instance the document detailed the need for creating safety internally and externally. Consequently, the construction of the clinic entailed walls and ceilings of iron-ore of more than 4 meters in widths. The IBD also emphasised the need for stability of the equipment, which meant that the groundwork of the clinic was of great importance. The heavy clinic and demands on stability resulted in more than 650 steel poles in the ground. In addition, access to electricity and cooling water was detailed along with the requirement of creating humidity of 30% inside the rooms to avoid the creation of static discharge that could affect the med-tech equipment. Hence the construction of the clinic was dependent on the guidelines of the IBD.

CONCLUDING DISCUSSION

The two cases illustrate how the clients' demands gave rise to new ways of interrelating and organising technological and organisational resources within the respective projects. In addition, although such demands targeted either technological or organisation issues, the effects did not only arise in the direct and corresponding type of resource but created various indirect effects across different types of resources and combinations. Some demands were directly related to specific technological solutions, for example, software solutions related to logistics (LogNet in example 1.3) and to design/planning (BIM in example 2.2), and the user related technology (in this case medical technology), but created both technological and organisational effects. Other demands were directly related to organisational aspects such as the need for various forms of partnering agreements (side-contractor partnering in example 1.2 and contractor-client partnering in example 2.1) and specific competences (the logistics specialist in example 1.1) in order to complete the project, which had immediate consequences for how both technological and organisational resources were used and developed. Thus, as the effects of specific demands and subsequent changes involve and re-combine different types of resources, the intended effect is not isolated, easily foreseen nor can it be truly evaluated beforehand. Table 1 illustrates how the client demands target one type of resource and affect either a corresponding or another type of resource. Consequently, four types of combinations appear in the cases: technological-technological, technological-organisational, organisational-technological and organisational-organisational.

Table 1: Technological and organisational client demands and effects on resources

Effects User demands	Technological	Organisational
Technological	BIM → BIM manual (2.2) Medical technology → new product supplier (2.3) Medical technology → building (2.3)	BIM → Work processes (2.2) LogNet → Work processes (1.3) BIM → new requirements of suppliers (2.2)
Organisational	SB → intermediate storage (1.1) Particular medical technology supplier → effects of IBD document (2.3)	SB → suppliers' routines for delivery (1.1) Side-contractor partnering → increased interaction among contractors (1.2) Partnering agreement → use of same set-up in subsequent projects (2.1)

Both client demands related to *ongoing* healthcare operations (the Linköping case) and to *planned* healthcare services (the Skandion case) influence the way of organising the projects not only in relation to onsite operations, but also to procedures related to ‘permanent’ networks (see Dubois and Gadde 2002) of actors and activities (e.g. offsite or other projects). For instance, the use of a logistics specialist on-site (example 1.1) resulted in the need for an intermediate storage facility to be set up by a supplier, located nearby the site. Hence, inter-organisational renewal is not isolated to the site, but clearly involves, and affects actors in the wider supply chain. These network effects are not distributed equally among the actors: what might be beneficial for actors on site might be less valuable for other actors off-site. Another example is how the partnering contract in the Skandion project (example 2.1) was applied again in a subsequent project. Organisational renewal taking place through inter-organisational interaction within a project can hence be spread among projects, involving a more ‘permanent’ network (as opposed to the ‘temporary’ network of the individual project). Consequently, this paper shows that the different ways in which clients and users inspire to innovation with regard to new ways of organising construction can create innovative effects outside individual projects, both technologically and organisationally. Therefore, any understanding of how construction innovation is to be promoted or organised must start from an understanding of how technological and organisational resource combinations are created and changed across organisational boundaries. According to our findings, in this process clients and users appear to have a central role to play.

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COMPARING SAFETY INTELLIGENCE IN AIR TRAFFIC MANAGEMENT AND CONSTRUCTION: A CONCEPTUAL COMPARISON

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Although safety interventions targeted at managers or supervisors are believed to be the most effective leverage for change, the mechanisms involved in developing and propagating a positive safety culture are poorly understood. “*Safety Intelligence*” was first proposed by Kirwan in 2008 as a response to growing disillusionment with safety culture, focusing on recruiting and equipping leaders with the personal attributes, skills, and knowledge required to positively influence safety in their organizations. So far Safety Intelligence has only been studied within air traffic management, but opening up the construct and exploring its relevance to managing complex and hazardous construction projects offers new theoretical directions for occupational safety and health research in the sector. Existing studies of safety-related leadership competences in the US, UK, Australian, and Danish construction industries were reviewed in light of the Safety Intelligence model. These studies have explored specific competences including knowledge; communication; leadership style; emotional intelligence; and emotional expression. By comparing these competences with those of Safety Intelligent leaders within the ultra-safe, highly reliable environment of air traffic management, the differences between the leadership styles required to cope with the differing priorities of the two sectors were highlighted. Safety Intelligent supervisors promote a just culture, empowerment and collaboration with members, proactivity, and communication – aspects of leadership which are difficult to achieve, but have nonetheless been shown to contribute to safe construction. Safety intelligence therefore holds considerable promise for improving safety in construction projects.

Keywords: competence, health and safety, leadership, organizational culture, training.

INTRODUCTION

Leadership is well-established as a defining influence in organizational culture (Zohar, 2010): Authority reinforces the social-learning process that takes place within leader-member exchanges, allowing members to recognize the values and behaviors that form the culture endorsed by the organization. Unfortunately, leaders' lack of commitment to safety has been implicated as a cause in the investigation of several

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major accidents including the Deepwater Horizon oil spill, the Texas City Refinery explosion, and the sinking of the Herald of Free Enterprise (Fruhen *et al.*, 2014b).

Cultivating employees' intrinsic motivation for safe behavior is an appealing prospect, and the concept of safety culture has been utilized by many safety programs such as Hearts and Minds (Hudson *et al.*, 2000), DuPont's STOP, ProAct Safety's Lean Behavior-Based Safety, and Geller's Total Safety Culture (Guldenmund, 2010). Programs like these have deprived safety culture of its intangible and implicit nature and instead attempt to engineer a culture through behavioral and visible characteristics - tackling the outer "*layers*" of Rituals (such as processes, dress-codes, and slogans), Symbols and Heroes, rather than the beliefs which underpin them (Guldenmund, 2010).

Disillusionment with safety culture is growing (Guldenmund, 2010). Rather than adopt ethnographic approaches traditionally used in anthropology, the majority of research into safety culture takes a functionalist approach, where culture is seen as a causal attitude and a variable subject to manipulation (Sileby, 2009). Given this backdrop, safety culture has been criticized for taking a Tayloristic view of safety. In the early 20th century the human factor was defined as "*Mental, physical and moral shortcomings that predispose a person to accident*" (Dekker, 2015). Accidents were primarily blamed on accident-proneness or a lack of attention and the factory inspectorates of the Industrial Revolution were only interested in accidents "*with technical causes, since others could not reasonably be prevented*" (Hale and Hovden, 1998: 129).

The emergence of Ergonomics in the 1940s shifted the focus away from so called "*shortcomings*" and approached accidents from the point of view that by applying research regarding human capabilities and limitations to the design of tools, tasks, jobs and environments human error could be mitigated. Therefore, attempts to change safety culture through propaganda to capture the Hearts and Minds of the workers implies some form of moral deficiency or a lack of effort and is incompatible with the "*fifth age*" safety paradigm that humans are an asset to systems because their adaptability produces resilience (Borys *et al.*, 2009).

Holistic systems and cultural approaches have liberated workers from fear of personal blame and punishment; however, safety culture has struggled to establish itself as a research topic in construction, emerging later than in other industries and declining since 2008 (Zhou *et al.*, 2015). Instead research has focused on individual characteristics, indicating that the competency-based model of Safety Intelligence could gain greater acceptance and purchase than "*fuzzy*" cultural methods.

Thus, although the concept of accident-proneness is now regarded as politically incorrect, unethical, and legally questionable, understanding the individual characteristics or conditions which increase the propensity for error is still valuable (de Winter, 2013). Safety Intelligence takes a positive approach and could open up the potential to research the characteristics which predispose a person to safe behaviors.

SAFETY INTELLIGENCE

Safety Intelligence was first proposed by Kirwan (2008) as an alternative to safety culture and a "*way of helping top level management understand safety and react appropriately, rather than just giving 'lip service'*". It recognizes the importance of CEOs and Directors in shaping culture by influencing members' attitudes to safety and defines the combination of personal attributes, skills, and knowledge required for

leaders have a positive influence. Just as leaders with higher Intellectual, Emotional and Managerial Intelligence are believed to be more effective (Müller and Turner, 2010), Fruhen et al., (2014a) propose CEOs with these characteristics are more Safety Intelligent and therefore better equipped to influence to safety culture in their organizations. Safety Intelligence offers a methodology to equip the top executive level of an organization with a means to understand and drive safety as part of their business agenda (EUROCONTROL, 2013).

The proposed Safety Intelligence model has remained undeveloped with the exception of a series of studies of senior managers in Air Traffic Management (ATM) (Fruhen et al., 2014a): Senior air traffic managers were surveyed through questionnaires and interviews about the ideal characteristics and behaviors of a CEO in relation to safety. The study focused on 5 characteristics: Personality, Problem-solving, Motivation, Safety Knowledge and Social Competence, the latter 2 of which were found to be most significant and are shown closer to the “core” in Figure 1.

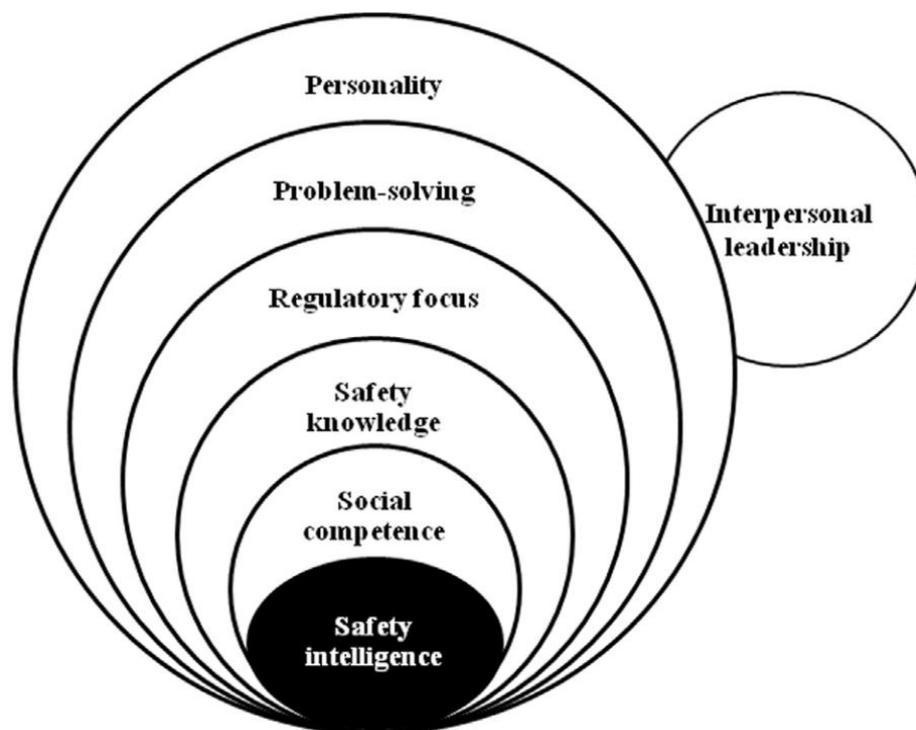


Figure 1: Conceptual Model of Safety Intelligence (Fruhen et al., 2014a)

So far, however, Safety Intelligence has only been studied in ATM – a highly-regulated, safety-critical industry with very different characteristics to construction. The extent to which it might have purchase within project-based environments, and to which it can account for the multiple temporalities and fragmented delivery structure of the industry, remains unexplored.

A competency-based approach to safety management in construction is not a novel concept. Accordingly, the authors' search identified 18 studies from the construction industry which take a similar competency-based approach to influencing safety, although each focusing on a specific safety-related managerial competence - including knowledge; communication; leadership style; emotional intelligence; and emotional expression. However, a study by Zou and Sunindijo (2013) used questionnaires and interviews to identify and rank safety-related competences and build a framework for

construction similar to Safety Intelligence. Using this as a starting point, this paper discusses these studies in light of the Safety Intelligence model in order to open up the opportunities it offers and uncover the differences between these sectors.

Table 1: Comparison of two models of competences for influencing safety

	Skills for Positively Influencing Safety in Construction	"Safety Intelligence" for ATM
Most significant Priority	Self-awareness, visioning, and Sincerity	Social Competence
	Scoping and Integration and Self-Management	Safety Knowledge
	Relationship Management, Social Awareness, and Social Astuteness	Regulatory Focus
Least significant Priority	Safety Management Tasks	Problem Solving
	(Zou and Sunindijo, 2013)	(Fruhen et al., 2014a)

SAFETY-RELATED COMPETENCES IN CONSTRUCTION

Zou and Sunindijo (2013) describe 4 tiers of skills for construction supervisors: Their most significant priority or 1st tier competences are self-awareness, visioning, and sincerity, followed by scoping and integration and self-management; then relationship management, social awareness, and social astuteness; and finally safety management tasks (Table 1). Parallels can be drawn between this model and that of Safety Intelligence; both list social, problem-solving and technical skills as important, although the definition and prioritization of these skills differ. The differences between safety-management in construction and safety-critical sectors can be explained by exploring these in greater depth.

Safety Knowledge

Behavioral competences without technical skill or knowledge are futile. Many studies have shown knowledge to be integral to authentic and committed leadership (Zou and Sunindijo, 2013; Fruhen *et al.*, 2014a). Hardison *et al.* (2014) explored knowledge-based competences for construction supervisors with respect to safety, and found that “*knowledge of pre job planning, organizing work flow, establishing effective communication, and of routine and non-routine work tasks are highly important*” (p. 45). This suggests that Safety Knowledge, from the perspective of construction, is the technical understanding of business processes relating to safety.

In contrast, the Safety Intelligence model puts a far greater emphasis on Safety Knowledge than Zou and Sunindijo, perhaps because its scope is considered to be broader than technical knowledge. EUROCONTROL (2013) advocates Safety Intelligent managers having a clear “*risk picture*” of the threats to their organization and an understanding of how safety works. In accordance with Weick and Sutcliffe's (2007) concept of Organizational Mindfulness, Safety Intelligent managers are encouraged to respond to weak signals of failure, develop a “*just culture*” where reporting is encouraged, and be sensitive to the human factors that are affecting

operations. However, High Reliability Organizing (HRO) has not yet been integrated into construction health and safety (Olde Scholtenhuis and Doree, 2013).

A specific understanding of both safety processes within the organization itself and “*how safety works*” (Eurocontrol, 2013: 8) in general is necessary for Safety Intelligence; thus, construction is hindered by its focus on technical aspects of safety which prevents new paradigms about how safety works, such as HRO, taking hold.

Problem Solving

Problem solving was ranked as the fourth priority (Fruhen *et al.*, 2014a) by ATM CEOs – after interpersonal skill, technical knowledge, and motivation – and is vital for understanding problems and generating solutions (Eurocontrol, 2013). In construction, conceptual or problem solving skill is seen as a higher priority: The project-based, dynamic nature of the construction industry, with its temporary workforce and extensive variety, presents challenges for safety management particularly in terms of coordinating subcontractors and keeping up with the pace of change (Biggs *et al.*, 2013).

Construction is formed of Temporary Multiple Organizations (TMO) “*where parts of several organizations – each with its own affiliations, its own goals and its own values – are all involved in the achievement of a plan or of an end-result*” (Stringer, 1967: 106). Learning is limited by the uniqueness of outputs and the transient nature, so managing these projects requires conceptual skill to view these complex projects from a “*big picture perspective*” (Zou and Sunindijo, 2013: 94). Visioning, Scoping and Integration were seen as fundamental to understand the dynamic relationships between stakeholders and components; ensure these are integrated as a whole; and influence safety (Zou and Sunindijo, 2013).

In their study entitled “*Preparing project managers to deal with complexity*” Thomas and Mengel (2008) suggest training for this context requires a greater emphasis on continuous change; creative and critical reflection; self-organized networking; and coping with uncertainty. Similarly, Müller and Turner, (2010) showed that construction project managers need greater propensity for Strategic Perspective and Developing.

In both ATM and construction, problem solving as a generic competence is important. However, in construction problem solving is considered more important than social skills as its dynamic, fragmented nature is a major barrier to implementing and influencing safety. The characteristics and pressures of the two sectors are very different, so the problem-solving approaches of the two types of managers are likely to be very different in reality.

Social Competence

Social competence is key in influencing employees’ behavior, as leaders’ commitment to safety is demonstrated by their interactions with others. Almost every study reviewed agreed that interpersonal skills are essential for successful leadership – both in construction and other sectors, and in safety or general management. The necessary competencies can be divided into Communication, Emotional Intelligence, and Leadership Style.

Communication

“*Soft*” skills of communication and consultation are often seen as incongruous with the uncompromising, methodical people needed to undertake complex construction

projects (Aulich, 2013). However, the need to strengthen health and safety coordinators' competence in communication and negotiation was highlighted by Antonio *et al.* (2013) and an intervention to train foremen in communication-based competences (such as mentoring and "toolbox talks") increased safety behaviors on residential construction sites (Kaskutas *et al.*, 2013). Similarly, Kines *et al.*, (2010) found a significant, positive and lasting effect on safety levels though providing feedback and coaching to site foremen in daily verbal safety communication.

Communication needs to be systematic, understood by all stakeholders, and intelligently applied: A communication strategy must be designed with a thorough understanding of the principles of social dynamics in joint undertakings and cognitive learning theory (Aulich, 2013). Sharing tacit knowledge within an integrated project team also builds connections between team members, leading to improved dynamic capabilities and ultimately, greater team flexibility (Zhang *et al.*, 2013).

While some research demonstrates that initiatives directed at managers can be more effective (Zohar and Luria, 2003), in construction the role of frontline supervisors has been shown to be more influential than that of senior managers (Lingard *et al.*, 2012) and safety competence at all levels of the hierarchy – workers, foremen, and managers – is equally important, because communication between these levels is critical (Hardison *et al.*, 2014). As Safety Intelligence focusses only on senior management, this suggests its methods may not be as influential in construction.

Leadership Style

Interviews with 41 construction safety leaders (Biggs *et al.*, 2013) identified leadership as a key factor for positive safety culture in the organization, with an emphasis on leaders' visibility and their demonstration of a commitment to safety. This is supported by the findings of a study into the relationship between project managers' leadership style, teamwork, and project success (Yang *et al.*, 2011). The results show increased leadership communication and involvement can enhance relationships, fostering teamwork, which is significantly correlated with performance.

Emotional Intelligence (EQ) is associated with many characteristics thought to underpin effective leadership: Improved self-awareness helps to develop effective relationships and understand others' emotions, thus enabling interpersonal skills such as communication, motivating others, resolving conflicts, and building teamwork (Sunindijo, 2013). Specifically, Zhang and Fan (2013) found a strong positive correlation between 6 EQ factors (emotional self-awareness, emotional self-control, empathy, organizational awareness, cultural understanding and communication) and construction project performance.

Although EQ and a transformational leadership style (Ramchunder and Martins, 2014) were found to be significant in leaders from all sectors, the traits of managers in construction do not match those found in other industries. Power, urgency, proximity, competitive threat, opposing position and neutral attitude are shown by the most influential construction stakeholders (Yang *et al.*, 2014). Lindebaum and Fielden (2010) show how construction project managers quickly resort to anger in order to resolve issues, and felt this was necessary to raise their visibility, achieve the desired outcomes, and maintain their image and reputation because the trait is seen as "role-defining" for managers in the industry.

The need to assert authority reflects the other pressures on construction managers including organizational culture, turnover, job pressures, working relationships, budget and safety communication which dictate safety performance (Kaskutas *et al.*,

2013). Conchie *et al.*, (2013) found that managers' engagement in "safety leadership" was hindered by workforce characteristics; role overload; production demands; and formal procedures.

Although managers in both sectors need to communicate strong messages, Safety Intelligent managers do this through engaging with others and listening (Fruhen *et al.*, 2014a). The way in which social competence is enacted in these two sectors is very different, and Zou and Sunindijo (2013) rate this as a lower of a priority in construction.

Table 2 - Summary of the contrasts between safety intelligent competences in ATM and Construction

Air Traffic Management	
Prioritisation	Interpretation
1. Social Competence	<p>Communication from management is the most important in improving site safety</p> <p>A Just culture</p> <p>Empower and collaborate with employees</p> <p>Engage with employees and listen</p>
2. Safety Knowledge	An understanding of contemporary and emerging safety constructs (such as Organisational Mindfulness) alongside technical processes
3. Problem Solving	Necessary to understand problems and generate solutions
Construction	
Prioritisation	Interpretation
1. Problem Solving	<p>Essential to cope with the fragmented and dynamic nature of the industry</p> <p>Emphasis on a strategic perspective</p> <p>Communication at all levels is vital to build integrated and flexible teams</p>
2. Social Competence	<p>Power, urgency and anger are traits of good leaders</p> <p>Self-awareness and Sincerity</p> <p>Emotional intelligence supports effective management</p>
3. Safety Knowledge	A technical understanding of business processes relating to safety

CONCLUSIONS

This literature review has highlighted the differences between these industries which limit the transferability of Safety Intelligence. As a TMO, it is more difficult for managers of complex construction projects to understand these fragmented and transient organizations. Problem-solving must take place between multiple contractors and stakeholders and reaching solutions is prioritized over their tactful delivery through developed interpersonal skills. The dynamic nature of construction and

production pressures also means leaders are required to deal with conflict in an assertive way, rather than collaborate as seen in Safety Intelligent leaders.

Despite the superficial similarities observed between the generic behavioral competences in ATM and construction, the “*job-task*” competences are highly industry specific (Cheng, Dainty and Moore, 2005). To influence safety, the papers reviewed show construction supervisors need to be more assertive and astute in their relationships, cope with constant change, and grasp a more complex operational picture than air traffic managers.

In light of the differences between these two sectors, it is apparent that the ATM Safety Intelligence model would need to be adapted to construction before informing the selection and training of construction supervisors. However, whether the differences in leadership style are due to weaknesses in managers’ competency-development, or the challenging environment in which they work, would need to be determined. Although the Safety Intelligence model provides an overview of management competences in an ultra-safe industry, a causal link between these competences and safe operations has not been explored. Validation is needed; in particular, testing a causal link between Safety Intelligence and safety in a more complex environment such as construction.

Risk is often accepted as an inherent part of construction work (Swuste, Frijters and Guldenmund, 2012) but the safe build of the Olympic Park challenged this, demonstrating that it is possible for construction to be a “*highly-reliable*” organization. This unique success was underpinned by a culture of “*respect, trust, clarity, pre-emption, challenge, consistency, collaboration, motivation, empowerment, communication, openness, fairness and assurance*” (Bolt *et al.*, 2012) – characteristics which are more consistent with an HRO like ATM than construction.

Safety Intelligent leadership poses a challenge for construction: Although the leadership style necessary to influence safety may be enacted differently in different sectors, the underlying principles of Safety Intelligent leadership – promoting a just culture, empowerment and collaboration with members, proactivity, and communication – have all been shown to contribute to the success of the Olympic Park. Although the uptake of safety culture methods (in their intended form) have been limited, Safety Intelligence provides an alternative with the potential to introduce resilient and proactive safety to construction in a pragmatic way.

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COMPARATIVE STUDY OF USER-CENTRED DESIGN APPROACHES

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This paper sets out to investigate user-centred design approaches utilised in design and construction of the built environment. “*User-centred design*” refers to design which focuses on users’ needs and wants. The term is widely used in software design, graphical design and in healthcare products used in the hospital and in design and construction of the built environment, for example in urban development, place-making, workplace design and refurbishment. The phrase covers a number of different approaches including Participatory Design, Co-Design, Space Syntax and Usability of Buildings. This paper compares these supposedly distinct approaches to better understand the different ways in which users’ needs can and are being incorporated. More specifically, it focuses on the deployment of these terms in construction research. A comparison of the definition of users, proposed role of users in the design process reveals significant differences in the definition and proposed role of users across the four approaches, with direct implications for the type of space envisioned and produced.

Keywords: co-design, participatory design, space syntax, usability, user-centred design.

INTRODUCTION

This paper investigates User-Centred Design approaches in design and construction of the built environment. It is motivated by two related interests - first, how users are incorporated into processes of designing and redesigning space, and second, how users’ experiences and existing practices can be used to inform design activity. Although there is a long tradition in the built environment professions in engaging with users, whether positioned as part of design, planning, the briefing process, stakeholder management etc, there is variation in the extent to which users’ needs and experiences are used to inform design (Ågerfalk, 2001).

User-Centred Design is defined as a design approach focuses on users’ needs and wants (Norman, 1988). It is widely used in software design, graphical design and in healthcare products used in the hospital and is also used in design and construction of the built environment, for example in urban development, place-making, workplace design and refurbishment (Sanders and Stappers, 2008; Sanoff, 2007). Variants include: Participatory design Co-Design, Space Syntax and Usability of Buildings. While all four approaches call for the more active engagement of users in the design process, they also often present themselves as distinct alternatives, either as research tools or more practical recipes or prescriptions for 'doing' user engagement.

This paper explores these differences with an aim to clarifying the different design options available and their implications for the type of space produced. It does this by

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selecting a range of papers from these traditions and evaluating them with respect to three dimensions; 1. The way the studies define 'the user'; 2. The methods of user engagement mobilised in practices and 3. The specificity and nature of the 'space' under negotiation during the (re)design process. The paper begins by briefly defining four distinct labels used with User Centred Design more broadly. It then describes the analytical approach used, and the analytical categories or dimensions that are developed. The analysis presents an evaluation of the distinctiveness (or otherwise) and features of these approaches.

DEFINITIONS

User-Centred Design tries to optimize the fit of product and services with how users can, want and need to use them, rather than forcing the users to change their behaviour to accommodate the product and services. This approach was first defined by Norman (1988) as *“a philosophy based on the needs and interests of the user, with an emphasis on making products usable and understandable”*.

According to Eason (1995), there are two possible meanings of user-centredness, 'Design for users' and 'Design by users'. The first calls on the designer to gather information about human behaviour and design the product and services for users, the second incorporates the user more substantively within the design process. Four, supposedly distinct, approaches currently dominate UCD. These include: Participatory Design, Co-Design, Space Syntax and Usability of Buildings.

Participatory Design originated in the Scandinavian Cooperative design tradition, where researchers engaged with workers and unions to explore how technology might be designed for skilled workers. The approach is characterized by its emphasis on cooperation between the researcher and users. Its strength lies in being a movement that cuts across traditional professional boundaries. This is based on the principle that the environment works better if citizens are active and involved in its creation and management instead of being treated as passive consumers (Sanoff, 2000).

Co-Design, a more recent version of UCD, goes even further by engaging users more actively in all stages of the design process as co-designers. Whereas Participatory Design calls on designers to interpret users' needs, behaviours, desires and contexts to learn about their needs, Co-Design calls on them to facilitate user participation, asking them to express their experience and knowledge directly in the design process (Rizzo, 2010). It would therefore claim to incorporate the user more closely in the process, and to not privilege the expertise of the designer over that of the user.

In contrast to both of these approaches, Space Syntax offers a view from outside of the designer-user relation. More specifically, it tries to understand the *“natural”* relations between users and built environment. The aim is to find out why certain spatial forms work for users and others do not (e.g. 1970's social housing estate and traditional houses in the city). A central assumption of Space Syntax is that space plays a distinct role in our existence in the world. *“Culturally and socially, space is never simply the background of our material existence. It is a key aspect of how societies and cultures are constituted in the real world, and, through this constitution, structured for us as 'objective' realities”* (Hillier 1996).

According to Hillier (1996), the relations between space and social existences do not lie at the level of the individual space, or of individual activity. It lies in the relations between configurations of people and the configuration of space. Thus Space Syntax focuses on spatial configuration and developed mathematical descriptions of spatial

configuration and shows how empirically testable outcomes can be predicted for aspects of collective human behaviour in building and urban settings. Designers use this to simulate the likely effects of the designs on the people who occupy and use the buildings rather than the democratic approach of taken in participatory design.

As described by Sanders and Stappers (2008), the Space Syntax design approach is more like a classical user-centred design process in that the user is a passive subject of study. The researcher produces knowledge, brings it to the designer who then uses it in the creative development of their design. This is in sharp contrast to the more democratic focus of participatory design and co-design.

Similarly, 'Usability of Buildings' focuses on the relationship between buildings and people or organizations. Usability is defined as the “*effectiveness, efficiency and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment*” (ISO 9241-11, 1998). According to this definition, three key factors determine usability - efficiency, effectiveness and satisfaction - and bring the user perspective into focus.

In 2001, International Council for Research and Innovation in Building and Construction (CIB) set up the Usability of Workplaces as a task group to investigate the application of an international standard on usability and techniques – often applied in the evaluation of consumer products – to the built environment. The aim was to identify methods and tools that could provide a better understanding of the user experience of buildings and enable a more positive user experience in organisational settings (Jenso, M. Hansen, G K. Haugen, T, 2004).

While these four approaches present themselves as distinct alternatives, the terms are often used far more loosely. This paper uses a review of articles claiming to adhere to each approach to explore variations in the approaches proposed. The aim is both to introduce a bit more rigour into the use of the terms and, more importantly, to clarify the alternative approaches currently being mobilized and their implications for the type of space produced.

METHOD

Selection of papers

Three papers which explicitly describe themselves as aligned with each specific design approach are selected for comparison. The criteria of selection are;

- Whether the title includes the design approach that is being used
- Whether the abstract or the keywords include the design approach being used
- Whether the main text includes the design approach that is being used
- Whether the paper offers an empirical example, which allows for an evaluation of the difference between the label and the approach deployed in the analysis.

Table 1 lists the selected papers. It is not the intention of this paper to suggest that these are fully representative of either each specific approach or UCD more broadly, but they do enable a comparison to be made, and align with our starting interest in assessing the distinctiveness and characteristics of these different UCD concepts.

Table 1: The full list of three papers from the different User-Centred Design approaches

Design approach	Ref	Author	Year	Paper
PD	Paper 1	Rachael Luck	2003	Dialogue in participatory design
	Paper 2	Julia A Garde, Mascha C. van der Voort	2008	The design of a new NICU patient area_combining design for usability and design for emotion
	Paper 3	Ole Sejer Iversen, Christian Dindler	2014	Sustaining participatory design initiatives
Co-Design	Paper 4	Yanki Lee	2008	Design participation tactics_the challenges and new roles for designers in the co-design process
	Paper 5	K Vaajakallio, J J Lee, T Mattelmäki	2009	It has to be a group work-Co-design with children
	Paper 6	Jiri Lallimo	2014	From pedagogical ideas to a school building: Analysis of user involvement in building design
Space Syntax	Paper 7	Kerstin Sailer, Andrew Budgen, Nathan Lonsdale, Alasdair Turner, Alan Penn	2010	Pre and post occupancy evaluations in workplace environments-theoretical reflections and practical implications
	Paper 8	Daniel Koch, Jesper Steen	2012	Analysis of Strongly Programmed Workplace Environments. Architectural Configuration and Time-Space Properties of Hospital Work
	Paper 9	Hui Cai, Craig Zimring	2012	Out of sight, out of reach. Correlating spatial metrics of nurse station typology with nurses' communication and co-awareness in an intensive care unit.
Usability of Buildings	Paper 10	Monica Jenso, Geir K Hansen, Tore I Haugen	2004	Usability of Buildings Theoretical framework for understanding and exploring usability of buildings
	Paper 11	Siri H Blakstad, Geir K Hansen, Wibeke Knudsen	2008	Methods and tools for evaluation of usability in buildings
	Paper 12	Siti Norsazlina Haron Md Yusof Hamid	2011	Patient perspective_the usability evaluation approaches as assessment for quality of outpatient spatial design

Development of dimensions

The study examines the different design approaches against three dimensions: how 'user' is defined, the method of user engagement employed in the design process and the conceptualisation of the 'space' being designed.

First, it will explore how the 'user' is defined in each design approach, what user unit they are engaging with and what their overall objectives as User-Centred Design are. For example, Granath (2001) defines 'user' as those who actually use the building in their everyday activities. Thus users are all people working in a building, staff, management and service personnel, but not patients, visitors, owners, union representatives and public officials. Other authors include a broader array of stakeholders within their definition of users - those individuals and groups who can affect an organization. For example, Kernohan *et al* (1992) classified stakeholders at the demand side or the supply side and defines three different kinds of users - occupants, visitors and owners/ tenants organizations. Olsson *et al* (2008) developed further user categories and proposes to include owners, facilities management personnel, indirect and direct service receivers as well as service providers. As we can see, there are several possible definitions of "user" that are used in different studies. But as well as who counts as a user, there can also be variation in how concrete the definition is, with some studies being concerned with a more abstract and generic

notion of the user. Therefore this paper will investigate whether the same definitions are used *within* each design approach as well as *between* different design approaches. It will examine who the user is and how specific the user is defined in the paper.

For instance, according to Vischer (2008), there are three user units that exist within an office building - the individual, the team and the organization. This is not only limited to the office building: there will be different user unit within any organizational environment. Then what user units are in each approach engaging with? Are there any common features within each design approach in terms of the user units that they engage with? User-centred design approaches set out clear objectives in order to design products and services that meet users' needs and wants. This study will compare what the objectives of different design approaches are and explore whether there are any difference between them, if there is, what it is and how this would impact on its development and outcome of the design process.

Secondly it will investigate whether there are any differences between the methods applied in each of the different design approaches. Eason (1995) distinction between 'Design for users' and 'Design by users' suggests that there is different way to engage users in the design process. 'Design for users' involves gathering information about human behaviour from the users and using this to design better products and services for users. In this paper, this will be called 'passive user engagement'. 'Design by users' is about helping the user to actively engage in design process. This will be referred to as 'active user engagement'. The analysis will examine whether there are clear distinctions in how users are engaged in the different design approaches or not and, if there is, what their characteristics are.

As the level of user engagement differs, their role in the design process changes. In the 'Design for users' approaches, users are research subjects who provide the information and designers/architects are experts who design the building. In contrast, in 'Design by users' approaches, users are actively engaged in the design activities and act as co-designers. This transforms the role of the designer into one of facilitator.

Thirdly, the analysis will look at how these design approaches and techniques impact on the outcomes of the design process, shaping the building that is created. In the traditional design process, architects and designers use their own knowledge and experience to create spaces, beginning with abstract ideas and transforming them to concrete spatial formations through their cognitive design activities (Dursun, 2007). User-Centred Design approaches aim to incorporate users' needs, experiences and practices into the design process. These approaches engage users to develop the abstract ideas of the building project, such as the perfect future hospital and most efficient or collaborative workplace design, and to create its concrete space.

However the level of user engagement differs, the space envisioned changes. In the 'Design for users' approaches, architects and designers use a range of techniques to understand the needs of users and use this information to design better products and buildings on behalf of users. In doing this they focus on 'objective components of space', by emphasizing spatial patterns of behaviour, by incorporating the spatial components of social space through social area analysis, and by studying a more micro level of social space using concepts such as action spaces, activity spaces, behavioural fields (Buttimer and Seamon, 1980).

In contrast, in the ‘Design by users’ approaches, users are acting as co-designers to express their experience and knowledge of the space and building throughout the entire design process. The aim of these approaches is to incorporate users’ perceptual and cognitive evaluations of space and building, in other words the subjective spatial experience. These approaches focusing on ‘subjective components of space’ are explored using concepts such as life space, cognitive maps and urban images (Buttimer and Seamon, 1980).

ANALYSIS

Definition

Table 2: Key definitions used in different approaches

Design approach	User	User unit	Their objectives
Participatory Design	Targeted user group/ stakeholders	Individual, groups	Emotional satisfaction and needs
Co-Design	Targeted user group/ stakeholders	Individual, groups	Emotional satisfaction and needs
Space Syntax	Mixed definition	Organization	Organizational goals and efficiency
Usability of Buildings	Mixed definition	Individual, groups and the organization	Efficiency, effectiveness and satisfaction

1 Who is the user?

As we can see from table 2, all the papers from different approaches use inconsistent definitions of the user. For example, in PD, paper 1 looks at a specific and targeted user group, such as people with different disabilities, while paper 2 and 3 defined the user more broadly as all relevant stakeholders. The papers from Co-Design tend to define users as stakeholders and engage with the representatives of each of the user groups, but paper 5 looks at a specific group (children aged 7 to 9). It is also noted that in paper 6 the school employed a full time 'head user' as their representative in the design process who was responsible for organizing the design activity and the communication between the users and the architects and designers. This approach was taken due to the time requirements of co-design processes and helped enable very busy users' to be involved in the design process while they were carrying out their everyday job. Similarly, in Space Syntax approach, paper 8 defined users as people who use the building in their everyday activities but select the representatives of three main roles of the hospital's healthcare work - doctors, nurses and auxiliary nurses. While paper 7 define it as people who use the building in their everyday activities, but in a flattened hierarchy of the organisation.

2 What user unit are they engaging with?

Participatory Design and Co-Design approaches engage the user through interviews, focus groups and workshops, thus these design approaches engage the individual user unit. For example, paper 1 uses semi-structured interviews to allow the user to express their individual experience. Similarly paper 3 uses a series of collaborative workshops to allow users to express their experiences and is used in the paper to create new learning environment that supports current and future school activities. The studies

using Space Syntax approaches studies the collective human behaviour (organizational behaviour) in the institution using observation, user surveys and interviews and so engages the organizational user unit. However paper 8 engages the individual user unit as the study selects representatives of the three main roles in the hospital's healthcare work. Interestingly Usability Studies seem to engage different user units, from the individual to the organization.

3 What are their objectives (users' need)?

As shown in table 2, the objectives of the Participatory Design and Co-design are more likely to be maximising individual's satisfaction and meeting their needs through giving users power to be involved in a decision-making process in the building project, while Space Syntax and Usability study are trying to achieve organizational goals and efficiency by providing an appropriate and efficient physical space.

Method

Table 3: Method-the level of user engagement and the role of actors in the design process

Design approach	The level of user engagement	The role of actors in the design process
Participatory Design	Semi-active engagement	Blurrily
Co-Design	Active engagement	Blurrily
Space Syntax	Passive engagement	Clear
Usability of Buildings	Semi-active engagement	Clear

4 The level of user engagement

Co-Design approaches engage users most actively in the design process, while Participatory Design and Usability of Buildings approaches engage less active in the design process. For example, paper 4 use the workshop to discuss users' experience and design the building blocks with them, while paper 2 ask users about their experience by interviews, survey and observation then workshops and a virtual reality setting to understand users' wants. However it seems that there are some confusion of the conception of PD and Co-Design. Paper 3 uses the workshop to actively engage with users as design partners, but it classifies itself as PD.

Meanwhile the Space Syntax approach was engaging user more passive as users are more likely research subjects to provide information about their needs. Paper 8 undertakes interviews and seminars with the representatives of the users to understand workflows and practices, and a series of experiments with the plan of the unit to test the impact of changes of the spatial configuration on workflow and staff' work conditions.

5 The role of the actors in the design process

Participatory design and Co-Design have very blurrily professional boundaries. As users engaged in the design process actively and become co-designer, designers and architects' role change and become a facilitator rather than the expert who design and construction of the building. It was difficult to distinguish between Participatory design and Co-Design in terms of the role of actors. This differs from the Space

Syntax approach as the role of actors clear. Designers and architects receive the information about users' needs and wants from researcher, and design buildings based on this information.

Space

Table 4: Space in the design process

Design approach	Envisioned Space
Participatory Design	Subjective components of space
Co-Design	Subjective components of space
Space Syntax	Objective components of space
Usability of Buildings	Subjective and Objective components of space

Co-Design approaches engage users actively in the design process allowing them to express their subjective spatial experience and desires. For example, in paper 5 two Co-Design techniques are used to enable users to think aloud about design ideas that are connected to their everyday life, and negotiate with others in the user group to justify different solutions that meet not their only individual user' needs and desires, but those of other users too. Thus this approach looks at 'subjective components of space' (see above table 4).

This contrasts with the other approaches, such as Space Syntax approaches, in which researchers study spatial pattern of human behaviour and spatial analysis to understand users' needs, with the designers using this information to shape their abstract ideas to create concrete space. Therefore it focuses on 'objective components of space'.

Usability of Buildings approaches try to accommodate both 'objective' and 'subjective components of space' as their aims are to increase the effectiveness and efficiency of buildings, and users' satisfaction. In paper 10, different methods are combined to measure and evaluate the building (objective components of space) and also to organize a workshop with different users to explore the user experience (subjective components of space).

DISCUSSION

This study explores different UCD approaches in design and construction of the built environment. It focuses on different ways of user engagement and compares the definition of users, roles of the users and the type of space envisioned and produced. The study reveals significant differences in the definitions and proposed role of users across the four approaches, with direct implications for the type of space envisioned.

The term user is used inconsistently across the different approaches. Some papers define it as people who use the building in their everyday activities while others use it to mean all relevant stakeholders. The papers using the first definition give each of the different users equal weight regardless of their position in the organisation – there is a, flattened user hierarchy. Space Syntax approaches use this definition to study the spatial pattern of human behaviour for a random selection of users, so it could represent any potential users in the buildings and cities. The papers using the latter definition select representative users from each stakeholder group reflecting the organizational structure. A number of approaches, including Co-Design, use this definition of the user, aiming to intensively engage users in the design process to

allow them to express their experience and knowledge. One challenge for these approaches is ensuring that the experience and opinions of the representative users who are engaged with is truly representative of those of the whole of the user group. Innovative techniques can help bridge this potential gap.

Co-Design approaches are engaged with more subjective components of space through incorporating users' cognitive and perceptual experience of the building. One potential risk of this approach is that the focus on what users think they *want* leads to some aspects being neglected and the outcome not providing what users actually *need* in everyday spatial practice and the building not functioning as it should do.

Conversely, Space Syntax approaches study 'objective components of space' by looking at spatial patterns of human behaviour in the building and using spatial analysis to understand users' needs and create space and buildings that support users' activities and organisational goal in the building. A potential risk of this approach is that people who are directly and indirectly affected by the building dislike it even though the focus in the design process has been on making the building function effectively and providing the space the user needs in everyday spatial practice.

The contribution of this paper is in raising a number of questions around the role and status of users in design, and the models and concepts of user-engagement that have been mobilised. These include tensions between individual and emotional needs versus organisation and efficiency oriented goals, the specific status and privileging of types of users in the process and consideration of the subjective / multiple or more unitary and objective conceptions of the design space. These questions are currently being assessed through a case study of user-engagement in a new hospital design in Denmark.

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BIM IN EUROPE: INNOVATION NETWORKS IN THE CONSTRUCTION SECTORS OF SWEDEN, FRANCE AND THE UK

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European countries are developing or implementing policies that promote or require the use of Building Information Modelling (BIM) and give BIM a central role in strategies for national sector-level transformation. It is necessary to understand BIM as a systemic innovation that is enacted and adopted by firms, projects and users but also by national actors. The Industrial Marketing and Purchasing (IMP) approach has shown how the evolution of innovations can be understood in terms of networks in which actors mobilise and combine technical and social resources in order to perform activities – the Actors-Activities-Resources (ARA) model. A comparative study of BIM adoption in France, Sweden and the UK was undertaken using data from independent country-specific research projects and a pooled desktop study. A grid was developed based on the ARA model that provided a framework to inform data collection and analysis salient for explaining the extent, processes and type of adoption of BIM in each country. Similarities between countries included: the importance of large and international firms in the innovation network; and project types (non-residential public buildings and either complex or repetitive building types). Differences were found in, for example, the activities and national institutions of architecture and the policy positions and mechanisms of government actors. The analysis highlights both the value and some limitations of a country-level focus and provides a basis for thoroughgoing network analysis.

Keywords: BIM, France, innovation, network, Sweden, UK.

INTRODUCTION

The construction sector is characterised by a high degree of fragmentation, the dependence on a broad variety of actors and relationships (Dainty *et al.*, 2001), the temporary project-based nature of construction activities (Winch, 2003), and increasing complexity of projects (Chan *et al.*, 2004). The sector depends on collaboration and interaction of many actors across many construction projects. This is thought to constrain efficiency, productivity and innovation in the industry. In the last two decades, ICT technologies have been adopted and in the last ten years Building Information Modeling (BIM) has been introduced to facilitate the construction process. Succar (2009: 357) defines BIM as “a set of interacting policies, processes

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and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle". BIM is both technology and a process for project or asset management (Bryde *et al.*, 2013). Implementing BIM as an innovation is not only a matter of technology but also a matter of re-organising work and work flows. Hence the implementation of BIM requires technological and organisational changes. Scholars put forward the difficulties in implementation and use of any new innovation due to the non-linearity, uncertainty and complexity of any innovation (e.g. van de Ven *et al.*, 1999).

Except for Bryde *et al.* (2013), there is little research on BIM on a general level beyond specific construction projects, also there is lack of cross-country comparisons. This paper presents preliminary data related to BIM in three European countries: the UK, France and Sweden. We investigate how the implementation of BIM as an innovation is played out in these different national contexts with the aim to discuss differences and similarities in facilitating and hindering new construction innovations.

IMPLEMENTING BIM

BIM use affects all stages and actors in a project: understanding needs, design, development, management, operation, and maintenance (e.g. Hartmann *et al.*, 2012). Travaglini *et al.* (2014) classify and rank construction sector actors according to their level of interest in BIM, namely; client, project manager, architect, principal contractor and engineer. These actors can be directly involved, such as an architect, or indirectly involved, such as national authorities. Benefits of BIM (e.g. Succar, 2009) include; cost reduction, efficient time management, improved communication and coordination along with quality improvement. BIM is globally associated with *"improved efficiency"* by *"limitating rework"* (Arenda-Mena *et al.*, 2009).

Barriers for BIM adoption include difficulties in changing working habits and adapting workflows (Sebastian, 2011) and legal issues (Olatunji, 2011). Sebastian (2011; 181-2) details the changes of activities that BIM implementation may entail: 1) BIM requires a new *"model manager"*, which *"provides and maintains technological solutions required for BIM functionalities, manages the information flow, and improves the ICT skills of the stakeholders"*, but will not *"take decisions on design and engineering solutions, nor the organisational processes"*, 2) BIM will impact on Intellectual Property Rights (IPR), 3) BIM will change the payment arrangements since *"a new proportion of the payment"* is required in the early design phase, 4) BIM will also change the use of open international standards.

The above discussion highlights that the implementation of BIM will require both technological and organisational changes and in particular new interaction patterns between actors of the supply chain (Succar, 2009). It also shows that the diffusion of BIM is dependent on a larger structure of interrelated actors, individuals, humans and other technologies in use. In the following we outline an approach to theorising and researching this structure that has influenced our data collection and analysis.

Innovation networks- a prerequisite of implementing innovation

Several authors (e.g. Miozzo and Dewick, 2004) highlight the importance of innovation networks to successfully implementing innovation in the construction industry. In line with earlier innovation studies (e.g. van de Ven *et al.*, 1999), these findings underline that the implementation of any innovation requires changes of already established work practices and technologies in use and is therefore dependent on a network of actors. Researchers of the Industrial Marketing and Purchasing Group

(IMP) developed the Industrial Network Approach (INA) based on the idea that industrial development happens through interaction and business exchanges between actors. These exchanges result in networks of relationships constituting the “market” (Håkansson *et al.*, 2009). For the INA, the development and implementation of innovation requires interaction between organisations (e.g. venture capitalists for funding; users for design and testing). As summarised by Håkansson (1987: 3): “An innovation should not be seen as the product of only one actor but as the result of interplay between two or more actors; in other words a product of a ‘network’ of actors”. To be successful, an innovation should thus be embedded into users’ contexts. This process involves several actors who combine and adapt their resources to commonly develop the innovation. The ARA model develops this link between Actors and Resources in innovation networks (Håkansson *et al.*, 2009). In this model, Actors are defined by the Activities they perform and the Resources they use and control. The ARA-model enables investigation of the network involved in the development and implementation of a particular innovation within a certain industry.

In this paper we present the different implementation patterns of BIM and discuss the different national construction contexts along with their specific conditions in promoting and hindering construction innovations. With a view to providing a basis for the analysis of the corresponding innovation network, we use the ARA-framework to structure our data collection and analysis on how BIM has been adopted by main actors and their role. The study is inspired by Miozzo and Dewick (2004) study on construction innovation across five European countries. However we focus on one focal innovation, BIM, to enable comparisons across three different national contexts.

METHOD

Primary data consists of expert interviews with construction companies, engineering companies, architects and project owners. Methodologically, these were expert interviews in which. Expert interviews are widely used in construction management research (e.g. Bassioni *et al.*, 2005) as an informed but indirect source of data about specific cases and the wider network. The data assembly, and some of the primary data collection, was guided by an analytical grid based on the ARA-framework. The issues covered by the interviews varied between studies but included: factors explaining the adoption or reluctance to adopt BIM; the main characteristic of the processes of adoption; the type of usage made of BIM. The interviews were predominantly conducted in person, ranged from one to three hours and were recorded and transcribed for analysis. Sample: France: 6 interviews at five architectural firms, 5 interviews at one construction firm, 3 interviews at two engineering firms, 1 interview at a software provider. Sweden: 4 interviews at four architectural firms, 4 interviews at four construction firms, 5 interviews at four engineering firms, 4 interviews at four project owners, 2 interviews at two suppliers, 2 interviews at two NGOs. UK: 4 interviews at one architectural firm, 16 interviews at one construction firm, 4 interviews at three engineering firms.

Secondary data came from the numerous industry and policy reports that have been produced about BIM with a European or national scope plus general sector-level overviews and statistics. These reports are particularly useful as a continuously updated source of figures on BIM adoption. While reports such as these are necessarily limited and vary in the quality of their methodological implementation they add detail and breadth to the sector-level picture built up from the interviews.

PRESENTATION OF DATA

The Swedish study

Construction companies: The total number of companies is around 93,000 but 81,000 of these have only up to 4 employees (BI analysis, 2013). Hence the construction industry is mainly constituted of very small firms and few large ones. Sweden has four big construction companies; Peab, Skanska, NCC and JM. NCC and Skanska have international activities, while the others focus on the Nordic countries.

Firms producing mostly single-family homes, they were first to adopt BIM (Myresjöhus, Fiskarhedenvillan). With the use of BIM they had already developed industrialised construction by the mid-2000s. The large construction companies became engaged in BIM from 2006-2008. NCC, Skanska and Veidekke Sweden are mentioned as having the highest BIM competence. NCC has the broadest experience with more than 700 projects related to BIM. Both NCC and Veidekke use the Virtual Design and Construction (VDC) concept to steer the technology, process and organisation. Veidekke have most VDC-certified personnel in Sweden with around 35 while NCC has 25 but another 25 on the way. Skanska have high BIM proficiency: the company is in charge of the largest hospital project in Europe, NKS, with one of the highest levels of BIM ambition in Sweden. The large construction companies started to implement BIM on internal housing projects and for Design and Build contracts, where they own the whole process. An internal BIM policy exists within all large companies. In general the large companies have invested in internal training of employees in BIM, also recruiting BIM-specialists; moreover VDC required investments in ICE-studios and new technology. Peab and JM are late-comers in relation to BIM, but Peab have during the last year implemented BIM-policies to increase BIM awareness at all levels. In general the status and power of construction companies have increased in Sweden and the companies aim at optimising the profit in the project delivery focusing on planning and production activities. There is a lack of attention to operations activities.

Engineering companies: Among engineering firms there are around 10 larger firms. Sweco being the largest followed by WSP Sweden, ÅF, Ramboll and Tyréns. These firms mainly have the Nordic counties as their market but WSP and Sweco have international operations. Engineering companies in Sweden have been leading the adoption of BIM. Engineering firms were open to new technology and realised the benefits of BIM and the possibilities to develop services in relation to BIM since 2007 onwards. All major firms have undertaken development projects to define the use of BIM and its possibilities. Engineering companies have a clear perspective of the clients; in the beginning these companies provided BIM competence to construction companies but due to increased BIM-competence within construction companies, engineering firms are now steering towards the client side of the construction industry. Engineering companies have made a profitable business of serving as BIM-coordinators along with providing BIM-training for companies. The BIM expertise among engineering firms seems to be lowest within mechanical services.

Architect companies: The Swedish Association of Architects has more than 12 000 members, and around 10 architects are larger firms (more than 50 employees), where White, Tengbom, Nyréns are the largest ones. In general architects have been slow in adopting BIM, according to the architects themselves they have been “*extremely uninterested*”. The large firms have been working actively with BIM from 2012, focusing on establishing its internal BIM-work and internal BIM-competence by

employing more engineers and providing training of employees. One main reason for the late adoption by architects is the traditional division of labour in the design process; the architect provides the creative vision and delegates the drawing and modelling to an assistant. BIM on the other hand requires changing work flows and new ways of organising work (variation among architects exists - the younger firms find it easier to adapt to BIM work processes). Moreover the status of the architect profession in Sweden has been decreasing since the 1960s along with the increased price focus of the industry. Also architects do not have a project manager role in Swedish projects. Architects mention the adoption of BIM is required for more complex projects and that some clients require BIM. It is mentioned that BIM is “*an opportunity for architects to gain status and power*”, which is supported by the notion in the industry that architects are increasingly contracted to act as BIM-coordinators in projects.

Clients/project owners: Construction clients and project owners are a broader variety of companies including real estate companies managing housing, public or commercial and industry buildings along with companies within road and transportation. The clients have been the last group to support the adoption of BIM. In the industry the clients are typified as having not “*understood*” (as opposed to not accepted) the long-term benefits of BIM. Clients are still regarded as unaware of BIM benefits for facility management and operations. Hence some clients demand BIM but on a low level, and using BIM during the whole process including operation and facility management is far away. Implementing BIM in facility management and operations demands the development of new facility management systems which do not yet exist in the industry.

There are some initiatives going on especially among the public project owners, however there are no regulations in relation to BIM in Sweden. The biggest project owner in Sweden, Swedish Transportation Administration, issued a BIM-strategy in 2013 with the aim to include BIM for all new investment projects from June 2015. The company was inspired to a high degree by the government initiative in the UK. Another initiative is from five large public clients that have jointly formed a BIM-strategy (Specialfastigheter, Akademiska hus, Riksdagsförvaltningen, Statens Fastighetsverk och Fortifikationsverket) with the support of an engineering company. Locum AB is in the lead in implementing BIM- for instance the whole property stock is described in BIM models and the company demands BIM in every project. The largest real estate company Vasakronan have just started to work with identifying demands in relation to BIM- supported by the engineering company Sweco.

The French study

Construction companies: As in Sweden, the French construction industry’s profile is two-sided. On the one hand, it is made up of a myriad of very small firms and on the other hand, it has some of the world’s biggest construction firms. 4 major construction firms dominate with 3 of them ranking among the 10 largest construction firms in Europe and having an international activity (Vinci with 40b€, Bouygues with 26.6b€, and Eiffages with 14.3b€). Worth noting is the specific position of Bouygues (2nd construction group) who started using BIM at the end of the 2000s (for a Canadian hospital project) while the 3 other largest French construction firms are currently at the early adoption stage of BIM. BIM was then mostly used for complex (hospitals, airports...), large or repetitive projects (e.g. large office towers or residential housing). For Bouygues (and later major French construction firms), BIM is a way to promote

more vertical integration (D&B; PPP/PFI, DBOM) and hence to be more active both upstream and downstream the supply chain (selling operations/maintenance services but also design services). This is consistent with their diversification strategy as most of them are able to offer all these services whereas smaller construction firms are not. This integration gives more power to construction firms. BIM is also seen as an opportunity to industrialize the production process and reduce construction costs through lean management. This early integration of BIM is intended to give them a cost advantage and to be more competitive in a period of economic crisis.

Engineering companies: France has a number of large, renowned engineering firms making more than 10M€ turnover (Altran, Setec, Egis, Ingerop, Systra, Technip). 20% of engineering firms have more than 1000 employees and 25% between 100 and 1000. Up until 2014, BIM had been mostly adopted by private architectural and engineering firms. In 2012, 51% of architects and 27% of engineering firms declared having adopted BIM 5 years ago or more while 29% of construction firms adopted BIM over the last 2 years. These early BIM adopters were mostly the biggest actors with international development plans. Engineering firms have been inclined to work with BIM due to the increased complexity of projects and to be able to work with the biggest construction companies such as Bouygues and later Vinci and Eiffages who use it as a criterion for choosing which engineering firms they appoint.

Architect companies: 80% of French architectural firms have less than 2 people and work on very small projects. 7 agencies have a turnover exceeding 20M€ and 9 between 10 and 20M€. Only the architectural firms with more than 30 employees develop an international activity (2.5% of the profession's turnover). A number of France's architectural agencies are world famous (Renzo Piano, Jean Nouvel, Portzamparc). Initially, members of unions and federations of architects were afraid of the required changes and investments linked to BIM implementation and to become, in the words of one respondent: *"the [unskilled workers] of large construction firms"*. Also there was also a lack of training available for architects on BIM use. For the architects, BIM was a means to increase their project success rate: *"When we use BIM, we win 3 projects out of 4"*; it acted as a lever towards internationalization and awareness: *"it is an excellent means of working internationally and transferring data"* or as a strategic bridging tool to access internationally renowned partners: *"it enabled us to work with Renzo Piano"* (comments from interviewees). At this time, the main motivations of these 'early adopters' in the AEC supply chain were to ensure differentiation on the French market, reduce costs and access to international projects and customers by acting as BIM model manager:

Client/project owners: Construction clients and project owners are for 72% of private origin (mostly individual customers and real-estate investors) and 28% public. Most public were not organized and did not have the resources to exploit BIM data. It was recognised that the French government did not support adoption up until recently: *"At the moment, the French legislation is not favourable to the use of BIM... A clear and predictable national framework at the highest levels are required conditions for the structuring of the sector"* (Sustainable Construction Plan, March 2014).

In 2013, *"BIM France"* (association of architects and engineers) followed later by the French government, public customers and professional organizations (FFB, CSTB...) decided to actively support the development of BIM in France. In 2014, the Ministry of Housing and Construction declared that the use of BIM will be mandatory in public markets from 2017 onwards. This public announcement was supported by several

initiatives: the promotion of a Golden BIM award by a famous trade magazine, the development of BIM investment packages to ease up the equipment by architects (software + hardware + financing) as well as the organization of several training sessions by their professional unions. Today, several trade associations support BIM in France including actors from the entire industry: product manufacturers, engineering and consulting firms; construction contractors, norming and standard bodies; research and technical institutes; economists; architects and urban developers. As a result, BIM adoption is now considered by most of the industry actors as inevitable. France is thus entering the institutionalization phase with BIM. As noted by one architect: *“we are now at year 0 of BIM in France. Over the last few months and especially since September 2014, everything is accelerating.”*

The UK study

Construction companies: The UK industry shares the same major structural feature as Sweden and France with a high number of very small firms and 60 that employ over 1,200. Large firms with turnover above £2b are; Balfour Beatty (£10b), Carillion (£4b), Kier Group, Interserve, and Morgan Sindall. There is a further split between general and specialist contractors with the latter tending to be smaller: larger firms are general builders, house builders, or civil engineers who operate similarly within their respective market sectors. Medium-sized firms are characterized by regional operations and/or specialization in one form of work. There has been both stability in the large firms and significant restructuring, with substantive changes and name-changing acquisitions. In general, BIM adoption has been led by larger firms, particularly major contractors that operate on a design-and-build basis and manage design work. Some reasons for adoption include: pressure from government clients; differentiation in bids; operational efficiency; and the desire to be seen as an employer of choice. Among smaller firms usage is less common, less developed and they are less confident. Smaller firms are less likely to be bidding for public-sector or complex work where BIM is technically indicated or required by an expert client. Smaller firms lack slack resources required to innovate. Smaller firms operating as tier-2 or -3 subcontractors still receive information in ‘paper’ form.

Architect companies: Architecture is similarly structured to contracting companies with 90% of architects having less than 10 employees and only 1% over 50. In general, far smaller firms than building firms. Larger firms include Foster + Partners, BDP, and Atkins and these are significant, international organisations with considerable influence. In the UK, architects generally had a traditional role as the leader of (building) construction projects but this is increasingly not the case following deregulation of the profession and the increase in design-and-build contracting. The leadership role was reflected in the historical split between design and construction realised via professional institutions, firms’ structures, contracts, education and practice. Construction firms rarely have design resources and architects have only been legally allowed to own construction business comparatively recently. On modern construction projects much of the design is actually undertaken by specialist trade contractors (M&E contractors, curtain walling firms) who can integrate management, design, manufacture, delivery and assembly.

The motivation for the adoption of BIM for the purposes of architectural design (rather than as a project information management solution) can be roughly divided into: the use of advanced CAD tools for sculptural, sometimes algorithmic, design; and the use of standard libraries of objects and parametric modelling in the design of

more conventional buildings. Adoption is led by larger practices but in small architecture practices, once startup costs have been overcome, potentially offers significant discrete benefits in terms of efficiency of workflow and information production that offers them a competitive advantage. Consequently, there is an emerging 'BIM for small practices' movement.

Engineering companies: While similar to architecture firms, engineering organisations tend to be larger with 70% of firms having less than 10 employees and only 5% over 50. Large firms include Atkins, URS, Arup, Jacobs, AECOM and WSP UK. There's an increasing trend for larger multi-disciplinary practices (construction professional service firms: Atkins; Mott MacDonald; AECOM; URS Scott Wilson; EC Harris; etc.). The number of qualified staff in such organizations has more than doubled in the last 20 years. Patterns of BIM adoption is similar to that for architects: large and advanced design consultancies. 3D design and analysis is a natural progression for structural designers although M&E consultants still seem to be something of a brake as they typically only produce a concept design, delegating the detailed design of installations to M&E contractors.

Client/project owners: UK government plays, and has played, a significant role in the industry (although national and regional government are no longer a major employer of construction labour). Activity and influence includes: monitoring and comment; acting as a major client; economic policy; legislation and regulation; subsidy; research/technical/facilitation. They have been influential in championing, facilitating and mandating BIM adoption by 2016 for some projects via procurement routes and have established the BIM Task Group. There is a push to adopt BIM from government and other public-sector clients increasingly in infrastructure. Government-backed facilitation has developed a network and set of communities to encourage BIM adoption including; professional institutions (RIBA, RICS, CIOB, ICE, I.Strcut.E, CIBSE), research and facilitation organisations and networks. (CIC, BRE, CIRIA, Regional BIM Hubs, NBS, CPIC).

DISCUSSION AND CONCLUSIONS

We have started to investigate the innovation networks of BIM in Sweden, France and the UK by focusing on large actor groups in construction. A significant similarity between the countries is the importance of large firms in driving BIM development. Some actor groups drive the implementation while other actor groups are late comers.

Early adoption

Even though France is deemed to occupy a leading position regarding BIM adoption in Europe in recent surveys, this seems to correspond to a rather recent move and the adoption of this innovation can still be considered at an introduction or early development stage depending on the actors. In the 2014 Mc GrawHill Report, UK is considered, in Europe still as a beginner in BIM adoption. The beginner status qualifies the first development stage of specific BIM skills (to be followed by a moderate, advanced and expert status). This status, according to the Mc GrawHill report is to be linked with the recently announced government mandate. Sweden can also be considered as an early adopter and the actors have during the last 5 years developed and established BIM skills.

Construction companies as early adopters

For all countries the clients have been late adopters and BIM development has been supplier-led. Even in the UK where the government in its client role has been

influential the mandate has largely reflected rather than driven capabilities and building owners are under-represented in the “*national conversation*”. Construction companies have been influential adopters in all countries. The value of the 3D CAD component of BIM for detailed design might help explain the relative rates of adoption between design firms in the different countries. Swedish architects role is largely limited to concept design and seem to lag behind in adopting the new technology compared to the UK where architects often produce detailed design information (a similar comparison can be drawn between the apparent readiness of structural and M&E consultants within the UK).

The role of government policies

The role played by the UK government plays is significant. By 2016, BIM use will be mandatory in all public sector projects. France is aiming for regulations and in 2017 BIM used will be require for all public buildings. No such BIM-regulation exists in Sweden however the large public actors have been inspired by the UK development when adopting BIM strategies, which is in line with the 2014 Mc GrawHill report that indicates many public properties and public clients require BIM for their projects. These differences are important to take into account, so far as the role of major private but also government owners were considered by the 2014 Mc GrawHill report important drivers for BIM usage acceleration.

Not yet an integrative tool...

Another aspect to note is that in all three countries observed, actors have adopted BIM from their perspective to achieve firm, rather than necessarily project or client advantage, hence focus is mainly on planning and design activities, maintenance and operation activities. This means that we are far from a situation of full integration of the different actors involved in a construction project. BIM, at the current stage of adoption, has not become yet the integrated collaborative tool supporting both data interoperability and life cycle management.

Questioning the traditional “*way of doing things*”

More broadly, we can see that BIM challenges the traditional practices of coordination and couplings in the construction supply chain. As shown by Dubois and Gadde (2002), the construction industry is traditionally characterised by loose coupling between actors outside of any project (strategic level) and very tight couplings within a given project (project level) to adapt resources to the specificities of each project and construction site. This adaptation model contrasted with the manufacturing industry that evolved towards increased collaboration and standardisation at the strategic level to gain economies of scale and reduce costs. The introduction of BIM challenges traditional practices of on-site adaptations and lack of standardisation. BIM encourages pre-fabrication and introduction of standardised “*objects*” (e.g. bathroom modules in hospital or student housing projects). The power is shifted upstream in the design stage and the construction site becomes more and more standardised with little room for change. The construction manager and his team will focus more and more on “*quality, security*” and optimisation aspects rather than on purchasing, redesign and adaptations on site of the project: changing the role of construction manager with less rooms for manoeuvring and adapting the project leading to a focus more on perfect execution and cost and time optimisation.

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WHEN BIG VISIONS MEET THE PRAGMATIC PRACTICE - FOLLOW THE INSTITUTIONAL LOGIC OR PERSONAL BENEFITS?

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In recent years Building information modelling (BIM) has been considered as a means for transforming the building and construction industry by introducing significant changes in the industry for all stages of the construction process. However, when new technologies are promoted they are almost considered as a magic bullet that should transform an industry, or an organization to the better. By drawing on the concepts of institutional logics and sense making, and a case study over 12 years of telemedicine use in a Swedish county, the objective of the paper is to analyse what actors in the building and construction industry can learn from other societal sectors implementing and using new ICT. It is concluded that the use of technology is heavily shaped by significant actor groups' sense making of the technology, that is grounded both an institutional logic and what benefits or disadvantages the group perceive from technology use. What can be learnt from the telemedicine case is the importance of analysing underlying reasons to why an application is accepted or not.

Keywords: BIM, sense making, institutional logic, telemedicine, implementation.

INTRODUCTION

Building Information Modelling (BIM) is claimed to be one of the most promising developments in the AEC - industry by introducing significant changes in the industry for all stages of the construction process (see e.g. Eastman *et al.* 2011). The belief in BIM as a means for increasing efficiency in the industry is for example expressed by governmental initiatives in countries like Great Britain and Sweden. However, in literature and practice information and communication technologies (ICT) are sometimes considered to possess an inherent transformative capacity that should change industries and organizations to the better. The technology is almost seen as a magic bullet that should solve a wide array of problems and transform an industry, or an organization (Markus and Benjamin 1997). But predicting how technology would shape society and organizations has through the history proven to be a difficult. In research it is well known that it can be a slight or significant shift in ICT's role and function in concrete situations of technology usage, compared to the planned, pre-defined and assigned objectives and requirements, irrespective of who plans or defines them (Ciborra 1996). Reasons for this technology drift are for example: knowledge development, organizational members learn more about a technology's features and its fields of application over time (see e.g. Orlikowski 1996); a heterogeneity among actor groups sense making of a new technology, which in turn shapes the use of

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technology. For example are various interpretations of BIM already existing? Aranda-Mena *et al* (2008) state that:

“For some, BIM is a software application; for others it is a process for designing and documenting building information; for others it is a whole new approach to practice and advancing the profession which requires the implementation of new policies, contracts and relationships amongst project stakeholders.”

Thus, the question can be raised how the unfolding of the use trajectory for technologies like BIM can be understood? In this paper the author will present findings from a case study of the introduction telemedicine (video conferencing systems) in a Swedish county that was followed for 12 years. The similarities between the two technologies, BIM and telemedicine, is the gap between the visionary thinking among technology advocates, and the sometimes messy practice in which the technology should be implemented and used. Even if the contexts for implementation are different, another similarity is the distribution of power. In health care, professional groups, i.e. physicians has a great influence over initiative these concerns them. The building and construction industry on the other hand is characterized by a fragmented distribution of power implying that it is a lack of a single authoritative force (Harty 2005). For example have site managers a great influence on what is going on in the construction site (see e.g. Dubois and Gadde, 2002). Accordingly, BIM and telemedicine are implemented in contexts where semi-autonomous groups influence the use of new technologies. Thus, the objective of the paper is to analyse what actors in the building and construction industry can learn from other societal sectors implementing and using new ICT.

ICT AND THE ORGANIZATIONAL CONTEXT

In order to understand adoption and use of ICT the importance of taking the organization, its context, and people affected by ICT into consideration has for a long time been recognized (see e.g. Lucas 1975). A further key to the understanding of ICT adoption and use is to analyse the processual and emergent nature of ICT-mediated change (see e.g. Markus and Robey, 1988). In this process peoples' sensemaking of a technology is an important component for the understanding of systems implementation and use (Griffith 1999). Information systems research has emphasised that (Orlikowski and Gash 1994, p. 175):

“...to interact with technology, people have to make sense of it; and in this sensemaking process, they develop particular assumptions, expectations, and knowledge of the technology, which then serve to shape subsequent actions toward it”.

The process of sense making is guided by the mental models, frames or schema of organisational members, organising and shaping their interpretation of organisational events (Porac and Thomas 1990). People's sensemaking process is hence limited to their ability to identify and bracket cues. Different people could in principle bracket different cues in a different situation and hence act differently. However, bracketing of cues is informed by participants' perception of their professional and organisational identity (Weick *et al.* 2005). Following the process of cues bracketing, participants relate the extracted cues to the repertoire of frames or certain institutional logics that participants hold (Jensen *et al.* 2009). Institutional logic can be understood as the organizing principles that underlie practices and belief systems within an institutional

setting, playing a powerful role in shaping individual's interpretations and legitimizing their actions (Scott, 2001). Scott (2001:41) commented that:

“Individuals do construct and continuously negotiate social reality in everyday life, but they do so within the context of wider, pre-existing cultural systems: symbolic frameworks perceived to be both objective and external, that provide orientation and guidance.”

However, important to note is that the impact of a meaning a group gives to a technology vary with their influence. For example have prominent individuals like executive champions, project leaders, or lead designers taken prominent roles in IT-mediated change processes (see e.g. Newman and Sabherwal, 1996), which makes it difficult to isolate the interpretive process from power and political processes (Markus and Björn-Andersen, 1987). Accordingly, significant actors groups who have an influence over an organizations dominating ideas (Normann 1975), can be assumed shape the sense made of a new technology and by that the future use.

METHOD AND CASE DESCRIPTION

The objective of the paper is to analyse what actors in in the building and construction industry can learn from other societal sectors when it comes to implementation and use of new technologies. The paper is based on a case of the introduction of telemedicine in a Swedish county, described in this section. In the discussion section, when references are made to the building and construction sector, this is based on studies presented elsewhere (see e.g. Jacobsson and Linderoth 2010) and informal discussions with representatives from the building and construction industry.

When the telemedicine case study was conducted, recommendations from Yin (1994) and Eisenhardt (1989) were followed and the empirical material was therefore collected from a variety of sources, including qualitative data such as semi-structured interviews, participant observations, meeting participation, and document analysis, and quantitative data consisting of records of frequency of use of the telemedicine in the studied organization. The data collection began with meeting participation and interviews. Meeting participated in were project meetings and meetings with equipment suppliers. In addition did I together with the project group participate in visits by four different equipment suppliers where telemedicine systems were demonstrated. The objective with the introductory data collection was to gain knowledge of organizational members' understanding of telemedicine with regard to a) for what specific purposes did they want to use the technology; b) how they wanted to use the technology; c) what did they want to achieve with technology use. Because the data collection began before project group members started to interact with the technology, and continued several years after the termination of the project, it is possible to analyse: 1) The original understanding held by project group members and other actors in the project context; 2) Discover how and if the understanding of the technology changed over time and if there is a changed focus on certain applications; 3) Compare the understanding of technology among social groups not involved from the outset, with the understanding social groups involved at the outset. To trace the underlying institutional logics shaping the understanding of the technology was first done in the analysis of interviews, because (Coffey and Atkinson (1996:80):

“...the analysis of narratives can provide a critical way of examining not only key actors and events but also cultural conventions and social norms.”

The data collection encompasses mainly two periods. During the first period between 1994-1999 a comprehensive case study of a telemedicine project was accomplished with the aim of uncover actors' expectations about the future use of technology and how the technology actually was deployed. In practice the project was divided into two-subprojects defined by the sites involved. The sub-project1 General Telemedicine (GTE) concerned communication between two health centres, one county hospital and one university hospital. The specialties involved were dermatology, orthopaedics and otorhinolaryngology (ear, nose and throat diseases). The second sub-project, telepathology (PAT), included pathology and cytology at the university hospital, and surgery and gynaecology at a county hospital. The data collection was undertaken during 1994 to 1999 (the equipment was purchased and installed in August 1996). Interviews were carried out on four occasions: in 1996, 1997, 1998 and 1999. In total 62 interviews were carried out with 32 respondents (physicians, politicians and managing directors of hospitals). Multiple interviews were conducted with 15 respondents. The data from second period encompasses seven formal follow up interviews (with physicians and the managers for the telemedicine support unit), on-going informal contacts, and access to a record containing data from 1650 occasions between June 2003 and January 2006 when telemedicine has been used. Each time the system was used, the part initiating an interaction needed to fill in some data before s/he could log off the system. Data registered encompassed: date, time, host (who initiate the interaction), connected (who has been contacted), duration of contact, comments and person initiating the contact. The 1650 interactions were first analysed with regard to frequency of consultations conducted at medical clinics and health centres. Then data was analysed with regard to task: clinical or administrative use; with regard to between which hierarchical levels consultations have been conducted: inter-regional, regional, county, or health centre. Finally, the data record analysed can be regarded as evidence of what the technology is used for with regard to who has used it, who has been interacting with whom, and for what purposes.

FROM VISIONS TO PRACTICE

Table 1 and table 2 can be seen as illustrations of what happened during the ten first years when telemedicine was introduced in the county. During the time of the GTE project, September 1996 – December 1998, 156 consultations were conducted between the health centres and medical clinics involved in the project. 55% of the consultations conducted were ad hoc and 45 % were pre-planned. The consultations from health centres to the medical clinics were distributed as follows:

Table 1: Medical clinics consulted by health centres

Medical clinic	Number of consultations
Ear, nose and throat diseases	44
Orthopaedics	41
Dermatology	47
Orthopaedics at County hospital 2	24
Total	156

A few years later another practice was established (table 2):

Table 2: Consultations between hierarchical levels, June 2003 and January 2006

Hierarchical level	Number of consultations	% of total
Hospital-Hospital, clinical	977	59%
Hospital-Hospital, other	18	1%
Hospital-Health Centre, clinical	357	22%
Hospital-Health Centre, other	105	6%
Health Centre-Health Centre	193	12%
Total	1650	100%

Contrary to the original ideas that ad hoc consultations from health centres to hospitals would be dominating, the majority of consultations became planned and were conducted between hospitals. What is worth to note is that use at the health centres and the departments of orthopaedics and ear, nose and throat diseases, involved at the outset, more or less faded away. Accordingly, the question can be raised: What happened between 1994, when visionary ideas for telemedicine was launched, and 2006 when another practice had been established? What happened on conceptual level is that actors extracted a mixture of cues, related them to their institutional logic and/or their daily practice, and took action.

The “*master*” cue is telemedicine's distance bridging features. This is, a cue that gives people an idea about the technology's core feature and its application in practice. In the first half of the 1990-ies, the major benefit of telemedicine use promoted in popular literature and practitioner conferences was the immediate access to medical specialists, regardless of the specialists' location. In the mid 1990-ies the author visited a number of telemedicine conferences where a standing item on the program was a medical specialist demonstrating a live session with one of his colleagues, usually in Tokyo or San Francisco. Telemedicine's distance bridging features were furthermore highlighted in the pioneering telemedicine projects in northern Norway (see e.g. Danielsen 1993). This region is similar to the studied county, sparsely populated with a number of health centres located more than 100 km from the nearest hospital. The understanding of telemedicine as a distance bridging technology was furthermore expressed in the overall goals formulated for the county's projects running between 1996 and 98. The goals, which can be seen as readymade cues, were to investigate to which degree telemedicine could: increase value for patients through access to medical specialists, without travel; support the development of competence in the organization; decrease the costs for the county; to investigate the long term effects that telemedicine may have on the structure of health care in the county.

The goals developed were broad enough to appeal to the actors concerned: patients, general practitioners, medical specialists, politicians, hospital managers, and tax payers. All interviewed: physicians, politicians and managing directors of hospitals shared the understanding of telemedicine expressed in the overall goals. In one sense or another it was possible to relate the bracketed cue to some core elements in varying actor groups' institutional logics. For example equal access to medical specialists, sharing of specialists' competence, and an efficient use of financial resources. But how goals would be reached was more unclear, even if the technical director was repeating at every project meeting that physicians needed to think about how telemedicine

should be used in their practice. One of the enthusiastic physicians stated that it was only the imagination that defined the limits, but the challenge was probably to convince the colleagues. Hence, the translation of the overall goals into practice implied that new cues would be bracketed and related to the institutional logic and daily practice.

When project group members visited technology demonstrations by equipment suppliers during the winter and spring 1996 a new cue was bracketed, to get instant access to medical specialists. Project group members realized that emergent, ad hoc, consultations would be of great value for both the general practitioner and the patient, instead of the previous idea of pre-planned consultations. A medical problem could be solved *“here and now”*. However, the idea of ad hoc consultations was not uncomplicated. A general practitioner enacted another extracted cue from the daily practice and stated before telemedicine was implemented:

“You understand rather fast, when you have tried to call the university hospital and get hold on a medical specialist, that this [telemedicine] will not function.....There must be a physician stand by, who you can call and who can walk to the room with the equipment.”

A hospital director stated that that telemedicine would hardly solve the problem of accessibility to medical specialists. However, by drawing on an existing institutional logic, the manager for the GTE-project meant that they had through the years learnt to manage incoming telephone calls from health centres, so they would probably learn to manage incoming telemedicine consultations. However, this opinion was not commonly shared among specialist. For example did the dermatologist in the project even view planned consultations as hassles in the daily operations for a few reasons. First, they did not have a telemedicine unit at their clinic. Instead they had to walk 400 m through the hospital to the video conferencing studio. Second, consultations initiated from health centres implied that medical specialists' interpretive power, to decide whether a patient should get access to specialist competence or not was challenged. Thus, the institutionalized roles and relationships between hospital- and primary care was challenged at its bottom line, especially by ad hoc consultations. Hospital care would become a service provider to primary care, which would be a radical re-thinking of roles and relationships. In an interview with one of the most enthusiastic general practitioner 10 years after the project started he did the following analysis of why ad hoc consultations faded away:

“Suddenly was the primary care coming and putting demands on the hospital care, to for example develop routines for managing incoming consultations from the primary care....or to develop services for the primary care”

Another bracketed cue that challenged the institutional logic was the absent patient. Some dermatologist feared that telemedicine use would imply a drain of patient flow to the clinic. This fear was grounded in the fact that financial compensation was based on the number of patients visiting the clinic, as well as research activities was depending on a continuous flow of patients. Moreover did dermatologists, as well as many other medical specialists interviewed, emphasize the importance of the physical meeting with the patients. A dermatologist stated that:

“....you need to touch, feel and smell the patient's skin and show that you don't think the skin is disgusting”

However, other medical specialists claimed that the physical presence of the patient could sometimes be overestimated, but they said that they would not speak out this opinion in front of colleagues. Thus, the present patient could be seen as an essential part in the creation of the clinical specialists' identity that became threatened by telemedicine.

Nevertheless, in the specialists' daily working situation, the presence of the patient was not non-negotiable. At the dermatology clinic the interpretive power was regained and alternative cues were bracketed. A new physician, who later became the head of the clinic, became responsible for telemedicine issues and identified a new application. She initiated a project investigating if telemedicine could solve staffing problems at the dermatology clinic at a district hospital 140 km away from the university hospital. The idea was that the nurse at the district hospital should take pictures of patients' skins, send the pictures to the university hospital where the dermatologist examined the pictures at the same time as s/he was in contact with the patient via telemedicine and further treatment was discussed. As the current situation was, the dermatologist departed by bus at 06.00 in the morning to the district hospital two to three times per week. At the hospital they meet and examined patients the whole day and in the late afternoon, they spent another two hours by the bus. This duty was rotating among dermatologists, but even if they got compensated with one day off, this duty was not popular. When finished, the project was considered to be a great success, as the dermatologists' discomfort with catching the bus at 06.00 in the morning was removed. No one involved complained about the fact that the patient not was physically present.

In the PAT-project the applications concerning ad hoc consultations also faded away. Arguments against the method was based on an institutional logic, but one reason was not rooted in the institutional logic. The application frozen section procedure is a pathological laboratory procedure to perform rapid microscopic analysis of a specimen and is most often used in ontological surgery. This is, a surgeon can get a rapid answer whether a specimen contains cancer or not. Even if surgeons interviewed were positive to the method, a number of arguments based on institutional logic were highlighted. The surgeons at the district hospital who should use the technology were sceptical if they could trust the answers, because the method was not scientifically validated. The method became rather soon validated scientifically by the manager for the PAT-project, and the results showed that there was no significant differences between the traditional frozen section procedure and diagnosing via tele-pathology. Concerns were also raised about how the patients would react if they were given the answer "*cancer*" half an hour after a specimen had been taken. The surgeons' felt a bit ambivalent, because no studies were known regarding patients reactions in these cases. The author was however informed by a physician, who worked with telemedicine in another county that studies existed, telling that the sooner a patient got the result of the analysis, the better it was, even if the result was negative for the patient. But discussing the coming treatment should be waited with. A few years after the first study, the author discussed an alternative explanation for the ambivalence among surgeons with some physicians and nurses. The idea was that if a test confirms cancer, the surgeon need more time to prepare mentally for giving the bad news, than the five to ten minutes they have from they got the answer of the analysis until they should give a patient the answer. Some physicians and nurses agreed with the idea, whereas some physician disagreed.

Another successful application was medical rounds, or medical conferences between medical specialists and laboratory specialists. In the PAT-project, pathology conferences between the clinic of gynaecology at the county hospital and pathologists and oncologists at the university hospital, was successful and became a part of the routine activities, and the application was adopted at another county hospital. One reason for the success, implicitly mentioned in interviews, was that all medical specialists had participated in these kind of activities and the most well-known, the radiology round had been present for more than hundred years. Another reason mentioned among pathologists and gynaecologists was the organizational routines established for facilitating conferences. For example, conferences were held at the same time, the same day in the week, and detailed routines were set up for how to report a case that should be discussed at the conference. Additionally was it important to engage medical specialists with the right competencies for the topics discussed, in order to provide the participating gynaecologists with a perceived value of participating in the conference. Moreover, at the outset conferences were used as a mean for gynaecologists' competence development, but after a year gynaecologists understanding of pathology conferences changed from that of a mean for competence development, to an integrated part of the operations. The manager of the department said that he sometimes heard gynaecologists discussing a patient case saying: *"Let's wait to the conference until we decide on further treatment."*

DISCUSSION

The objective of the paper has been to analyse what actors in the building and construction industry can learn from other societal sectors implementing and using new ICT. By taking the point of departure in the concepts of sense making and institutional logics, facilitated the identification of a flow of bracketed cues from actors' interactions with telemedicine in practice. These cues were related to parts of actors institutional logics, identity, and practice, and created meaning and guided further action. However, the influence of institutional logics weakened considerably if significant actor groups perceive that technology could solve some problem in the daily practice, or if technology was perceived to create considerable dis-comfort.

At the outset a *"master"* cue, the technology's distance bridging feature, is identified and further translated by technology advocates, conscious or not, into a number of bracket cues these are broad enough to be aligned with institutional logics of actor groups concerned, implying that a priori resistance is avoided. By drawing parallels to BIM, the question can be raised weather it *"exists"* a master cue for BIM? When saying that telemedicine is about bridging distance, people can rather easy get an idea about the technology's core feature, and imagine some practical application. But if the *"master"* cue for BIM is *"object based information"*, how does that make sense to people in an industry where problems and their solution should be on a very practical level (see Löwstedt and Räisänen 2014). Or, is BIM's master cue something that should *"introduce significant changes in the industry for all stages of the construction process"* (see Eastman *et al* 2011), how well received will such a cue be among contractors who strive for *"becoming to remain the same"* (see Löwstedt and Räisänen 2014)? Thus, by comparing the early introduction of BIM and telemedicine, telemedicine is launched as something harmless, whereas if the discourse on BIM is linked to construction practice, BIM might be perceived as something not *"concerns us"*, or even as something threatening. Thus, what is of central importance for the acceptance of an application is that a bracketed cue can trigger a sense a making process where the technology is seen as solution of some perceived problem, and/or is

aligned with the institutional logic. Clash controls can be seen as a bracket cue easy to make sense of and connect with an institutional logic, keeping the budget and time plan. However, when it comes to 4D- and 5D-BIM challenges might be greater. If the time plan is incorporated in the model (4D-BIM) and the plan should make sense for production managers, they need to have an influence over the time plan. However, this group might be difficult to mobilize because they are occupied with another project when the time plane would be outlined. An alternative would be to try to standardize the production process more. This might, however, be perceived as threat to the site managers semi-autonomous nature. Thus, applications these challenge significant actor groups' identity, like doing pre-surgery judgement via telemedicine, or requires re-organization of work processes, like managing urgent consultation in the telemedicine case, or strive for a far reaching standardization of the production process in construction, will not easily be accepted.

A central difference between telemedicine and BIM is that the former at the outset is embedded into the daily practice when applications are tested and experimented with. BIM on the other hand has from the outset more been a concern for a development department somewhere, or scholars testing different applications, these might be years ahead of practice. Thus, in these cases it will be very demanding to implement some BIM-application into a practice where actors want practical solutions to practical problems. On the other hand, in the telemedicine case, an application that is tested and accepted among the actors concerned can seamlessly become a part of work processes. A BIM-application tested in a project might have a potential, but when it should be implemented, there will be a new project with new actors who might bracket other cues than actors who tested the application.

CONCLUSIONS

The immediate conclusion is that the use of technology is heavily shaped by significant actor groups' sense making of the technology, that is grounded both an institutional logic and what benefits or disadvantages the group perceive from technology use. What can be learnt from the telemedicine case is the importance of analysing underlying reasons to why an application is accepted or not. In the case an application not might accepted in a significant actor group, an analysis of underlying reasons is needed, as well trying to find alternative interpretations these not are felt as a threat by the group.

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HOW DO TECHNOLOGICAL NICHEs EMERGE? A CASE ANALYSIS OF SERVITIZATION IN CONSTRUCTION

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It is widely recognised the design and operation of more energy efficient solutions within buildings will play a significant role in the wider global battle to reduce energy consumption over the coming decades. If the industry is to succeed in delivering high energy performing buildings in the future then it will require the implementation of a variety of radical innovations. One potential avenue is for organisations involved in the design and manufacture of building systems to find innovative ways of playing a more prominent role in enhancing the through-life performance of those building systems. It is here that we locate this study, with an in-depth case analysis of a construction firm that is transitioning toward the delivery of servitized solutions. We position the paper within the field of socio-technical transitions. These studies have highlighted the role technological niches play in socio-technical change. There is, however, a limited understanding of how technologies acquire the form and attributes of a niche. In this paper, ConstructCo's pursuit of a technological niche as they transition towards greater servitization. We trace this pursuit of a niche through three turns: the turn towards establishing a business need, the turn towards developing product intelligence, and the turn towards supplier development. The findings suggest that technological niches emerge as constellations of different technologies develop in parallel in different projects. Secondly, that by developing radical through-life solutions organisation seek to acquire greater control of the nature and direction of sustainable transitions. Finally, by unpacking different interactions between multiple actors involved in the pursuit of niches we offer fresh insights into the costs and contradictions involved in making sustainable transitions within construction.

Keywords: mechanical and electrical products, servitization, technological niches, transitions.

INTRODUCTION

The building sector is responsible for approximately 40% of total energy consumption in the EU (European Commission 2008). Thus, increasing energy efficiency within buildings will play an integral role in the global challenge to reduce energy consumption. Looking forward this will require the emergence of new energy-efficient solutions that radically challenge existing socio-technical regimes within the construction industry (Rohracher 2001) (Quitza et.al, 2014). Traditional boundaries between design, construction, maintenance and operation, as well as predominantly capital cost-driven procurement routes, represent just a few of the numerous barriers facing radically new innovations in the industry. Organisations within the industry

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will be required to re-examine their existing business operations and actively pursue the design and development of innovative solutions that enhance the ongoing energy performance of building systems. To unpack this challenge, we position our enquiry in the context of the growing debates surrounding sustainable transitions (Geels 2002) (Schot and Geels, 2008). These studies found that sustainable transitions are stimulated by radical innovations which breakthrough in niches. A niche is a protected space where a radically new innovation is offered the opportunity to develop in isolation from wider market conditions in selective market, cultural, technological and geographical environments (Kemp et al 1998). The studies suggested that sustainable transitions are brought about as niche innovations emerge due to instability in existing socio-technical regimes (Geels, 2005). The studies have taken on particular significance in policy studies where ongoing work explores the role of developing appropriate policies to protect and empower niches during the management of sustainable transitions (Smith and Raven 2012) (Schot and Geels, 2008). The socio-technical transitions studies offer a suitable perspective for policy studies because of their ability to examine the wider and longer term picture (Geels 2011). However, by placing the emphasis on understanding the wider perspective, there is an underlying tendency to over-simplify the micro-processes included in niche formation and development (Shove and Wlaker, 2010) (Smith et al 2010). Research into niches as sources of radical innovation can be enhanced by paying greater attention towards the role of specific organisations in influencing the formation and emergence of niches. We purposively avoid taking a niche as a starting point because it offers the opportunity to retrospectively simplify the complex dynamics and multiple contradictions at play as new technologies acquire the form and function of a niche.

Therefore, the purpose of this paper is to examine how and under what circumstances do organisations pursue technological niches when transitioning towards greater servitization. To do so, we focus more explicitly on how the visions and goals of organisation actors interact with the wider selection environments to influence the motive to finance and protect the development of certain technological innovations. Case analysis unpacks a construction firm's pursuit of a technological niche in the context of their motivation to develop more servitized ways of operating. Existing research (Tukker and Tischner, 2006) suggests that by shifting their attention towards the through-life performance of the systems they design and deliver, there is the potential to develop new ways of increasing the on-going efficiency of their assets and collaborating with end-users to reduce energy consumption patterns. We observe how they explore integration of several technological innovations into one niche space as they pursue more servitized operations. Our findings indicate that the development of radical innovations is beyond the control of one organisation and that our case organisation's pursuit of a technological niche was being framed by their continuous interaction with supply chain partners and reactions to customer demands. We also observe that constellations of technologies that gather momentum and backing separately can combine and complement each other to stimulate emerging niches. Furthermore, that the costs of implementing radical innovations were multi-layered. Therefore, the contribution of this article is two-fold. Firstly, that by elaborating on the development of visions and goals within certain organisation we can better understand the complex dynamics that play out as technologies acquire the form and function of a niche. Secondly, we elaborate on how a multi-level approach is required to deconstruct in greater detail the multiple interactions at play as firms in construction pursue more servitized ways of working.

SOCIO-TECHNICAL TRANSITIONS

The socio-technical transitions literature advocates that radical innovations emerge in niches (Schot and Geels 2008) (Kemp et.al 1998). Niches are depicted as being incubation rooms for radical novelties that are insulated from normal market conditions within protective spaces (Schot 1998). Geels (2002) introduces a multi-level perspective to enhance our understanding of how radical innovation within niche spaces can stimulate wider sustainable transitions. The emergence of these niches is understood as being dependent on the interplay between three different analytical levels: technological niches, sociotechnical regimes and sociotechnical landscapes (please see Geels (2002) for clarification of what these levels consist of). Changes at the landscape level are understood to trigger instability within existing socio-technical regimes which creates opportunities for emerging niches to breakthrough. Geel's draws upon the transition from sailing ships to steamships 1780-1900 within the shipping regime as the basis for his first study. The retrospective study found that the emergence of the steamships could be traced back to the development of a niche. The niche consisted of small wooden vessels using low pressure steam engines whose development had been stimulated through a range of macro and meso factors. This most prominently included the emergence of inland waterways during the canal boom (Geels 2002). Subsequently, similar retrospective studies have explored how the emergence of niches has triggered socio-technical transitions (Geels, 2005) (Verbong et.al, 2008). Subsequently, the concept of niches has been used to look forward and explore the implementation and diffusion of sustainable solutions (Smith 2005).

Whilst using niches as a means to examine the breakthrough of radical innovations has become increasingly popular, commentators maintain that greater attention needs to be paid towards the interdependencies and interactions between internal niche processes and external processes as niches develop (Raven 2005) (Smith 2007). Early research suggested that the successful emergence of a niche was dependent on three main internal processes: articulation and adjustment of expectations or visions, the breadth and strength of the network of social actors enrolled and learning and articulation process (Geels 2011). Raven (2006) suggested that the likelihood of niche innovations breaking through is dependent on the comparative stability of emerging niches and existing regimes. Smith (2007) analysis of the niches eco-housing and organic food illustrated that the translation of niches into regimes is a reciprocal process. Subsequently, a typology for depicting different pathways for socio-technical transitions brought about by niche innovations has been developed which are identified as: transformation, de-alignment and re-alignment, technological substitution and reconfiguration. By constructing these different typologies they acknowledge the need to shift away from a niche-driven bias and illustrate how the timing and nature of multi-level interactions conditions the pathways of transitions. Verbong et.al (2008) explored the relationship between parallel emerging niches within the Netherlands (solar PV, biomass and wind energy) and found that the breakthrough of one niche is dependent on the momentum surrounding parallel niches.

Understanding niches as opportunities for sustainable innovations has provided commentators with a tool to understand socio-technical transitions from a wider and long term perspective (Schot and Geels, 2008). However, it is by taking this more distanced view (Shove and Walker, 2007) that a tendency is developed to neglect how specific organisation are implicated by these transitions. Consequently, there remains a paucity of research depicting how organisations can develop new ways of delivering sustainable solutions (Shove and Walker, 2007) (Berggren et.al 2015). Indeed much of

the research on niches focuses on informing policy about how radical innovations can be constructed, protected and maintained (Shove and Walker, 2010). In this paper, we argue that greater attention should be paid towards how visions and motives towards more sustainable operations emerge within organisations. In doing so we can build upon the sustainability transitions literature by shedding greater light on how and why firms re-configure their processes towards radical innovations in niches. With this in mind, we do not take a ‘niche’ as our starting point but rather the “*pursuit of a niche*” becomes our route of enquiry.

RESEARCH SETTINGS: A CASE STUDY OF CONSTRUCTCO

The analysis presented in this article is drawn from a single case study of ConstructCo, a major contractor in the UK formed in 2001, with historical roots stretching back to 1848. ConstructCo has since expanded its operations beyond the UK to cover international markets in Canada, Europe, the Middle East, Asia and Australia. It is well-known for its role in delivering high-profile iconic projects. Access to study this transition was granted in earnest in December 2012.

Case Context

In this study, our research concentrated on the department within ConstructCo that focused specifically on the design, manufacture and installation of mechanical and electrical systems. In its quest to grow and diversify its revenue streams, they had embarked on a strategy (and emergent journey) of servitization. Our research team observed closely as they explored ways in which they could develop through-life solutions for the systems they deliver. Their emphasis was shifting away from selling products towards delivering value propositions geared around selling their customers the use and performance of their products. For example, rather than selling their customer a boiler system, they sell them the availability of heat to specific areas of the building. Existing research (Tukker and Tischner, 2006) (Mont 2000) indicates that by taking a view to take responsibility for the ongoing performance of their systems through-life they can radically reduce the emissions associated with those systems. They can do this by optimising the ongoing performance of their assets and developing innovative ways to influence their customers' usage processes. Shifting towards delivering these through-life solutions is requiring the firm to radically re-evaluate their business operations. Central to this process is the development of new technological properties within their mechanical and electrical products. Indeed, evidence from other industries suggests that transitioning towards greater servitization often requires significant technological change (Lay et.al 2014) (Wise and Baumgartner, 1999) (Vandermervé and Rada, 1988) (Mathieu 2001). We observed within the company and across their value chain that new innovations geared towards greater modularity, greater embedded intelligence and remote monitoring capabilities were becoming increasingly available. However, the challenge of integrating all these innovations, which were located within different supply chain actors into one radically new through-life solution still remained a huge challenge. One way in which they were seeking to overcome this challenge was by actively seeking out specific markets and specific technological offerings in which they could integrate all these innovations into one servitized offering. Therefore, for the purpose of this paper we explored how and under what circumstances they were pursuing this potential niche.

Data Collection

The case study research was informed by two phases of data collection and analysis. The first phase involved an exploratory set of interviews (n = 24) with a range of key personnel in ConstructCo. The purpose of the exploratory interviews was to elicit perspectives from these interviewees regarding their experiences, highlights and challenges faced in their everyday routines. Because we wanted to capture perspectives that were relevant to the central theme of servitisation and technological change, we deliberately selected interview participants who were enrolled by selected mechanical and electrical technologies. This proved an invaluable phase for the research team to quickly enter the field as relative outsiders. The second phase entailed following a live hospital project. This yielded, to date, a further set of 17 interviews with participants directly involved in this hospital project. Additionally, follow-up interviews (n=10) with manufacturers and suppliers of technological solutions associated with ConstructCo and/or the hospital project were also undertaken. The interviews were supplemented by a range of other data sources, including non-participant observational notes developed by the research team, visual representations of the materials and technologies used on the project (e.g. schemes and drawings), and other forms of textual data (e.g. project documents, technical specifications, email correspondence etc.). This provided a rich set of data to help in piecing together a fuller picture of ConstructCo's journey towards greater servitization. The field notes and documentary evidence also allowed us, to a degree, to corroborate the claims made by our interviewees. Interviews were audio-recorded and transcribed verbatim.

Data Analysis

At the end of each interview, the interviewer would reflect on the interview and record, using interview summary sheets to identify key emerging themes that are striking from each interview. The transcripts were then read and reviewed by the two authors, and discussions ensued such that analytical categories would inductively emerge. From our different data sources, we observed that three turns were apparent as the organisation were pursuing a niche for greater servitization. These turns were: establishing a business need, developing product intelligence and embarking on supplier development. For the purpose of this paper we analysed our transcripts to explore how our interviewees' everyday practices were changing in reaction to these three turns and ways in which they were questioning the implications of these turns on their own everyday practices.

FINDINGS AND DISCUSSION

In this section, examine how ConstructCo is pursuing a technological niche in engineering greater servitization. We present this transition through the three turns identified above. It is critical to note that these turns are not necessarily sequential; rather, the turns happen simultaneously.

Turn 1: Establishing a business need

ConstructCo's transition to greater servitization had at least two starting points, both relating to the need to respond to and drive consumer demand. By the time we entered the field in December 2012, ConstructCo was emerging from the fallout of the global financial crisis. The construction industry in the UK had seen its output fall by 8% in 2012 (see Construction News, 8 March 2013). This was exacerbated by ever-tightening public sector budgets. ConstructCo were keen to explore how they could

shift away from these product-dominant practices by leveraging ideas about servitization from other industries. Furthermore, there was a growing need for consumers to reduce the cost associated with energy consumption. This in turn created an opportunity for ConstructCo to look more seriously into servitising their mechanical and electrical product offerings.

As one of ConstructCo's Design Managers interviewed remarked,

“So we are in the building industry, we are still years away. So it’s not only the automotive and aerospace probably in terms of monitoring and maintenance – predictive maintenance – I think we should look also to the supermarket and retail sector”

Another interviewee, a Construction Process Engineer, refers to the fact that in doing so they can capture and conceptualize new management opportunities to pursue greater opportunities within the product aftermarket:

you’ve got so much certainty around that that if your building diagnostics and everything else you are lining yourself up to delivering a long term service and we will have that capability going forward.

We observed how ConstructCo's motive of diversifying their revenue streams and surviving in a competitive but financially-constrained environment play out. We saw how ConstructCo actively sought to identify equivalence from other industries, learning from a diverse range of other industries including retail, automotive and aerospace. Indeed, as the aerospace sector is generally well-known for leading in the area of servitization, ConstructCo deliberately sought to recruit senior executives and engineers from that sector, in the hope of accelerating developments of their own model of servitization. This turn towards other industries began to raise new questions for ConstructCo, including exploring equivalence in the technological space (e.g. comparing aircraft engines with turbines in boilers) and trying to unpack similarities in terms of life cycle performance and critical components. Other forms of establishing equivalence included the need to alter the rules of engagement between ConstructCo and the clients. Comparisons were often made between the construction sector and the automotive and aerospace sectors to see how contractual obligations ought to change towards performance guarantees for different M and E technologies. Thus, in establishing a need for a technological niche, ConstructCo actively turned to learning from how other sectors transformed their operations through developing new tools (or technological devices), new rules of engagement, and new communities of practice, geared towards increasing the reliability and efficiency of their products.

Turn 2: Developing product Intelligence

The turn towards learning from other industries revealed to ConstructCo the need for developing new knowledge and competences. More specifically, there was a need to create new product intelligence that was not required before within a product-based way of working. This new intelligence related to understanding performance envelopes and interfaces between design, manufacturing, and maintenance. A service-based way of operating required deeper understanding of how mechanical and electrical products were used, and how the products were themselves interacting with one another within the services system. We observed how ConstructCo were now trying to answer these new questions by investing in a whole range of new activities, including capturing asset information through building information models, interrogating performance envelopes (e.g. through technical data sheets, historical

models and datasets, facilities management helpdesk records etc.) more carefully to consider how new maintenance regimes would work, and integrating new technological products such as pressure, temperature and flow sensors. Thus, we see how developing the technological niche demands the incorporation of yet new specialisms (e.g. BIM modellers) and new devices (e.g. sensor technologies). In turn, these new models, devices and competences enabled the existing ConstructCo staff to change in their thinking. As the Lead Mechanical Engineer interviewed noted, the use of these new sensor technologies stimulated the need to deepen his understanding of their products. He was no longer thinking in terms of systems but deconstructing how things work at a component level:

“So then the big challenge is understanding the physics of failure”

Throughout our case study research, we see the creation of new spreadsheets and new ways of coding data within ConstructCo as they attempted to get closer to understanding the physics of component failure. Yet, this creates the information paradox; that is, there is now so much data that it requires more people and intelligence to analyse the data and do something with this analysis. Thus, we find Engeström's framework useful again to unpack the turn towards developing new product intelligence. The realisation of the need to develop new technological devices raises new questions about how products are used and how products interface with one another at both a system and component level. This again enrolls new actors (e.g. BIM modellers) and new rules for recording technical data not only of the product but also of its use. This in turn calls for the embedding of new sensor devices. It is the embedding of new sensor devices that ConstructCo has to also turn to developing its suppliers.

Turn 3: Embarking on supplier development

“No. I think the supply chain for the construction industry is not ready for that. So if you buy, you know, a clamp for an injection system of a car then you know, because they are used every time BMW buys a part, they want to know a lot of stuff; like a medium time between failures, you know, they want to know everything. But we are not used to that level of detail in the construction sector.” (Lead Mechanical Engineer)

In developing a technological niche that would help in ConstructCo's transition towards greater servitization, we have previously described how they turn externally to the marketplace, and how they turn to reflect internally on their (lack of) intelligence. This involved the need to capture new forms of data and data modelling, facilitated by the use of sensor technologies to help ConstructCo better predict failure. To accomplish this requires ConstructCo to turn towards their suppliers. But, there are hurdles in this respect. As an interviewee working for a chiller manufacturer noted, sharing of knowledge between suppliers and ConstructCo can be difficult, especially where failure rates are concerned.

“The thing I think our factories do have, is failure rates for some of the key components, but yes I don't think our factories are going to want to give that.”

Nevertheless, we have also observed instances where ConstructCo collaborates with their suppliers to develop new technologies. Here, we hear of how a long-term partnership between ConstructCo and a boiler manufacturer facilitated the desire on both sides to develop a new 'intelligent' boiler:

“This is a good point. The secret is in long term relationships. So with [these suppliers], we had dozens of meetings with them because they are now our preferred supplier. So we can do some co-design. They tell us their new developments, so they tell us, “Oh, in two years I am going to launch a new boiler.” So, “Oh, interesting; so can you add this feature because it’s interesting for us?”

Therefore, using Engeström's Activity Theory framework, we can see that ConstructCo's object of developing more intelligence has resulted in the need to have meaningful conversations about embedding technologies like sensors within the products offered by their suppliers. This can be challenging given the short-termism and fragmentation that typically characterises the construction industry. But, by adjusting the rules of engagement - through incentivising long-term partnerships in the case of the boiler manufacturer - we can see how this can pave the way for greater collaboration and co-production of technology between ConstructCo and their suppliers.

CLOSING THOUGHTS

The reduction of energy consumption within buildings over the next 20 years will continue to play a prominent role within the global drive to reduce energy consumption and carbon emissions. There will be increased scrutiny on organisations to deliver radical innovations geared around energy efficient solutions. The socio-technical transitions literature indicates that radical innovations often breakthrough in the form of technological niches. However, because these studies take a more distanced view they often underplay the complex micro-level dynamics at play during the formation of niches. Therefore, in this paper we propose a different approach. Rather, than taking increased technological complexity, increased technological intelligence or a new technological niche as a starting point for conditioning greater servitization, we subtly change the focus towards analysing what happens within an organisation as they pursue the development of a technological niche. We have drawn upon extensive research with ConstructCo, a supplier of mechanical and electrical products, to unpack the interactions and developments that take place within the organisation as they pursue a technological niche when they transition towards the delivery of servitized solutions. Servitized solutions offer the potential to develop new revenue streams as well as reduce the consumption levels of their customers. We observed that during ConstructCo pursuit of the development of a new technological niche that three main turns (a new business need, developing product intelligence embarking on supplier development) were increasingly conditioning new processes and new relationships within the organisation. By tracing how events unfolded as they pursued a niche we unpacked new dimensions of complexity with respect to the multiple costs that organisations face when they implement radically new innovations. Furthermore, we observed how the pursuit of radical innovations was underpinned by an aspiration to proactively steer the pathway of sustainable transitions by taking greater control of consumption processes. We recommend that research must pay greater attention towards the role that specific organisations play in socio-technical transitions. In doing, so we can shed greater light on the interactions and contestations that play out during the formation and development of niches innovations in construction. This will allow future studies to add a new dimension to existing sustainable transition studies when conceptualising niches as a source for radical change.

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DIGITAL INNOVATION IN CONSTRUCTION: EXPLORING THE FIRM-PROJECTS INTERFACE

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This paper reports on an in-depth qualitative study of the diffusion of digital innovation in a large UK engineering firm. Previous research in the diffusion of innovations in construction emphasises either projects or the firm with little attention to the interface between the firm and its projects, and the effect of this interface in diffusion processes. This research however employs a contextualist process approach which accounts for more than the individual choice, and considers non-linearity and iteration within the chronology of a diffusion process. The findings of this research provide a case for learning and capabilities development for BIM across the firm through strategic technology group which the firm mobilised to provide innovation championship and digital leadership. It also captures important tensions and challenges at the interface between the firm and its projects, which are largely related to the need for standardised processes across the firm to achieve repeatable solutions, and at the same time being able to meet the unique requirements of specific markets and projects. The implications of these findings in practice and in research in the diffusion of innovations in construction are discussed.

Keywords: BIM, diffusion of innovations, digital innovation, project-based firms.

INTRODUCTION

The advantages of the flexible and informal form of project-based organisations to innovation have received considerable attention in organisation and management literature (Galbraith 1971, Mintzberg 1983, Teece 1996, Hobday 2000). However, this project-based nature of organisation also poses challenges for diffusion especially with regard to learning, knowledge transfer, and capability development over time and space.

While learning and accumulating knowledge is a critical component of innovation implementation and consequently diffusion, it remains problematic for project-based firms. Lessons learnt in projects are often lost as they are not automatically incorporated into the firm's business processes. Instead, this knowledge remains tacit across different individuals (Reichstein, Salter and Gann 2008). Understanding the organisational conditions and norms which influence learning and knowledge transfer in project-based firms, and subsequently impact the diffusion of new innovations, is critical, as is the nature of the knowledge creation and transfer between construction projects and to the firm.

In the construction management literature, construction projects as temporary project-based organisations have received considerable attention (Morris and Hough 1987, Flyvbjerg, Bruzelius and Rothengatter 2003, Davies, Gann and Douglas 2009, Gann *et al.* 2012). And construction firms' organisation and innovation have attracted similar

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attention (Sexton and Barrett 2003, Dodgson, Gann and Salter 2005, Barrett and Sexton 2006). However, less is known about the interface between the firm and its projects. Therefore, the purpose of this paper is to explore the diffusion of innovation within the project-based firm at the interface between the firm and its projects, with specific focus on digital innovation because of its rapid diffusion within the industry due to government discourse. The aim is to understand how the firm mobilises resources and builds capabilities to diffuse digital innovation, not only between projects but also between projects and the firm.

LITERATURE REVIEW

Within the construction's "*complex web of contractual and managerial relationships*" (Mike and Nick 2001: p 339), learning and knowledge transfer are influenced by the transient and multidisciplinary nature of projects. While major infrastructure projects are themselves considered temporary organisations they are embedded in more permanent contexts. These permanent contexts vary from organisational units, organisations, inter-organisational networks, and organisational fields (Sydow, Lindkvist and Defillippi 2004). The tension is always between the performance demands of current projects, and the knowledge and learning carried to future projects or as Sydow and his colleagues discuss: "*coordination within and across organisations is often critical for ensuring, for instance, that knowledge gained in particular project is stored for use in other projects or that project routines are improved over time*" (Sydow, Lindkvist and Defillippi 2004: p 1476).

Two streams of research are found in the literature to address the issue of project-based learning: In one hand there is a body of research that is concerned with the codification of knowledge through tools and digital systems which are reported to have limited success in solving the problem of knowledge sharing and learning within project-based firms in practice (Newell 2004). Scholars also argued that "*there is no single model for managing technical support and R&D in project-based environments*" (Acha, Gann and Salter 2005). This is attributed to the focus of the knowledge codification studies being only on the outcomes rather than the dynamics of the knowledge management and learning processes itself (Prencipe and Tell 2001).

On the other hand there are studies which address the management and integration of knowledge within and across projects and teams through investigating learning mechanisms, this research highlighted important issues: First, The firm develops new capabilities across different organisational levels (strategic, project and operational). And learning for new capability development follows a two-way path that is a mix up of top-down strategy exploitation and bottom-up exploratory learning (Gann and Salter 2000a, Brady and Davies 2004). Second, the firm mobilises its resources between projects and the firm to develop new capabilities to gain competitive advantage, the new capability development process entail adaptation and change in the firm meaning that an integration capability has the potential to improve learning (Davies and Brady 2000, Brady and Davies 2004). And third, the differences between project processes and the firm business process lead to a double-edged effect for project-based learning which result in learning boundaries between projects and the firm (Scarbrough *et al.* 2004).

These issues shed light on some of the complexities of the project-based firm as a context for innovation and learning. However, it falls short of explaining the dynamics at the interface between the firm and its projects, and the integration processes between the different markets and sectors within one firm. Moreover, the growing

research in digital innovation in project-based firms to date has tended to either focus on major projects and networks (Boland, Lyytinen and Youngjin 2007, Harty and Whyte 2010, Whyte and Lobo 2010) rather than one project-based firm which is engaged in multiple infrastructure projects, or, cross-sectional comparative studies of groups of firms (Gann and Salter 2000b, Brady and Davies 2004, Dodgson, Gann and Salter 2005), which only provide a snapshot of the innovation process at a specific time. The research presented in this paper seek to present a diffusion process which account for both the firm and its projects, drawing from an in-depth, interpretative and contextual approach..

METHODOLOGY

The findings presented in this paper are based on an in-depth process research in diffusion of digital innovations in a large UK engineering firm conducted over four years (see (Shibeika 2014) for more information about the research method). The data is particularly drawn from observation of meetings of a technology group, which was set up in response to the UK government strategy to require BIM 'level 2' in its role as client on major projects by 2016 (Strategy 2011), also it was a recognition of the firm's UK strengths in digital delivery.

Observation is useful source of data, it provides first-hand and rich knowledge about the organisational phenomena under study (Lee 1999). The primary advantage of observation is that it provides behavioural and environmental evidence for complex interactions within the natural setting of the research (Marshall and Rossman 2006, Yin 2009). Despite its usefulness for building theory from case study research, observation techniques are underutilized in management research (Lee 1999). This is attributed to its labour-intensiveness and time consuming nature.

The first author observed technology-focused meetings between November 2012 and April 2013 which was part of a strategic initiative to diffuse BIM across the firm. The researcher attended those meeting as part of the firm, and was introduced as a researcher supported by the company to investigate technology use and management which would result in writing a case about the firm. This enabled note-taking with few opportunities to express the researcher's view of the technology and its diffusion when asked.

In this research, narrative was used as a primary analytical tool to capture important events related to the diffusion of digital innovation in the firm, and to reveal the underlying logics that give events meaning and significance (Pettigrew 1990). Constructing detailed stories from raw data is an analytical strategy well known for process studies, especially those in innovation, organisational change and strategic management (Pettigrew 1990, Van De Ven and Huber 1990, Van De Ven and Poole 2005, Langley *et al.* 2013). It is also a primary tool for contextualist investigations(Pettigrew 1990).

THE TECHNOLOGY GROUP MEETINGS

The membership of the technology group under study included technical directors from various market sectors within the firm: water operations, rail, airport planning, highways and bridges, tunnelling and earth sciences, commercial facilities, geospatial, and business economics. The group meet every month to discuss the firm's evolving BIM strategy. The group was supported by UK Regional Director, operating within the UK with the aim to pilot activities that will be extended to other regions in the future. The meetings lasted 2hours and 20 minutes on average, and involved the 10-

13 participants from different regional UK offices as well as the US head office. Professionals from a collaborating firm, technology developer, technology consultancy firm were also invited to three out of the five meetings.

In the first meeting, the scope of the technology group's activities was outlined. The agenda included the firm's involvement with major UK projects that are pioneering BIM, collaborating firms, and active industrial bodies involved on BIM standards development. Documents circulated before the meeting included a presentation by a technology director, which was presented to the firm's senior management team earlier in 2012. It introduced the concept of BIM and highlighted business benefits of adoption. A BIM white paper by a long term collaborating technology training and consultancy provider was also circulated by e-mail before this meeting.

In the second meeting, BIM market sectors' positions were identified through discussion on the feedback by each market sector on their current BIM situation especially in regards to current BIM projects, major clients requiring BIM, drivers, challenges, benefits and considerations within each market sector. A presentation by the firm's US headquarters was also given through video conferencing, and the firm's BIM leaders across the globe were introduced to each other. Documents circulated by e-mail in advance of the meeting included a presentation by a major BIM technology provider about the concept of BIM and its application on infrastructure projects, presentation on BIM application on a major UK airport terminal project, and overview of the firm's software training as a result of a global licensing agreement with a major software provider.

A collaborating firm was invited to the third meeting; their BIM manager demonstrated a BIM portal. This presentation generated discussion and questions about the benefits and challenges for designing such portal. Documents circulated in advance to this meeting were: presentation by the firm's Digital Delivery Director to the US headquarters on the opportunities for BIM roadmap for the firm, and a report on the outcomes of a BIM workshop for a major UK rail project with which the firm is engaged.

The fourth meeting focused on a presentation from the rail sector on their market sector's BIM journey, and the highways and bridges market sector's BIM roadmap. The group compared and contrasted these two presentations and discussed how the market sectors within the firm can learn from each other. Also a document for the standard use of a software package for highways and bridges was presented and discussed. That document was developed in collaboration with the firm's technology training and consultancy provider. Documents that circulated by e-mail in advance to this meeting were an industry report on the business value of BIM in North America and document outlining the firm's BIM vision for a new major underground station project.

A major BIM software provider was invited to the fifth meeting to provide up to date information on data management technology. The meeting also discussed the feedback from the group presentation to the firm marketing directors on the value of BIM to the business. The documents associated with this meeting was the recent UK standard, PAS 1192-2, and the Construction Industry Council (CIC) guidance on BIM and professional indemnity insurance when using BIM.

In addition to the technology group meetings, the firm hosted an industry event for BIM in April 2013, which involved presentation by the firm's Digital Delivery Director and discussion with wide range of firms representing different construction

companies, software providers, major projects organizations, and academic institutions. This director presented the firm BIM history and introduced the technology group and its activities.

FINDINGS

The activities of the technology group highlighted important issues related to the diffusion of digital innovation in the firm. These issues were concerned with internal processes of learning and exchange of ideas and knowledge among the firm's different teams, and external processes of knowledge transfer to the firm from collaborators and industry bodies. Furthermore, the analysis of the technology group meetings revealed the role of the group as focal in the firm and also showed that the group activities involved knowledge brokering to develop new digital capability for the firm. There were three distinct and interrelated mechanisms for learning associated with this firm-centred imitative:

Capturing existing competencies for BIM

The data shows that the meetings of the technology group were seen as a forum to exchange BIM knowledge across diverse projects and clients within the different market sectors of the firm. This is particularly evident on the interaction and the circulated documents in relation to developing shared and contextual understanding of BIM through reporting on motivations for and challenges of BIM delivery across the firm market sectors, capturing existing digital competencies which can be developed into BIM competencies, and sharing lessons learned and best practice from leading practice areas and exemplar projects to inform new competency development.

The main challenges faced the newly formed group were the diverse interpretations for BIM by the different clients, and the varied requirements and competencies for BIM by the various market sectors. The first task for the members of the group was to outline their markets' BIM positions by identifying each market sector client's needs, current BIM projects and capabilities, and to develop generic as well as market sector specific roadmaps for BIM strategy and project execution plans.

The presentations by three market sectors within the firm in the fourth meeting, and the report by the associated director of the Business Economics sector on the market position for his sector showed that there were rising numbers of clients requiring BIM, but at the same time, there were some clients who are still unaware of BIM, at least as a term. This highlight challenges for managing clients expectations. Another issue was the suitability of BIM to all types of projects. For example the Water Director expressed his concerns that the projects his market sector is engaged with are small compared to transportation projects for example. This shows that BIM can't be diffused as a simple product or process, it rather need to be scaled up or down depending on the market sector and the projects.

The group members' also discussed existing digital competencies within their market sectors. For example in the second meeting the airports practice area representative expressed that "*we model passenger movement in airports but we don't give these models to our clients*". This shows that this market sector despite being seen as less advanced is in fact capable of providing visualisation techniques to their clients; this can be considered as a BIM competency which the firm can strengthen and market as a BIM capability. To capture similar competencies, the highways group started with a web survey about current BIM software and skills within their sector, the survey targeted the various skills groups' discussion forums within the firm's intranet.

Exemplar projects across the firm's portfolio were discussed during the group meetings to highlight benefits and challenges of BIM and to capture lessons learnt. One particular example of the knowledge sharing activities within the technology group is the presentation by the Rail Director in the fourth meeting to share the rail sector history of using BIM from 2007 to 2012 showing how digital capabilities grew and evolved over time through project work and despite the hesitance by some clients, and the lack of suitable resources at the start. The rail group currently considered as one of the hot-spots with regard to systems and processes for BIM, this presentation has provided a learning opportunity for the less digitally-aware sectors in planning their BIM roadmaps.

Gathering information through interacting with industry technology groups

The observation of the technology group activities shows that the firm developed new capabilities through making sense of existing technology developments within its operating environment. This was evident on the firm participation on emerging industry standards through: the involvement with professional institutions and mega projects BIM committees, learning from collaborating firms, and seeking updates from technology providers.

Members of the group including the group leader took part in several BIM action groups within different institutional and professional bodies, as well as being members of several mega UK projects' BIM experts groups; they shared information with the rest of the technology group. For example in the fourth meeting for the group an engineering director joined the meeting halfway through to report on standards developments within one engineering professional institution. Moreover, government strategy, as well as competitors' activities, was discussed in light of the information gained through the interaction with these professional communities. National and international BIM reports and guidance was main item of the meetings' agendas, and was normally circulated before the meeting and discussed in more details between the attendances.

The data shows that the development of BIM strategy and capabilities within the firm was not in isolation from other firms within the industry. This was evident in the presentation of the BIM strategy for one of the firm's long term collaborators in the third meeting to learn lessons from the experience of this collaborating firm. These communication channels with collaborators improved learning, and also made the buy-in from top management more feasible as it enabled the group to demonstrate tried and tested tools and systems that can improve the firm's digital capabilities to compete for BIM projects. Furthermore, the presentation and discussion with the major technology provider during the fifth meeting informed the firm with new directions for the development of BIM technology. This complements the firm's efforts on being up-to-date with developments on BIM processes and standards across the industry.

Mobilising resources to respond to clients

The analysis also demonstrates that the technology group activities sought to build BIM capabilities through the consolidation of existing and new competencies into repeatable and customised processes and systems to enable the firm to successfully bid for new BIM projects. This was evident on: devising firm wide BIM standards and working processes, getting the buy-in from senior management to financially support the BIM task group activities, and developing business propositions and publicity materials for the firm to share with their clients.

One example from the observation of the technology group and its activities was the document developed in collaboration between the firm's highways market sector and a software training consultancy to specify processes and routines for the use of a software package from a famous technology provider within BIM environment, this document was discussed in the fourth meeting, it demonstrated how this type of document can be tailored to other types of packages and markets.

With the BIM concept still being ambiguous and clients were not sure about their needs, the group facilitated basic shared understanding of BIM to enable the firm to better understand clients' needs and develop business propositions to enhance bidding for new complex projects. Members of the group prepared a presentation about the benefits of BIM for the business which presented to the marketing directors of the firm in their February meeting; the presentation was received positively by the marketing directors who are responsible for identifying new markets and managing clients' relationships. The group members considered this presentation as their chance to get the buy-in from top management and to get the required financial support for training and resources.

As the firm was operating within a competitive environment and facing more uncertainties associated with the digital delivery of infrastructure projects in which the firm engaged, the group developed some publicity materials to show the firm's BIM capability and to attract more work based on these capabilities.

The activities of the group and the learning mechanisms discussed above show the integration efforts for building new digital capability and diffusing BIM across the firm. This required building communication channels within the firm among its various projects and market sector. And also communication channels across the boundaries with the industry and technology providers. However, building and managing these communication channels and adopting learning mechanism to support diffusion faced numerous challenges at the firm interface with its projects and with both the industry and technology providers. Continuous efforts were sought to align the firm strategy with: varied clients' needs, emerging industry best practice, and evolving technologies.

CONCLUSIONS

The aim was to understand digital innovation in construction project-based firms. This is achieved through the exploration of the activities of a strategic technology group which the firm mobilised to diffuse BIM across the firm. The findings provide theoretical insights in the projects-firm interface and contribute to the construction project-based learning literature in the following key areas:

Integration and learning processes

Learning from previous and existing projects, and the transfer of this learning into future projects, was key in the diffusion of digital innovation in the firm, although it was not always simple or fully successful. The findings of this study resonate with previous studies which highlight project-based learning as double-edged (Bresnen, Goussevskaia and Swan 2005) or multi-dimensional (Prencipe and Tell 2001). While the project-based literature is dominated with exploration- exploitation models for learning, this study contribute to the literature by revealing a mixture of informal and formal learning processes between the different parts of the firm which influenced the diffusion of the digital innovation. Furthermore, it highlighted some challenges which

face learning processes at the firm-projects interface (Gann and Salter 2000b) and also the interface with the industry, technology providers and the clients.

The learning mechanisms facilitated by the technology group also resonate with the different typologies for project-based learning. Examples of these are: relating, reflecting and routinizing as suggested by (Söderlund, Vaagaasar and Andersen 2008), or replication and recombination (Davies, Gann and Douglas 2009). The difference here is the constant negotiation between the firm and its market sectors and the projects within which the firm is engaged. One of the main contributions of this study is that it shows how the tensions between the firm's strategy and industry best practices or between the firm's capability and the clients' needs and expectations make these mechanisms challenging in practice.

Technology champions and brokers at the firm - project interface

As the data shows, professionals engaged in the BIM diffusion initiative played the role of systems integrators (Winch 1998) and technology brokers (Hargadon and Sutton 1997). Systems integrators integrate top-down and bottom-up processes of strategy making and learning and so are involved in persuasion activities to achieve the buy-in from both the business and the projects. Technology brokers broker digital knowledge and experience across the different parts of the firm, and bring the latest industry best practice into the firm. However, in this case the activities of integration and brokering are happening within a complex interface between the firm and projects, a one which dominated by varied demands and challenges.

Further research

This study has shown that observation and narrative are useful approaches to understand the diffusion of digital innovation in a project-based firm. The findings of this research along with its contribution to construction project-based organisation and literature provide grounds for extra exploration and investigations not only around the nature and dynamics of the tensions between the firm and its projects, but also at the interface between the firm and the industry and between the firm and their clients.

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MANAGING THE COMPLEXITY OF INFORMATION FLOW FOR CONSTRUCTION SMALL AND MEDIUM-SIZED ENTERPRISES (CSMES) USING SYSTEM DYNAMICS AND COLLABORATIVE TECHNOLOGIES

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With the increase in e-commerce and the digitisation of design data and information, the construction sector has become reliant upon IT infrastructure and systems. The design and production process is more complex, more interconnected, and reliant upon greater information mobility, with seamless exchange of data and information in real time. Construction small and medium-sized enterprises (CSMEs), in particular, the speciality contractors, can effectively utilise cost-effective collaboration-enabling technologies, such as cloud computing, to help in the effective transfer of information and data to improve productivity. The system dynamics (SD) approach offers a perspective and tools to enable a better understanding of the dynamics of complex systems. This research focuses upon system dynamics methodology as a modelling and analysis tool in order to understand and identify the key drivers in the absorption of cloud computing for CSMEs. The aim of this paper is to determine how the use of system dynamics (SD) can improve the management of information flow through collaborative technologies leading to improved productivity. The data supporting the use of system dynamics was obtained through a pilot study consisting of questionnaires and interviews from five CSMEs in the UK house-building sector.

Keywords: construction small and medium-sized enterprises (CSMEs), cloud computing, information mobility, productivity, system dynamics.

INTRODUCTION

The construction sector is fragmented, project based (and therefore mobile/temporary) with many types of information needed by so many different stakeholders (Betts, 1999), including clients, regulatory authorities, consultants, contractors and the supply chain.

Information flow serves as the backbone for all successful projects across the construction sector. Construction small and medium-sized enterprises (CSMEs) are an important part of the UK construction sector to absorb collaboration-enabling technologies such as cloud computing that has the ability to provide a platform for cloud collaboration tools, facilitating transfer of information and data in digital format using digital devices such as smart phones, tablets and laptops on construction sites. The aim is to provide accessibility to information to improve productivity. Productivity is defined as a ratio of a measure of output to a measure of some, or all of the resources, used to produce this output (Grimes, 2007). Productivity improvement

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is an increase in the ratio of produced goods or services in relation to resources utilised (Pekuri *et al.*, 2011).

The research investigates the use of system dynamics (SD) methodology as a modelling and analysis tool in order to identify the key drivers in the absorption of cloud computing in CSMEs. The aim is to determine how system dynamics (SD) can improve management of information flow leading to improved productivity, using cloud computing technology and cloud collaboration tools for CSMEs. The focus is at the production stage on the construction site. System dynamics is a tool that can be used to address the complexity in the management of information flow on construction sites. Consideration is given to information flow through the value chain from the design team to the speciality contractor, focusing upon the speciality contractor. Most research has been concerned with information flow between the design team and the main contractor, whereas with specialisation and the out-sourcing of work packages, the role of specialist contractors is increasingly important in the information flow process.

INFORMATION MOBILITY

Information and data moves from the design offices through to the construction site, it needs to be accessed by construction personnel to carry out relevant construction activities. The site is concerned with converting the design into production processes, which involve a plethora of different skills and trades. Whilst the overall process is interdependent, each of the specialty contractors is focussed on their work package. Each specialist requires different information to fulfil their work package, with the overall goal of the main contractor to co-ordinate such information and data. The specialty contractors care about safety, delivery on time, within budget, to ensure the work package is profitable. Computer Aided Design (CAD) and Building Information Modelling (BIM) has meant that design is more dynamic, with faster reaction times on projects. The speciality contractor must deal with change orders, materials delivery, and resource availability. However, there is generally a paucity of information and data on construction sites (Chen and Kamara, 2008). The information and data is frequently of variable degrees of intensity and diversity with variability in accuracy. The research has focussed on project information which includes models, drawings, emails, mark-ups, submittals, transmittals, images, contracts, specifications, change orders and other documentation that are created in the course of designing, building and operating facilities.

On-time and accurate information provided during the production stage reduces errors, rework and delays reducing the likelihood of contractual claims, disputes, and the requirement for change orders. Timely information and communication also contributes towards improved health and safety on construction sites (HSE, 2002). It helps in completing projects on time, with reduced costs and improved quality (Titus and Bröchner, 2005). Moreover, information in real time about external factors that influence production, such as inclement weather, or a significant design change being proposed by the client and design team, can help to forward plan activities, so that to minimise disruption to production.

There is a need to manage the complexity of information flow on construction sites from the perspective of all the stakeholders in the production and delivery chain. The characteristic of this research is that it takes a bottom-up approach, viewing production from the site team. Collaboration-enabling technologies have the ability to provide a platform for software collaboration tools that can improve information

mobility and the information and data transfer. Information mobility is about ensuring seamless exchange of information in the right version, in the appropriate format and with the required level of reliability, accessed by the right people, at the right time. The users are as important to information mobility as the technology; mobility will depend on the user's motivation, whether they can afford to use it, and if they have the ability to do so (Peters, 2004). Collaboration between all organisations involved in a project has become a fundamental requirement in construction. Effective collaboration strategies provide document access across any endpoint, deepen connections with partners and increase productivity.

CONSTRUCTION SMALL AND MEDIUM-SIZED ENTERPRISES

Figure 1 shows that small and medium-sized enterprises (SMEs) in the UK account for 99.8 % of all businesses, 60 % of employment and 47 % of turnover. Construction SMEs are 18.12 % of all SME businesses, with 85 % of employment and 73 % of turnover in the UK construction sector (BIS, 2014).

Figure 1: UK SMEs' Statistics (BIS, 2014)

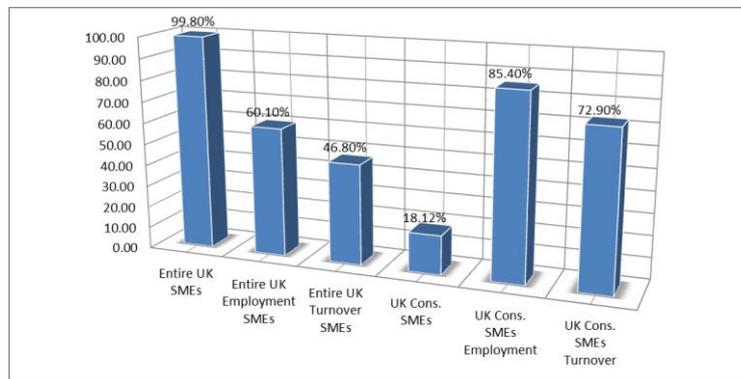


Table 1 shows the European Commission (2005) definition of an SME according to number of employees and annual turnover of a business.

Table 1 Definition of SME's (European Commission, 2005)

Enterprise category	Headcount: Annual Work Unit (AWU)	Annual turnover	or Annual balance sheet total
Medium-sized	< 250	≤ € 50 m	≤ € 43 m
Small	< 50	≤ € 10 m	≤ € 10 m
Micro	< 10	≤ € 2 m	≤ € 2 m

In a small firm, the productive activity represents the heart of the organisation (Di Tommaso and Dubbini, 2000). This led this research to focus on the firm's productive capacity and capability on the construction site. Sexton and Barret (2003a) identified four unique challenges and characteristics of small construction firms:

1. limited staff capacity as well as capability restricting their ability to undertake necessary research and development (R&D);
2. limited time and resources for external interaction that results in restricted flow and amount of information;
3. mostly dominated by single owner or small team who may use inappropriate strategies and skills; and facing difficulty in maintaining an adequate cash flow that results in limited scope for capital or on-going investment in innovation activity.

To the list can be added two further factors, firstly, the lack of systems and procedures with feedback loops providing real-time information on performance and productivity. Secondly, lack of formal organisational structures in CSMEs, which means the lack of systems integration across the business. CSMEs work on both small and large projects as main contractors, sub-contractors, or specialty contractors. Large projects involving work packages that are outsourced to specialty contractors. Large organisations outsource to reduce overheads (Langford and Male, 1992), leading to an increase in number of specialist contractors. Such an increase requires more information and document management with increased integration across all the stakeholders, including consultants and contractors. This can be achieved through increased information mobility especially in the house-building sector that involves a lot of specialist contractors working on a single generic product.

CLOUD COMPUTING AND THE CONSTRUCTION SMES

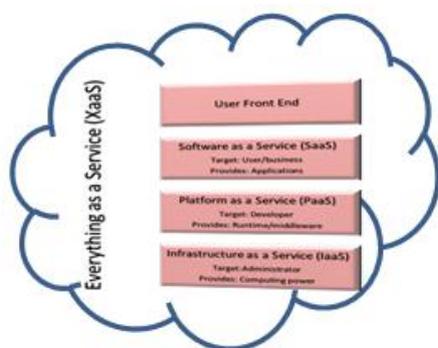
The US National Institute of Standards and Technology (NIST) define cloud computing as:

“a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.”

(Mell and Grance, 2011, p. 2)

Cloud computing is a general term for anything that includes providing hosted services over the internet (Beach *et al.*, 2013). Everything in cloud computing is treated as a service i.e. (XaaS) e.g. SaaS (Software as a Service), PaaS (Platform as a Service) and IaaS (Infrastructure as a Service). These services define a layered system structure for cloud computing as shown in Figure 2. At the Infrastructure layer, processing, storage, networks, and other fundamental computing resources are defined as standardized services over the network. Cloud providers' clients can deploy and run operating systems and software for their underlying infrastructure. The middle layer, i.e. PaaS provides abstractions and services for developing, testing, deploying, hosting, and maintaining applications in the integrated development environment. The application layer provides a complete application set of SaaS. The user interface layer at the top enables seamless interaction with all the underlying XaaS layers (Pallis, 2010).

Figure 2: Cloud Computing: a general layered architecture (Pallis, 2010, p. 71)



Cloud computing consists of four deployment models: firstly, private cloud, which is a cloud infrastructure meant for exclusive use by a single organisation. Secondly, the community cloud; a cloud infrastructure meant for exclusive use by specific

community of consumers from organisations that have shared concerns. Thirdly, the public cloud which is a cloud infrastructure meant for open use by the general public, and fourthly the hybrid cloud consisting of two or more cloud infrastructures (private, community or public cloud) that remain unique entities, but are bound together (Mell and Grance, 2011).

Information Technology (IT) has always been considered as the most vulnerable aspect for technology absorption, despite being extremely important to the construction sector. Construction SMEs are an integral and important part of the UK construction sector. The absorption of IT technologies is low mainly due to the lack of human and financial resources required to use and maintain IT investment (Cheng and Kumar, 2012). There is a general lack of awareness and indifferent attitude towards new information technology displayed by construction SMEs. Cloud computing is an emerging technology that is both innovative and cost-effective. It does not require huge investments in money and time; it can make use of the existing IT infrastructure and get access to computing resources that can be configured according to the requirements of the organisation, with payment based on pay-as-you-go. The main drivers of cloud computing include economics, simplification, and convenience, in the manner that computing related services are delivered (Erdogmus, 2009).

CSMEs can adopt the Hybrid-SaaS model, with a combination of public and private cloud. The Hybrid-SaaS model provides opportunities to store data on an 'on - premise' server that is managed by the organisation, while providing opportunities to use the cloud (Hoehne, 2012). The Hybrid-SaaS model can facilitate both the specialist contractor, and the main contractor to regulate accessibility to information, allowing only the relevant project information to be accessible to all the concerned parties and the construction site personnel. There are many cloud collaboration tools, including Microsoft One Drive, Google Drive, iCloud Drive, Huddle, Evernote and Dropbox. Information can be accessed through cloud collaboration tools using digital devices such as smart phones, tablets and laptops on construction sites. Digitisation has meant the availability of more information, ultimately leading to greater complexity and interconnectivity. System dynamics is a way of managing complexity.

SYSTEM DYNAMICS

System Dynamics (SD) was developed by Forrester (1961) to reflect the view that the dynamics of industrial systems result from underlying the structure of flows, delays, information and feedback (Dangerfield *et al.*, 2010). Mathematical models of the relations between system components are constructed and computer simulation can help to optimise the system. System dynamics (SD) offers a perspective and tools that enable a better understanding of the dynamics of complex systems.

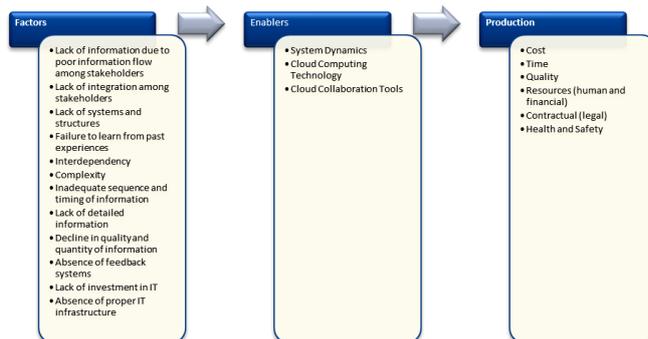
System dynamics is interdisciplinary and in order to study the behaviour of complex systems, it is grounded in the theory of non-linear dynamics and feedback control developed in mathematics, physics, and engineering. These tools are applied to the behaviour of human, as well as technical systems. It also draws on cognitive and social psychology, organization theory, economics, and other social sciences to solve important real world problems (Sterman, 2000). System dynamics approach has the ability to create 'micro worlds' that present real world issues in a manner that are simple, practical, structured, and comprehensible. The strength is in the ability to break down complex systems into comprehensible sub-systems. System dynamics addresses complexity and process relationships based on non-linear feedback systems.

It can help improve information flow, through collaborative technologies leading to improved productivity.

MAPPING CONSTRUCTION PROCESS

A pilot study was conducted using questionnaires and face to face interviews was used to investigate the challenges faced by the CSMEs in information management on projects, and the impact on various parameters relevant to CSMEs during the site production phase of projects. The pilot study considered how system dynamics can help to improve information flow through collaborative technologies. The findings have been categorised as 'Factors', 'Enablers' and 'Production' illustrated in figure 3 and will feed the main data collection.

Figure 3: Mapping the Construction Process



The 'Factors' are the issues faced by CSMEs; the respondents described the increasingly complex nature of the construction sector. The 'Production' category lists the elements directly affected by the 'Factors' affecting both the construction project, and the specialist contractors. The 'Enablers' lists important tools that have the ability to address the issues in the 'Factors' category. It is focussed on the use of system dynamics to manage the complexity of information flow using collaborative technologies leading to productivity improvement. The 'Factors' act as an input to 'Enablers'. The 'Enablers' help address the issues in the 'Factors' category which in turn helps to address the elements listed in the 'Production' category.

A major failing in many systems is the influence of complexity and feedback systems. The construction sector is particularly poor in using robust and reliable feedback systems. Therefore, system dynamics was used as a tool to address complexity and process relationships, based on non-linear feedback. A model was developed to improve the management of information flow, using cloud computing technology and cloud collaboration tools for CSMEs on construction sites. The model is useful for the specialist contractors, it provides a system and procedures with feedback loops that has the potential to provide and capture real-time information on performance and productivity.

SYSTEM DYNAMICS MODEL

SD modelling tools consist of causal loop diagrams (CLDs), and stock and flow diagram (SFDs). CLDs are an important tool that represents the feedback structure of systems. It consists of variables that are connected by arrows representing causal influences among the variables. These can be either negative (balancing) feedback or positive feedback (reinforcing) loops. Stocks are accumulations and depict the state of the system that generates information upon which decisions and actions are based (Sterman, 2000).

Figure 4: Causal Loop Diagram (CLD)

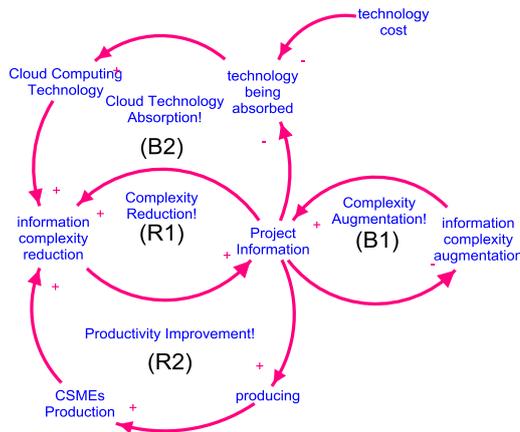


Figure 4 illustrates a causal loop diagram (CLD). The CLD is based upon the findings of the pilot study and consists of four important loops which are described as:

Reinforcing Loop R1: Complexity Reduction

In the causal loop diagram, the reinforcing loop (R1) shows that an increase in 'Project Information' leads to an increase in 'information complexity reduction' and an increase in 'information complexity reduction' leads to a corresponding increase in 'Project Information' thereby improving information flow on construction site.

Balancing Loop B1: Complexity Augmentation

The balancing loop (B1) shows that a decrease in 'Project Information' leads to an increase in 'information complexity augmentation' which leads to a decrease in 'Project Information' on construction site affecting productivity.

Balancing Loop B2: Cloud Technology Absorption

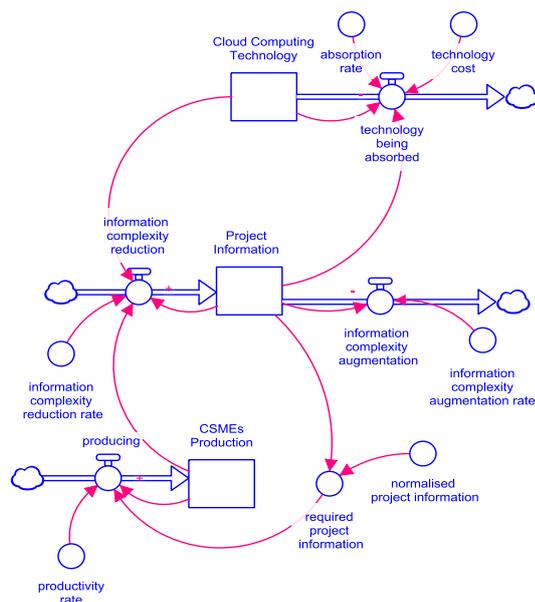
The balancing loop (B2) implies that a decrease in 'Project Information' prompts the CSME to absorb technology shown by the causal link 'technology being absorbed' which eventually leads to the absorption of 'Cloud Computing Technology' including cloud collaboration tools. 'Cloud Computing Technology' absorption increases the 'information complexity reduction' which increases the 'Project Information' flow on construction site. There is also an exogenous influence which is the cost of the cloud computing technology shown by 'technology cost', however, the cost being negligible does not affect the CSME in the absorption of cloud computing technology.

Reinforcing Loop R2: Productivity Improvement

The reinforcing loop (R2) shows an increase in 'Project Information' flow facilitated by 'Cloud Computing Technology' (using cloud collaboration tools through smart phones, tablets and laptops) which results in an increase in 'producing' levels leading to productivity improvement resulting in an increase in 'CSMEs Production' on construction sites. An increase in 'CSMEs Production' leads to an increase in the 'information complexity reduction', and closes the feedback loop.

The CLDs provide a representation of the complexity of information and necessary measures to manage the complexity, through the improvement of project information flow. The CLD provides a dynamic hypothesis and forms the basis for the stock and flow diagrams (SFDs). The SFD is a formal approach towards addressing the problem.

Figure 5: System Dynamics Model

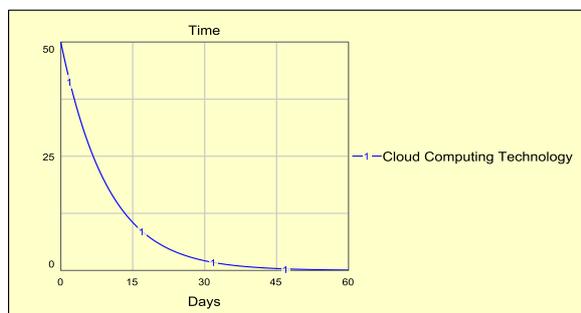


The model consists of stock and flow diagrams with feedback structure. It consists of three main components, which include 'Cloud Computing Technology', 'Project Information', and 'CSMEs Production'. The SD model shows that the absorption of CC technology (including cloud collaboration tools) using digital devices, such as smart phones, tablets and laptops, increases project information flow. The improved information flow leads to improved productivity for CSMEs. The SD model was developed taking the findings from the pilot study into consideration. The model will be further developed following the main study incorporating variables, including endogenous and exogenous factors.

SIMULATION RESULTS AND DISCUSSION

The SD model was validated by the construction SMEs in the sample who were the participants of the pilot study through focus groups. The model consists of three main components including 'Cloud Computing Technology', 'Project Information', and 'CSMEs Production'. The simulation represents the behaviour over time graph, which illustrates the absorption of 'Cloud Computing Technology' as shown in figure 6.

Figure 6: Cloud Computing Technology



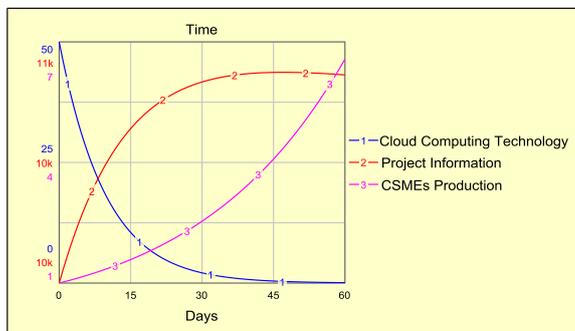
The graph represents the corresponding increase of 'Project Information' due to absorption of 'Cloud Computing Technology' illustrated in figure 7.

Figure 7: Project Information



Figure 8, illustrates that an increase in absorption of 'Cloud Computing Technology' results in an increase in 'Project Information' leading to productivity improvement resulting in an increase in 'CSMEs Production', ensuring greater information mobility using digital devices, such as smart phones, tablets and laptops on construction sites.

Figure 8: CSMEs Production



CONCLUSIONS

The transfer of effective information and data on construction sites has become more complex with more parties involved and greater interdependence of digital information. More effective collaboration is required between all organisations involved in a project, recognising the long and interrelated production and supply chain. Cloud computing is a collaboration-enabling technology that provides a platform to cloud collaboration tools, facilitating transfer of information and data using digital devices such as smart phones, tablets and laptops. The Hybrid-SaaS model is suggested, which is beneficial for both the specialist contractor and the main contractor having the ability to regulate accessibility to information.

System dynamics (SD) is an effective tool that was used to develop a model to help improve project information flow, leading to productivity improvement, through the absorption of cloud computing technology and cloud collaboration tools for CSMEs. The model is useful for the speciality contractors, it provides a system and procedures with feedback loops that has the potential to provide and capture real-time information on performance and productivity. The SD model is based on the findings of the pilot study and will be further developed in the research.

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EXPLORATION OF FACTORS WHICH AFFECT TRUST WITHIN THE CONTEXT OF CONSTRUCTION PARTNERING

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In recent times partnering strategies for procurement of major capital construction projects have been promoted as a vehicle to obtain better value and increase levels of quality and service delivery. Yet there is still evidence of low levels of client satisfaction, owing mostly to lack of trust. A review of literature has identified a theoretical framework for the creation and development of trust as a means to facilitate more effective business relationships which the study will discuss within the context of the UK construction industry and specifically partnering agreements. Possible explanations why organisations are wary to trust their partners are outlined as scepticism of realisable benefits, opportunism and inequitable working relationships. Trust is considered from the perspective of its attributes and factors that will have an influence on it. A qualitative research methodology approach is adopted through interviews with eight senior construction professionals with the research sample restricted to those UK based contracting, consulting and client organisations that have had experience of partnering projects and strategies. Coding and analysis of the resultant data has provided some insight as to why organisations may feel vulnerable about vesting trust in their partners. This lack of trust may have caused a lack of appetite for taking perceived unnecessary risks considering certain practices, attitudes and behaviours of partnering organisations. This is especially the case in project partnering, where relationships are perceived to be short term, as opposed to strategic partnering. Potential trust building measures to overcome such dilemmas have emerged and these include informal networking, professional development and team workshops. Future research is recommended to further explore how trust building initiatives can be designed and implemented in developing a framework for increasing trust in partnering strategies.

Keywords: collaboration, partnering, procurement.

INTRODUCTION AND BACKGROUND TO RESEARCH

The UK Governments' Construction 2025 report (HM Government, 2013) and the Construction Products Association (HM Government, 2010) both highlighted a growing need for increased collaboration, integration and trust across the industry in order to make greater contributions to the pursuit of efficiencies. Notwithstanding these measures and perceived benefits for construction clients, consultants and contractors, partnering and other collaborative strategies have not always achieved their expected outcomes. This may have resulted from poor stakeholder's commitment

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to partnering arrangements grounded in a lack of trust which could be damaging the interests of the whole supply chain (Challender *et al.*, 2014). This lack of trust, according to Larsen (1997) has emerged from the highly competitive nature of the UK construction industry where commercial considerations and opportunities have prevailed over partnering philosophies. Such examples include clients adopting strategies linked to 'bullying' contractors to gain lowest price tenders and main contractors deliberately slowing construction progress to force clients into instructing costly acceleration programmes (Korczynski, 1996). This has led in some cases to long seated adversarial practices and behaviours. Wong *et al.* (2008) supported this argument and articulated the perspective that 'trust appears to be a stranger in construction contracting where confrontation remains the prevalent environment'. Such lack of trust could therefore explain the downward trend in collaborative working practices in recent years as identified by the RICS (2012), in favour of more market-based approaches to contractor procurement. Initiatives designed to encourage partnering have also suffered from 'collaborative inertia' due to lack of trust, guidance, support and understanding (Challender *et al.*, 2014). To investigate this further, the aim of this study is to provide insights into increasing trust in partnering arrangements, and to explore why organisations are sometimes reluctant to trust their partners. It will also identify potential trust building mechanisms that could possibly address such a dilemma, and benefit all construction industry stakeholders.

REVIEW OF LITERATURE

Trust and its application to construction partnering

Although there are many different definitions of partnering (National Audit Office, 2001), it can be defined as 'business relationships designed to achieve mutual objectives and benefits between contracting organisations' or alternatively as 'a structured management process to focus the attention of all parties on problem resolution' (Larsen, 1997).

Although there is a general lack of consensus as to the meaning of trust (Bigley and Pearce, 1998) it can be defined as 'the willingness to become vulnerable to another whose behaviour is beyond his control'. Korczynski (2000) explained the importance of trust from economic and sociological perspectives. The former relating to mutual objectives not to exploit the other and the latter linked to motivations not to damage personal relationships and friendships. Trust constitutes a construct which is multidimensional with different conditions in which it may develop and incorporates emotional, cognitive and moral components and qualities (Jones and George, 1998). In such cases, levels of trust can grow if acts of trust can be reciprocated (Wong *et al.*, 2008) but risks of non-reciprocation can be high, however, especially at the early stages of a new relationship (Blau, 1964). This theory could be applied to construction partnering, in which all parties should be conscious of the virtues of instigating acts of trust, such as sharing sensitive information, and the need for reciprocating their partners trusting behaviours (Chow *et al.*, 2012).

Expectations of trust, when broken, can have emotional consequences with parties feeling violated and can signal that relationships have become damaged. Furthermore this can change the dynamics of trust between parties and in extreme cases can lead to its complete collapse. In less severe cases, however, specific behaviours may need to be changed to repair and prevent further damage to relationships (Jones and George 1998). Applying this theory into practice, perhaps this justifies the claim that more is required to train project teams to deal with situations as they arise. This can be

corroborated by recent findings from Strahorn *et al.* (2014) who report that in UK construction management 'trust repair skills appear to be rare' especially following disputes.

Potential benefits of trust for partnering; incentives to trust

Many academics have focused on theories relating to the creation and development of trust as a potential means to reduce opportunism especially when business environments are prone to hidden agendas and conflicting objectives (Silva *et al.*, 2012). Other theories, conversely, advocate that trust within relationships can safeguard against excessive formal contractual relationships developing between partnering organisations which could be misinterpreted as signs of distrust (Li, 2008). This is supported by Colquitt *et al.* (2007) who found that the potential benefits of developing and nurturing trust in the workplace could have positive influences on job performance whilst allowing vital risk taking where there are no other safeguards to protect partners. Another interesting perspective comes from Korczynski (2000) who opined that the benefits of trust within a capitalist economy should allow for greater co-operation without exertion of power and from a transaction cost economics perspective reduce opportunism. This has become more profound in developing economies where economic shifts from large independent competing firms to smaller interdependent firms who cooperate which each other more readily (Korczynski 1996). The perceived benefits of trust have, however, attracted their critics in some instances. Some have debated whether such reliance on trust is appropriate where large sums of money are involved and opportunism could emerge (Lann *et al.*, 2011). This is clearly at odds with the aforementioned views of Silva *et al.* (2012). The other contentious factor is whether the fractious nature of the UK construction industry, based largely on 'one off' projects facilitates the right environment and conditions for trust to prosper (Fawcett *et al.*, 2012).

Trust as a collaborative necessity in benefitting construction partnering

Trust is considered to be a 'bonding agent' between collaborating partners and as an 'essential foundation for creating relational exchange' (Silva *et al.*, 2012). Fawcett *et al.* (2012) presented a perspective that 'without trust collaborative alliances cannot be created or maintained'. Despite this trust appears to be a stranger in construction contracting where confrontation remains the prevalent environment (Wong *et al.*, 2008). One contributory factor for such lack of understanding may emanate from trust receiving only limited attention in construction project management (Maurer, 2010). These arguments appear to support the case that trust amongst construction project teams certainly needs to be significantly increased (Dainty *et al.*, 2007) especially since it is 'central to every transaction that demands contributions from the parties involved' (Cheung *et al.*, 2011). Despite this there has been much debate in academia as to how to achieve this in practice. Cheung *et al.*, (2003), in this regard, stressed the importance for project teams to communicate well and operate within an environment leading to 'an upward cycle of trust'. Conversely some academics have argued that it is the creation of shared ethos based on equity and fairness embedded in aligned organisational strategies that best promotes trust between partners (Thurairajah *et al.*, 2006). Notwithstanding these views there has been little written on trust building measures and mechanisms for construction relationships and even less for construction partnering.

Potential barriers to trust in construction partnering

The quality of collaboration can be reinforced or weakened, depending on the behaviour, approaches and attitudes of organisations and individual participants (Kalarachi and Jones, 2007) and in practice the time that is needed to nurture key relationships is often lacking in construction management procurement systems (Walker, 2009). Also the project-based nature of much construction work can be seen as a fundamental barrier to the development of trust in practice, where relationships are often perceived to be short-term, and true collaborative working practices struggle to emerge (Walker, 2009). Furthermore reliance on the known and controllable has previously been identified within the UK construction industry, as a symptom of a lack of trust and 'negative culture', sceptical and suspicious of new initiatives.

Other problems for partnering have emerged on occasions where a perceived abuse of power has occurred (National Audit Office, 2001) or deployment of market leverage to disadvantage their 'partners' (RICS, 2005). Briscoe and Dainty (2005) supported this through development of their propensity to trust theory and in practice this could manifest itself as 'buyers' dictating to 'sellers' the terms of their employment and what is required of them (Mathews *et al.*, 2003). Korczynski (1994) referred to this type of practice and other forms of opportunism as the main source of mistrust in the UK construction industry.

Summary

There are clearly problems and challenges for construction partnering, owing to the perceived lack of trust between 'partners' and potential barriers that exist within the construction industry. There are conflicting views on whether trust is appropriate, beneficial or detrimental in some cases and the arguments presented around opportunism highlights the alternative debates that currently exist. To explore this further, this study offers construction practitioners' insights into the problem of trust and their view on what could constitute trust building initiatives for the industry.

METHODOLOGY

In consideration of the above, a small qualitative study was undertaken (Flick, 2009). Semi-structured in-depth interviews (Gillham, 2005) were held with eight North West UK construction professionals from different construction industry disciplines; a client project manager, property lawyer, architect, quantity surveyor, main contractor, subcontractor, mechanical and electrical engineer and a structural engineer. This purposive sampling approach selected professionals with experience in many different types of construction procurement including partnering, and all who have had experience in representing client organisations. However, beyond these two criteria, the sample was essentially one of convenience.

The interviews were undertaken between late 2014 to early 2015. They were digitally recorded, transcribed verbatim, coded qualitatively and sorted (Silverman, 2001; Langdridge, 2005). As recommended by Taylor and Bogdan (1998), the raw data was summarised in tables; codes were listed, themes developed, content analysis data presented, key literature sources identified, data consistencies and inconsistencies noted and propositions made. Table 1 has been prepared to compare and contrast such inconsistencies and similarities from the interview findings against the respective theme from the review of literature.

RESEARCH FINDINGS AND DISCUSSION

Importance and benefits of trust in partnering

From a general perspective the majority of interviewees expressed support for increased trust in partnering and advocated that it can encourage greater scope for cooperation, teamwork and collaboration. They opined that it can lessen the need for excessive monitoring and formal control mechanisms through reduced risk of opportunism. This generally supports the literature review findings, Chow *et al* (2012) and Silva *et al.* (2012) but robust contractual provisions to lessen the risk of potential exploitation are still deemed required by the participants in line with Lann *et al.* (2011). Although differentiation of partnership arrangements and their respective importance was not apparent from the literature review, it is felt from the interviewees that trust is more important for strategic partnering and lesser so for project partnering based on 'one off' projects. This is justified on the basis of greater scope and motivation for building relationships and learning from experiences, where repeat business from one project to another is facilitated. In this way it would address the fundamental problem outlined by Walker (2009) and Fawcett *et al.* (2012) concerning the short term nature of the construction industry. From some of the participants there was suspicion of realisable benefits for trust in partnering. This has emanated from past experiences where traditional commercial positions have re-emerged, through claims and disputes, causing parties to retreat back to adversarial contractual positions.

Providing the right environment for trust in partnering; Possible trust building mechanisms

In consideration of what can encourage trust, interviewees opined on the many wide ranging sources or attributes of trust. Either positively or negatively, confidence, teamwork and personalities of individual team members were all found to be important trust building attributes in partnering. Notwithstanding this, findings indicated that the strength of trust generated is more dependent on individual personal relationships, developed from mutual respect, rather than simply 'good' working relationships. Trust originating from previous positive relationships and dealings between individuals at senior levels is regarded as critical in the cascading of trust throughout partnering organisations. The above supports Thurairajah *et al.* (2006) which were referred to by one participant as 'aligned synergies'. Not surprisingly at an operational level, 'human' factors such as integrity, honesty, consistency, reliability and competency are regarded as essential facilitating factors in building trust and gaining good collaborative working relationships. This is supported by other qualities including commitment, communication, initiative and conscientiousness to provide the required degree of integration within teams. Such 'soft' factors and skills as depicted by Cheung *et al.*, (2011) are confirmed by the interviewees, to be vital for the greater integration and cohesion of project teams. Yet, hard factors are also put forward by those interviewed as crucial in the partnering process: experience, technical ability, education and competence of individuals, management systems and resources of the partnering organisations. Participants opined that the robustness of the partner selection processes was important in evaluating the most preferred and compatible partner to be appointed, which was not covered widely in the literature.

The interviewees outlined their opinions on many different trust building mechanisms in an attempt to increase trust in partnering arrangements. These included measures to increase fairness of contract terms and the existence of a dispute resolution process

which could address the abuse of power (NAO, 2001) and deployment of market leverage (RICS, 2005) scenarios previously outlined. Others measures were to encourage informal and open communications and willingness to share sensitive information. Workshops were also suggested as the means to facilitate CPD and networking events to promote open informal communications and engagement on other trust building initiatives. The participants opined that these could encourage dialogue and teamwork to provide the right conditions for embedding those partnering philosophies as advocated by HM Government (2013). In this regard one interviewee, referring to previous projects, suggested that a partnering charter to encompass such measures had been successful in the past. A potential counter argument also emerged; however, in that even when there are high intentions to commit to such measures and undertakings some partners simply lack the practical experience, knowledge and resources to embed and develop trust within inter-organisational relationships.

Table 1: Qualitative themes and data analysis

Qualitative Themes	Literature Source	Observation, Proposition or Explanation	Data Inconsistencies	Data Similarities
Factors that instil trust in partnering arrangements. Trust building mechanisms.	Cheung et al. (2003).	Shared ethos based on trust, equity and fairness between partners is essential.	Trust generated from previous relationships especially at senior levels.	Equitable working relationships coupled dispute resolution process.
	Briscoe and Dainty (2005)	Levels of trust can grow if trust reciprocated between partners.	Lack of knowledge and commitment to initiatives in some cases.	Importance of communications and commitment.
	Thurairajah et al. (2006)	Social interaction, power, identities and expectations influence the degree and quality of trust.		Sharing of information. Use of workshops for facilitating teamwork.
Importance and reliance on trust in partnering arrangements	Wong et al. (2007)			
	Kaluarachi and Jones (2007)	More trusting relationships facilitate increased collaboration.	Trust only felt desirable to project partnering whilst essential to strategic partnering.	Loss of trust can result in untenable working relationships.
	Walker (2009)	Trust considered to represent 'bonding agent' between collaborating partners.	Trust appears to be a stranger in construction contracting.	Trust enhances collaboration and bonds teams together.
	Lann et al. (2011)	Degree of trust shapes relationships of project teams and influences project outcomes.		Closer working relationships can provide right context for trust.
Perceived benefits of trust in partnering arrangements	Silva et al. (2012)			
	Larsen (1997)	Increased collaboration is a crucial factor to deliver successful construction projects.	Suspicion of realisable benefits and negative past experiences.	Less antagonistic and stressful environment, improved teamwork, cooperation and collaboration.
	Colquitt et. al (2007)	Trust can safeguard against excessive contractual provisions and/or risk adverse practices.	Risk of exploitation.	
	Li (2008)	Can reduce opportunism.	Perception of too 'cosy' business relationships.	Risks especially on complex projects can be identified earlier and managed more effectively.
	RICS (2005)		Can increase opportunism.	
Potential barriers to trust in partnering arrangements Potential origins of lack of trust/mistrust	NAO (2001)	Use of market leverage and lack to trust more powerful partners.	Lack of professional development, education and training felt most important factor.	Insecurity, uncertainty and scepticism of trusting relationships
	Korcynski (1994)	Fragmentation and short term nature of industry.		
	Walker (2009)	Negative adversarial behaviours and attitudes	Conflict can be a positive factor.	

Factors which could inhibit trust in partnering

Notwithstanding the aforementioned positive influences of trust building measures, there was some scepticism that has emerged from the research on their influence and effectiveness. Whilst shared ethos built upon trust between partners is supported theoretically (Thurairajah *et al.*, 2006), according to those interviewed, rarely is this fully realised and embraced in practice. This is clearly a departure from the review of literature and interviewees reported that integrated teams and partnering has been tainted by inequitable working arrangements and anecdotal evidence was presented of organisations that have suffered financially.

The emergence of such factors as social interaction, power, relationships, identities, expectations, and commitments could, if not managed correctly, result in anxieties, tensions and conflicts between partners. According to those interviewed potential outcomes such as these were generally regarded as negative forces which could lead to mistrust in partnering which confirms the findings of Korczynski (1994). However, an alternative isolated argument, representing a departure from the literature review, was presented that conflict is a necessary component of relationships and as such should not necessarily be removed all together. This potentially controversial view could be justified on the basis that it could add tension and inspire motivation and innovation by challenging existing practices. In this way it could arguably be regarded as a positive force. The disparity of power between 'buyers' and 'sellers' in partnering arrangements was reported to be a factor that could have a negative impact on trust in partnering. This may have allowed the former to use the power derived from scarcity of work elsewhere in the economy to adopt a 'take it or leave it approach'. The interviewees felt that such a shift in philosophy during operational partnering frameworks, renders organisations highly vulnerable to exploitation as they are virtually held to ransom; to accept revised or reduced terms, or be cast back into 'the other' competitive cut-throat market place. Such exploitation may increase the perceived risk of partnering options through lack of trust, reducing their attractiveness and contributing to a reduction in willing partners. These findings broadly support Briscoe and Dainty (2005) and Mathews *et al.* (2003). Taking this into consideration some interviewees did believe that for trust to prosper an overhaul of current partnering contracts could avoid potential abuse in such cases. Other views, however, were dismissive of this approach on the basis that contract terms alone would not prevent this type of opportunism in practice, calling for a more deep rooted approach to fairness and equality as the only real address.

The interview findings also revealed that a lack of trust may have emanated from previous dealings between partners where poor experiences of other parties had become apparent. Such evidential accounts included the reluctance to share information, respond to urgent requests or failure to make payments on time. Although not covered widely in the literature review the study uncovered that such adversarial practices and behaviours had led to inter-organisational mistrust between partners, clearly demonstrating a departure from partnering philosophies. This may explain why some of the construction professionals interviewed articulated their reluctance at times to put themselves and their interests at risk through a perceived vulnerability in trusting other partnering organisations. An extreme view was presented which was critical of the development and employment of trust itself within partnering and the wider organisational context. This revolved around the notion that it is simply too naive to trust in such business relationships dominated by significant

sums of financial expenditure and where potential profits are critical to organisational success. The emergence of this controversial and arguably misguided perception could be interpreted to mean that individuals and organisations alike will act instinctively to protect their interests and be sometimes reluctant to trust their partners in some cases. This may be especially profound in certain instances where it could put them at risk and make them become vulnerable. Although Lann *et al.* (2011) questioned the role of trust where large sums of money are at stake, these findings from participants did represent a significant departure from the literature review. Such 'ghost stories' for the future of trust in partnering arrangements could possibly demonstrate a need for more trust building mechanism and initiatives to be encouraged and developed for the UK construction industry. Professional development, education and training and increased participation were presented as possible catalysts to overcome this dilemma and this supports Maurer (2010).

For those interviewees that operate within the public sector there was a perception that trust in partnering where financial governance, audit and public accountability are paramount could be regarded as 'too cosy' by some more discerning parties. This could in some cases lead to a departure away from trust in partnering and negotiation and encourage more traditional competitive arrangements that provide more robust audit trails.

CONCLUSIONS

The research presents similarities, inconsistencies and new insights to the review of literature. It demonstrates that, despite a prolonged government push via framework initiatives and other interventions designed to raise participation of partnering practices, there still remains little appreciation of some of the difficulties inherent with the reliance on trust in working collaboratively. Long-stated, sceptical arguments theoretical against partnering may have gained credibility from practice, as tales of abuse in organisational relationships and the trust that should underpin them have been told. The absence of trust certainly appears to be a major obstacle for realising the potential benefits from partnering strategies accordingly. In addressing this challenging dilemma a greater understanding of those trust building mechanisms that are potentially effective in 'turning the tide' and embedding more trust in partnering is therefore required. This study has provided a contribution to knowledge in this regard and provides various examples of successful initiatives and measures previously adopted by participants for contemplation. Such mechanisms may provide the catalyst that 'keeps the partnering trust flag flying' in this regard. Other possible ways forward for industry to develop trust and break down traditional adversarial barriers emerged as (i) informal networking and social events, (ii) organic in-house project bespoke continual professional development, (iii) informal team workshops, (iv) improved understanding at board level of the value of collaborative trust in partnering and (v) organisational and inter-organisational restructuring to improve communication and cooperation.

Further research to focus 'upstream' on those constructs, attributes and factors which could influence trust in the context of partnering practices is recommended. This could seek to further identify and evaluate trust 'generators' and 'inhibitors' with the aim of facilitating greater understanding of how trust building initiatives can be designed and implemented in developing a framework for improving public sector procurement strategies.

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THE VALUE OF TRUST IN CONSTRUCTION SUPPLY CHAINS

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This research generates insights on the value of trust in construction supply chains, in particular the relationships between construction actors. One of the difficulties for developing and managing trust in construction supply chains (cSCs) is the project-focused (P-F) characteristic of construction projects, which results in a limited understanding of the role of relationship and the short-sighted and P-F view on value creation in industry. Trust-based and long-term relationships are often assumed to be unnecessary and/or impossible to nurture and sustain in temporary construction projects. However, trust as a foundation for business relationships appreciates with use and generates long-term benefits during interaction through more effective communicating, relating and knowing that should not be neglected. A change in focus from project towards service in construction project businesses has been argued as service-dominant (S-D) logic is inherently relational and considers value created both within and beyond the scope of projects. Thus, this paper discusses the value of trust under the S-D setting by illustrating how trust develops during service provision and how the development of trust enhances service value in use. This paper contributes to research by exploring the value of trust through S-D lens and in construction supply chains.

Keywords: service-dominant, supply chain relationships, trust, service value.

INTRODUCTION

Trust and trust-based relationships have drawn increasing attentions in a wide range of areas such as psychology (Rotter 1967), organisational behaviour (Mayer *et al.* 1995, Zaheer *et al.* 1998) and project businesses (Hartman 1999, Smyth *et al.* 2010). Trust has been perceived to be conducive to organisation and project performance as it can improve organisational culture through fostering 'fair' play, create a collegial working environment and better in-role and organisational citizenship behaviour inside organisations (Mayer and Gavin 2005), leading to long-term commitment, effective communication and cooperation between organisations (Brinkhoff *et al.* 2014, Talay and Akdeniz 2014). In construction where businesses are highly project-focused, trust has been suggested to be difficult to generate and develop (Kadefors 2004). Even in project businesses focused on relationship (e.g., partnering projects), trust building has been mostly discussed as a solution for adversarial relationships among key actors (Laan *et al.* 2011). Consequently, trust in construction project businesses has been viewed as 'lubricant' for managing project partnering and alliances. However, some researchers have pointed out that partnering does not necessarily guarantee success. Not all partnering projects perform well due to the elusive partnering practices and the complicated mechanisms required for establishing and maintaining trust-based collaborative relationships between construction actors. These arguments further

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question the possibility of and necessity for building trust-based relationships and the value of trust in construction supply chains (cSCs).

The *aim* of this paper is to generate insights on the value of trust in cSCs, particularly in enhancing service value in supply chain relationships, where service value is defined in terms of the service-dominant logic (S-D) set out below. This is a neglected area in research on trust. One difficulty for developing and managing trust in the context of cSCs is the project-focused characteristic of construction projects, because it leads to the view that cSC relationships are temporary and project-focused (P-F). Thus, the objectives of this paper is to illustrate: (1) a revised logic of value creation in cSCs and projects – using S-D logic, which provides an original contribution; (2) how trust conceptually develops in supply chain relationships; and (3) how trust development theoretically helps create higher service value. In the next section, we will briefly introduce construction industry context, in particular the P-F view of value creation, followed by an overview of trust development in relation to domains such as psychology, general management and organisational behaviour. These two sections provide a foundation for the illustration of the value of trust in construction supply chains. To be specific, how potential value is conceptually derived in part by developing trust will be discussed in this section. A conclusive summary and implications will be given in the final section.

CONSTRUCTION INDUSTRY AND VALUE CREATION

Construction is inherently project-focused, where a short-term coalition of actors is formed around a specific project that works as a ‘temporary multiple organisation’ in principle collaboratively for the sake of project success in context and use. In practice project conduct is frequently adversarial. This renders the development of trust and trust-based relationship in the context of construction projects and supply chains problematic (Laan *et al.* 2012). On the one hand, the temporary multiple organisation is confined to a specific project and personnel normally change with projects. Thus, temporary organisational forms inhibit the nurture of trust-based relationships. On the other hand, although some main contractors and tier one supply organisations continue business between projects, in whose organisational interests trust would conceptually and in principle appear desirable, construction actors arguable have insufficient support, resources or time to engage in the process of trust building to yield the project and organisational benefits. It is possible that construction is completed while the extent of a business partner's trustworthiness has yet to be demonstrated.

The P-F feature has led to prevailing view of value creation in construction projects. It holds that value is created by contractors and suppliers in the construction process. For example, buildings are constructed out of materials and components. Contractors and suppliers embed and integrate value in those materials, components and their assembly during construction, which forms the final tangible facility or building. The whole value creation process is regarded as inputs delivered on time, to budget and the required scope and quality levels. Value is thus created by individual contractors and suppliers and measured by exchange transactions. The P-F view works as projects are completed and organisations are paid, sustaining the market as a result. However, the emergence of specialisation and subcontracting has made construction actors more interdependent upon each other than ever (Dubois and Gadde 2000). Moreover, technology developments, social pressures, and other forces have drawn in increasing numbers of stakeholders, such as government and environmental organisations, who place various demands upon construction (Walker 2007). Thus construction projects

and firms exist in a social text, and cannot operate entirely from ‘self-interest’ (Smyth *et al.* 2010) – there are social and ethical issues to be considered to keep the market functioning. Under the circumstances illustrated above, the P-F view seems inadequate in explaining value created in project businesses, which includes benefit and impact outcomes. Investment made within projects yields benefits post-completion, since networks of relationships tend to extend beyond the scope and lifecycle of the project. Further, value created on one project can provide social resources for future projects through learning, knowledge transfer and application of other social capital and project capabilities. Such benefits are conducive to firms’ well-being, but are largely neglected by the P-F view. Trust, for instance, takes time to build and maintain but once developed, it may reduce objective and subject risks (Smyth *et al.* 2010), decrease transaction costs (Zaghloul and Hartman 2003), link strategy and operational practices (Gustafsson *et al.* 2010) and derive financial value for both customer and supplier (Smyth *et al.* 2010). Furthermore, P-F tends to fail to consider some social issues (Vargo and Lusch 2008), since it usually neglects value derived from reputations or network positions. Importantly, P-F tends to become less convincing as increasing numbers of contractors and suppliers find it perceptually difficult to develop and maintain core competencies to derive potential value from their activities in this competitive market.

Both the difficulty in maintaining competitive advantages beyond price and inputs and the inadequacy of the P-F point towards a revised logic of value creation – service-dominant (S-D) logic. Proposed by Vargo and Lusch (2004a), it has been applied in project businesses (Wells and Smyth, 2011, Liu *et al.* 2014, Smyth, 2015). Under this logic, the basis of exchange is the service rendered (outputs and outcomes), which are derived from operant resources (knowledge and skills) that are the fundamental source of competitive advantage. Customers are not recipients of ‘value’ inputs; they become co-creators of value by actively learning and integrating its resources into the service provided. Thus, suppliers and contractors can only offer value propositions and support customer’s value creation as co-creators. Ultimately, value is uniquely and phenomenologically determined by customer in use and context. S-D can be substituted for P-F in construction project businesses. As Vargo and Lusch (2008) stated, S-D is inherently relational, relationships being necessary for both adding potential value to the product or services of the project and in project delivery as a service. Trust as the foundation for relationship has been suggested as a means to enhance the value by bettering joint activities and improving customer experience (Ballantyne and Varey 2006, Cheung *et al.* 2010, Truong *et al.* 2012). Therefore, trust is part of co-created service value in execution and may enable value co-creation for value co-creation post-completion.

TRUST DEVELOPMENT

Building on Mayer *et al.* (1995) and Smyth *et al.* (2010), we define trust in construction supply chains as a construction actor’s current *intention* to rely on the actions of or to be vulnerable to another party. The expectation is that other parties can reduce risks, creating opportunities to enhance service value in execution. We focus on inter-firm trust between main contractors and subcontractors during execution.

The cycle of trust development

Although trust is a *current* state, in its process of generation and development trust also tends to relate forward to *the future* and backward to *the past*. Trust builds on learning consisted of assessment of a situation, including both another party

considered and the relationship between trustor and trustee, and a judgement about the future relationship. To secure positive outcomes of learning so that trust is developed, it is necessary that another party behaves with trustworthiness, or at least is perceived to be trustworthy enough to reduce risks existing in the situation. For example, their competence can be trusted to fulfil their obligations or they act fairly when facing opportunities for opportunism. But trustworthiness alone is not adequate for increasing trust as relationship involves in the context. Trust development also depends on the quality of relationship. Trust will not develop if trustor has no intention to further expand the relationship with another party even if their past relationship is considered positive.

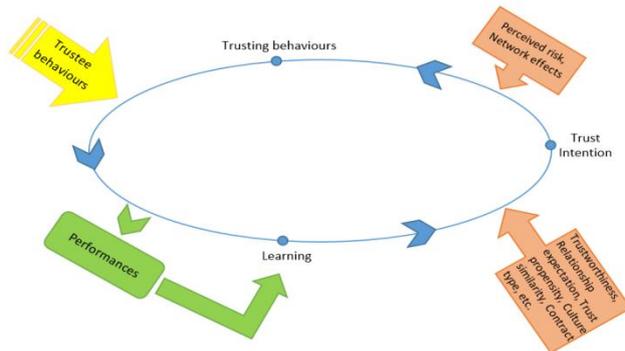


Figure 1 Cycle of trust development

It is notable that the process of learning discussed above is not purely calculative or weighing up the other party's trustworthiness and the quality of relationship. Actually, the process is usually mainly, if not wholly, relational, because the situation is assessed and judged in trustor's lens, or by trustor's interpretation, which is influenced by relationship with and attitude towards others and one's own disposition. Mayer *et al.* (1995) noted that disposition and attitude vary with different experiences, culture and personality, resulting in degrees of trust. This accords to organisational learning literature contenting that organisations vary in the ways they make sense of the same information and in the mechanism for sense making (Fiol and Lyles 1985). Also, the interpretation on another party is largely based upon experiential learning in relation to others and under the influence of the quality of relationships, and thus is relational and subjective (Smyth *et al.* 2010). In short, for trust to develop, a series of experiential learning is required and the outcome of such learning determines the extent to which trust develops. The development of trust leads to a set of trusting behaviours benefiting interactions between parties, the outcomes of which become parts of the contents of learning for a new cycle of trust development.

Consequently, a dynamic cycle of trust development is initiated, consisting of three elements – learning, trust intention, and trusting behaviours (see Figure 1). This dynamic cycle is subject to a diversity of factors that influence the degree of trust intention or mediate the relationship between trust intention and trusting behaviours. For example, extant research has suggested that power is essential to trust development, but the relationship between them is still unclear, especially at inter-organisational level (Fulmer and Gelfand 2012). Cox *et al.* (2000) defined power as the extent to which one party depends on another for particular resources, implying that resource and capability availability is the source of power asymmetry. On the one hand, power imbalance between firms has been suggested to hinder the development of trust (Smyth and Pryke 2008) and equality tends to foster collaborative, effective and trust-based relationship (García-Canal *et al.* 2003). For example, by investigating

a network of suppliers, retailers and manufacturers in Finish food industry, Kähkönen (2014) found that trust-based collaboration is more shallow when power is imbalanced between firms than when balanced. Actually, collaboration between manufacture and retailer happened only because retailer at higher power position was willing to do so and the depth of collaboration was set by retailer. On the other hand, some studies suggested that power asymmetry can co-exist with the development of trust, as in the case of aerospace company and its suppliers in Cuevas *et al.* (2015).

The measure of trust intention

The extent to which trust develops is a fundamental area that researchers have attempted to explore (e.g., Laan *et al.* (2012) and (Laan *et al.* 2011)). However, when researchers provide comprehensive descriptions and measurement, trust tends to dissolve into several types of dimensions, depending on the perspectives researchers viewing the process of trust development. Most extant research on trust dimensions or models tends to focus either on the breadth of trust dimensions alone (e.g., Hartman (1999)) or only illustrate the path of trust development without specifying the extent to which trust develops (e.g., Rousseau *et al.* (1998)). Dimensions that indicate the depth of trust are largely under-researched, but expectations can be found in Smyth and Edkins (2007) and Fawcett *et al.* (2012), both of which emphasised trust dimensions in a dynamic view and related to the evolution of relationship. However, without referring specific aspects of trust (breadth), it is hard to detect the development of trust, whereas without indicating the extent to which trust develops (depth), it is difficult to explore the influence of trust on service value. Thus, this paper argues an alignment of trust dimensions in terms of breadth and depth to analyse the development of specific aspects of trust in a given time point, but also assist the comparison of the influences of trust between different degrees (see Figure 2).

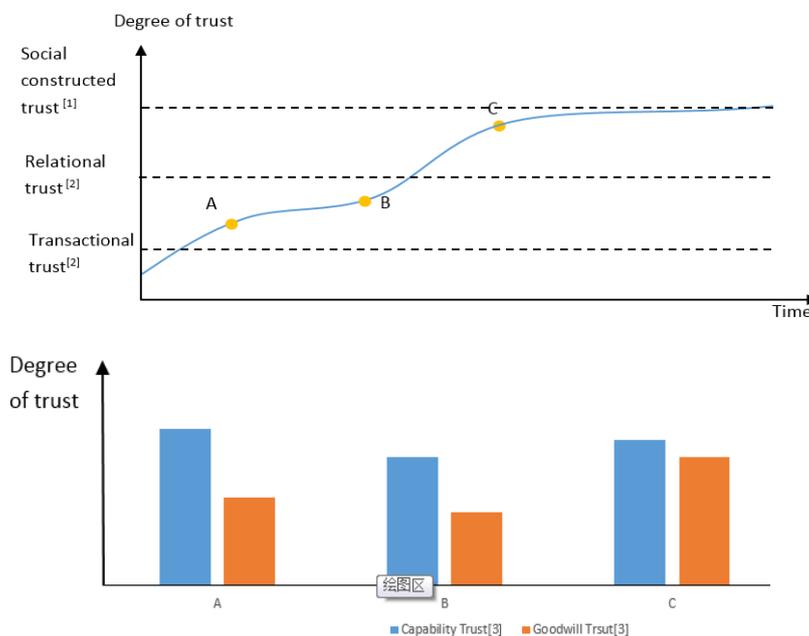


Figure 2 Trust dimensions (Source: [1] Smyth and Edkins (2007); [2] Fawcett *et al.* (2012); [3] Das and Teng (1998))

THE VALUE OF TRUST IN CONSTRUCTION SUPPLY CHAINS

Value co-creation

Building on Grönroos (2008) and Vargo and Lusch (2004a), we define value as customers' experiential perception of the benefits of service in use. Value is not unidimensional, but consists of multiple dimensions such as competence value, relationship value, social value and emotional value. How value is dynamically co-created by main contractor (MC) and second tier subcontractor (SC) is illustrated in Figure 3. Consider a building contracted to a MC, who subcontracts the electricity installation to a SC. The service of installation provided by SC is embedded with value propositions instead of 'real value'. The contents of this service will be adapted to and integrated with MC's resources in use or during execution. For MC, the use of service is to integrate electricity installation provided by SC into the whole project or facility, which is delivered to MC's customer – the client. Thus, value creation is depended on both SC's service contents and value propositions and MC's efforts to integrate resources, and the perception of value from MC's perspective depends on the extent to which the service can be integrated to and adapted with MC's own resources and the whole project or facility.

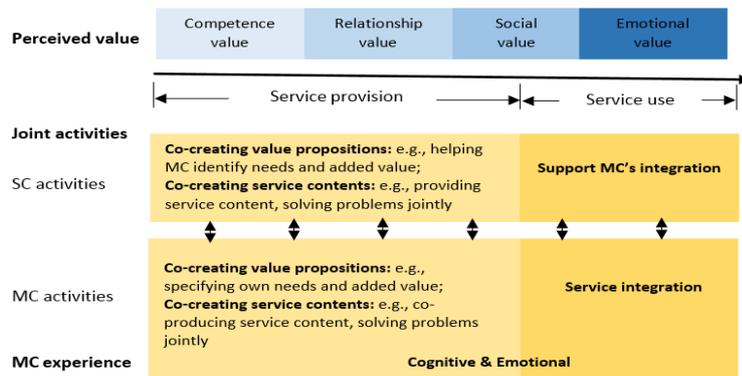


Figure 3 Value co-creation in construction

Co-creation of value involves a series of joint activities between MC and SC during service provision. Ballantyne and Varey (2006) identified three basic elements in value co-creation activities – relating, communicating and knowing. For example, when co-working emergent problems such as unfit size of components in assembly, MC and SC apply own knowledge and skills in communications to deal with the problem while relate to each other's objectives, working styles and capabilities. Not only problems are more likely to be solved in a way both parties satisfy, but also more operant resources, mutual understanding and reinforced relationships can be achieved so that higher added value for MC and benefits such as repeated businesses for SC are both secured. In other words, emergent incidents during service encounters are opportunities for learning and adding value under the S-D, rather than risks that should be avoided as assumed by P-F. The quality of communicating, relating and knowing is a determinant of the quality of contents. Also, working jointly tends to render better value propositions as customers can identify more opportunities for value creation with the help of SC who is more knowledgeable about the service provided. On the other hand, if SC is able to provide better value propositions (e.g., more customised solutions) that tend to bring higher value for MC, MC will regard this SC as more competitive than others and is more likely to repeat business with this SC, which is a benefit for SC.

By participating in value co-creation, MC is involved in an experience that is cognitive and emotional (Payne *et al.* 2008). Customers evaluate their service experience by resources and outputs required, but also through their own lenses that are largely determined by affects and emotions. Facing the same objective outcomes, customers' perception will differ depending on emotional bonding and affective preference that might be accumulated in relationships across projects (see example in Smyth *et al.* (2010)).

The value of trust in co-creation of value

The use of service, from MC's perspective, is to integrate service into the project as a whole by using organisational and project capabilities as well as operant resources required from learning during interaction with SC. So the quality of service in use is largely depended on both MC's capabilities and the extent to which SC is integrated in value creation. Trust is a prerequisite of value co-creation to build relationships, hence 'lubricate' customer interactions and engage in value co-creation (Abela and Murphy 2008). More importantly, trust has been suggested to have the potential to enhance value by bettering joint activities and enhancing customer experience (Ballantyne and Varey 2006, Cheung *et al.* 2010, Truong *et al.* 2012). Service provided with better value propositions and more customised contents are more accessible to be integrated with customer's resources and thus have higher potential to enhance value. Also, better learning and communicating associated with enhanced customer experience make MC acquire more operant resources benefiting service use after service delivery. Cooperation, exploration of new information, market opportunities and technologies, and product, service and process innovation enable the enhancement of service value, all of which depend on the trust between organisations (Zaheer *et al.* 1998). Figure 4 illustrates the conceptual relationship between trust and value-in-use.

Trust leads to high quality relationships to enable the process of relating, communicating and knowing, which influences the outcomes of joint activities such as service contents and propositions. Stable and sustainable relational structure, network communication and learning contributing to interactive relationship development are all founded on trust. This mutually sustains value-creating activities. As a facilitator of knowledge sharing, for example, trust activates the knowledge renewal that supports sustainable value co-creation. Consequently, customers acquire more operant resources through co-creation experience, learn more skills and knowledge to use service and perceive more value out of usage. This in turn upgrades organisational capabilities that benefit future value creation. The relationship between trust and value propositions tends to be self-reinforced. On the one hand, value propositions that provide better opportunities for MC to create value via higher benefits leads to SC being perceived as superior (Ballantyne *et al.* 2011), motivating MC to develop closer relationship that leads to higher degree of trust. However, superior value propositions are usually accompanied by higher risks as they tend to be more complex and interdependencies and require more intensive interactions and negotiations between MC and SC (Kowalkowski 2011). Trust is salient in dealing with high risks and interdependencies and thus is required for producing intensive collaborative service propositions (Jones *et al.* 2010). Decreased opportunism, improved goal alignment, resource allocation, collaborative problem identification and enables improve propositions during execution rather than merely in bidding stages. Further, customers who trust their providers are more likely to be open to unpack their preferences, share experiences as part of the interactions to improve service and technical content and customisation (cf. Neghina *et al.* (2014)). Also, as trust develops and relationships

deepen, customers are more likely to sacrifice short-term individual gains in favour of long-term benefits of the partnership (Cheung *et al.* 2010), meaning that suppliers are able to secure more benefits under high-level trust, especially in S-D settings. Thus, both propositions and service contents crafted in trust-based relationships are more customised, emphasising value and mutual benefits.

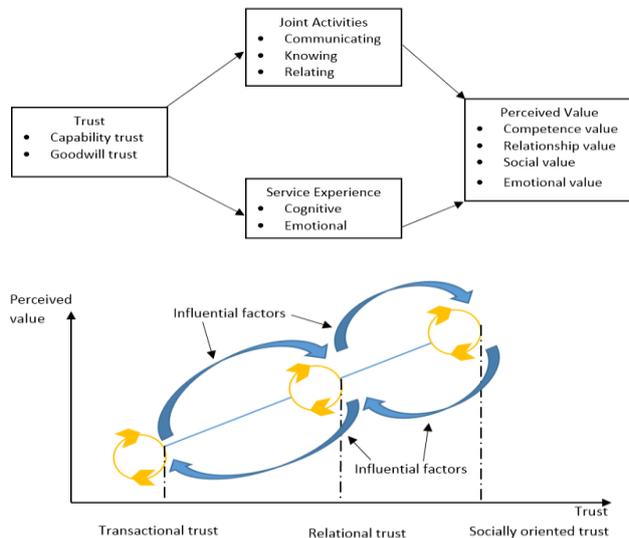


Figure 4 Conceptual relationship between trust and value-in-use

Consequently, customer experience and the perceptions of value will change as trust develops; the higher level of trust the customer has of a service provider, the more value from that service is perceived by the customer. Trust is more likely to reach socially oriented level under S-D settings because the diverting attention from project to service and from tangible competences to intangible competences enables MC to consider SCs with superior operant resources rather than operand resources alone as an extension of their own resources. Relational investment as trusting behaviour is more likely to occur such as skill enhancement and repeat businesses.

CONCLUSIONS

This paper sheds light on the value of trust in value creation process in construction supply chains, in particular relationships between main contractors and second tier subcontractors. This is thought to be the first paper to explore the value of trust through S-D. It has focused on value derived from operant resources using operand processes of co-creation. It has concentrated on downstream supply chain relationships, MC-SC relationships, as an under-researched area. The S-D logic as a substitute for P-F explains value created both within and beyond project lifecycles by focusing on service, operant resources and relationships. Trust as a relationship foundation to facilitate communication, knowledge sharing and relating enables the process of value co-creation, hence enhancing service value in ways such as producing customised service and effective learning over project lifecycles. A model of trust that illustrates the breadth and depth of trust dimension was developed, with the aim of facilitate future empirical research on how trust dynamically affects the value co-created in construction supply chains

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PARTNERING IN CONSTRUCTION: A FIELD STUDY TO FURTHER DEVELOP THE FRAMEWORK OF SUPPLY CHAIN INTEGRATION

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According to Eriksson (2015) ‘there is still a lack of comprehensive conceptual and practical frameworks that enable both a detailed and systemic understanding of integration in project-based supply chains.’ He therefore developed a theoretical framework that includes the four dimensions of strength, scope, duration and depth of integration. In this study we used this framework to describe four cases on relatively small scale (1M - 12M Euros) social housing refurbishment projects which are delivered through strategic partnerships. The data was collected through field research. The aim of this study was to further test the four levels of integration on their usefulness and to further elaborate on what could be added to the framework and how to operationalise its dimensions. It's our aim to use this operationalisation for an overarching study. In general, we think this framework provides a useful instrument in describing the level of integration in project based supply chains. We conclude that it is comprehensive in regard of critical elements that influence the performance of the partnership. Additionally, we found elements that can be added to the framework.

Keywords: strategic partnering, supply chain integration, collaboration.

INTRODUCTION

The physical nature of construction products; the loose and often adversarial relations between supply chain actors; the organisational structure in terms of the separation of design and production, and growing degree of specialisation makes construction industry (CI) an environment that severely restricts team learning which in turn is deemed to lead to its poor performance (Miozzo and Dewick, 2004; Vrijhoef, 2011). To overcome these problems, supply chain partnering (SCP) is often promoted as means of improving performance by establishing close relationships and integrating activities between supply chain actors (Vrijhoef, 2011). While the application of SCP seems like a logical step forward for the CI, this industry is having problems in managing partnerships and obtaining the intended improvements (Briscoe and Dainty, 2005). More recent literature reviews on the relationship between supply chain integration and performance which indicate that the results are mixed and not very convincing (i.e. Fabbe-Costes and Jahre, 2007). According to Eriksson (2015) this is due to a lack of comprehensive conceptual and practical frameworks that enable both a detailed and systematic understanding of integration in project-based supply chains. Therefore, Eriksson developed a theoretical framework which describes the integration in project-based supply chain teams along four dimensions. First, the strength of integration: the extent to which integrative activities are carried out within

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a team such as formulation of joint objectives and follow-up meetings. The second dimension is the scope of integration, referring to the number and nature of supply chain partners and their interdependencies. The third dimension concerns the duration of integration. The duration of construction projects facilitates strong integration within one project, particularly if partners collaborate over many project stages and get early involved. Finally, the depth of integration reflects the extent to which integrative activities are performed jointly. For instance, many partnering arrangements only involve the higher managerial levels and do not consider personnel at lower hierarchical levels.

Eriksson used his framework on large scale industrial projects. In this study we applied it on four relatively small scale (1M - 12M Euros) social housing refurbishment projects that were delivered through strategic partnerships. These strategic partnerships were characterised by high levels of integration on all four levels. Therefore these cases appeared suitable to further investigate the four levels of integration on their usefulness, to further elaborate on what could be added to the framework, and how to operationalise its dimensions when they are used in this particular context. We aim to use this operationalisation for an overarching study in which we aim to further investigate the relation between the organizational team setting and psychological processes in collaborative construction teams that are working on housing refurbishment projects and link them to team performance.

This paper is structured as follows. In the next section the research method is explained. Then, the four cases are described using the framework of Eriksson. The following section explores the differences within and between the four cases using the framework of Eriksson as a guide. In this section we have aimed to focus on adding elements that are not present in the framework as yet, or that may deepen our understanding on how to operationalise its dimensions. In the final section, conclusions are drawn and theoretical contributions to the framework are discussed.

METHOD

We aimed to investigate the four dimensions of integration and their interaction how they actually occurred in a project. Therefore, we have taken a participative observation approach in which the researcher (1st author) became part of the project team. The participative observer collected data by participating in the daily life of those who were studied for a considerable period of time (Bryman, 2008). This involves 'direct and sustained contact with human agents, within the context of their daily lives, watching what happens, listening to what is said, asking questions, and producing a richly written account that respects the irreducibility of human experience, that acknowledges the role of theory as well as the researcher's own role, and views humans as part of the object and subject' (Pink *et al.* 2013). There are various ways of characterising participant observation (Kawulich, 2005). In our cases the researcher took the role of team coach who works for a consultancy firm. Together with one of the directors of this firm, he coached the strategic partnership. The director coached the management team and the researcher coached the project team. Through his role the researcher became a full and active member of the project team. Because the observer is so closely involved, it 'permits the investigator to experience and observe the group's norms, values, conflicts and pressures, which (over a long period) cannot be hidden from someone playing an in-group role' (Hargreaves and Hargreaves, 2006, p. 139). To guide us in our study, we used prior research on supply chain integration by Vrijhoef (2011) and Vrijhoef *et al.* (2014). We used the concepts

from these studies as sensitizing concepts to provide a starting point for this study. In this paper we eventually used the framework recently published by Eriksson (2015) to present our findings because this framework mainly focusses on the integration in project-based supply chain teams. This focus fits the overall aim of the overarching study.

Case selection

To increase our understanding and uncover areas for further research, multiple cases were analysed to explore differences and conformities within and between the four cases (table 1). For this research we selected ‘extreme’ cases in regard of the level of supply chain integration. We were able to participate in four strategic and highly integrated partnerships. The partnerships are setup by four different Dutch housing associations which gives these projects a similar cultural context. This has enabled to focus mainly on the differences and conformities how the partnerships were implemented. When we look deeper into the project characteristics, we see that these characteristics vary considerably in terms of monetary size and complexity. These differences gave the chance to see how project characteristics affect the dimensions of integration.

Table 1 Project description

	Project A	Project B	Project C	Project D
Size of HA/ location in NL	8.500 houses North/East	10.500 houses South	32.700 houses North/West	27.500 houses South/West
Type of houses	row houses	row houses	apartments	row houses
Year or constr.	1920's	1965	1940's	1940's
Project size	26	100	189	79
Year project	2012	2012	2013/2014	2014/2015
Description of the work	Insulation of facades, new roofs, restoration of window frames and window shutters, specialist re- pointing and brick restoration, new chimneys and new glazing.	Abatement of asbestos, renovation of chimneys, roofing, new insulating glass with ventilation grilles, insulation of floors, painting of windows and doors. Tenants could choose for new bathrooms, kitchens and/or toilets.	Insulation of facades, new aluminium window frames, new roof finishing, PV- cells, restoration of concrete balconies, new mechanical ventilation and central heating. Tenants could choose for a new kitchen and/or bathroom. Layout of the apartment could be changed.	Chimneys, roofing, new window frames with ventilation grilles, insulating glass, new doors, new mechanical ventilation and central heating, impregnation and insulation of facades. Tenants could choose for new bathrooms, kitchens and toilets. Layout of the houses could be changed.
Specific technical issues	Monumental	N/A	Regarded as monumental	N/A
Procurement method	Strategic partnering	Strategic partnering	Strategic partnering	Strategic partnering

Data collection and analysis

The researcher was an active member of the project team. Every team meeting the researcher was present. As a member of the team, the researcher received the project team e-mails and had access to the documents on the projects' websites. Therefore, the researcher was able to follow the project and the project team on a daily basis. The researcher spent a considerable amount of time with the team members to gain their

trust. This position gave the researcher the opportunity to get their reflection on observations and to gain insight in their real ideas, thoughts and intentions. Together with the other coach, the researcher gave workshops, did evaluations and executed specific interventions to help the project team to develop mutual goals, team spirit and a joint process. It also gave us a deeper understanding about how people interpreted situations and behaviours of others.

CASE DESCRIPTION

This section describes the four cases by partnering using the 4 dimensions of integration proposed by Eriksson (2015).

Table 2 The four dimensions of integration in project A-D

Dimensions	Project A	Project B	Project C	Project D
Strength	Partners selection: Based on past experiences. The SC's were selected by the client and GC together. Payment/Performance: GC and SC's had similar payment schemes open book accounting for direct and indirect costs. Pain/Gainshare contract on the riskfund and profit. Payout is connected to project goals. Integrative activities: startup workshop, joint objectives, joint IT tools, facilitator, weekly project team meetings, monthly management team meetings, concurrent engineering, lean methods.	Partners selection: Partners GC, SC-E, SC-HVAC, SC-P, SC-A/D were selected based on past experiences on conventional project. The SC's were selected by the client and GC together. The SC-R was selected based on experiences of a neighbourhood housing corporation. Payment/Performance: Same as project A. Integrative activities: Same as project A	Partners selection: GC was selected based on past experiences on conventional projects. SC-E, SC-HVAC, SC-P are (daily) maintenance partners of the HA. Payment/Performance: Same as project A. Integrative activities: Same as project A + use of BIM 3D tool. The joint IT tools to share information was abandoned by the project team. The use of a BIM tool, which was mandated by the client, led to a lot of frustrations within the project team.	Partners selection: GC, SC-P/G/W were selected based on past experiences on conventional projects. SC-HVAC was involved through the GC (the preferred SC-HVAC of the housing corporation did not have time). Payment/Performance: Same as project A. Integrative activities: Same as project A + use of IT Take in tool to record current state of the buildings.
Scope	project team: C-PM, C-BS, C-PrM, T-R_client, T-R_tenant GC, SC-P/G/W, SC-M, Mun-M partially involved: ECO, Cost, D-O	project team: C-PM, C-BS, C-PrM, GC, SC-E, SC-HVAC, SC-P, SC-R, SC-A/D partially involved: ECO, Cost, D-O	project team: C-PM, C-BS, C-PrM, A, BIM, E-BS, E-S, GC, SC-E, SC-HVAC, SC-P, SC-A/D partially involved: ECO, Cost, T-R_b	project team: C-PM, C-PrM, T-R_tenant and b, GC, SC-E, SC-HVAC, SC-P, SC-P/G/W partially involved: SC-A/D, Cost, A, D-O, E-BS

Depth	High hierarchical levels in management team. Project managers and work planners of GC and SC's are part of project team together with repr. of the client and tenants. Foremen/blue collar workers: were involved in design.	Structure is the same as project A.	Structure is the same as project A. The SC-A/D was added later. This partner was critical due to the high risk of asbestos. Foremen were invited too late to the design table. This led to last minute changes.	Structure is the same as project A.
Duration	Involvement: Whole project team was involved from the feasibility stage until final delivery. Long term: The strategic partnership was continued with all partners on a similar project. After this 2nd project, the strategic partnership was asked to do another 3rd project.	Involvement: The project brief was made by the C-PM, C-PrM and E-BS. The project team was established soon after. Together with the project team, design scenarios were investigated and matched with the budget. Long term: The strategic partnership was continued with	Involvement: Only A, GC, E-BS and E-S were involved in feasibility study that took more than 2 years due to unclear goals that came from the board of the housing corporation. The project team was established soon after the project brief and budget was established. Long term: Due to a change of	Involvement: The project started as a conventional project. Only E-BS and A were involved in feasibility and concept design. Strategic partnership was setup after concept design. The concept design was largely abandoned due to budget constraints. Long term: The HA ended this strategic partnership Main reasons are: (1) awareness of
Project results	Costs comparison feasibility-realised: The project budget was 1,2M. Capital costs in the end were 1,0M euros (-16%). Cost comparison with traditional: Capital costs were 6,9% lower. Project time: 5 months to make the design and to prepare construction. Construction took 4 months. A traditional project would normally take about 18 months in total. Quality: The aim was to reach label B. This label was reached. Tenant satisfaction: was regarded as very high in comparison to average. Defects: Unknown.	Costs comparison feasibility-realised: budget 2,5M euro's. The project was delivered for this amount. Cost comparison with traditional: Capital costs were 26,7% lower. Time: 4 months to make the design and to prepare construction. Construction 6 months. A traditional project would normally take about 18 months. Quality: aimed energy label was level C. Lower D label was reached. Tenant satisf.: very high in comparison to average. Defects: av.6 per house. This is low.	Costs comparison feasibility-realised: Budget 12,1 M euro's. The project has been delivered for 10,5M euros (-12%). Cost comparison with traditional: Unfortunately no comparison was made. Time: 6 months to make the design and to prepare constr. Construction took 10 months. Planned time to prepare. was 12 months and the planned time for construction was 18 months. Quality: After feasibility the aimed Energy label was level B. Higher overall label A was reached. Tenant satisf.: was low for the first 40 houses. Defects: unknown.	Costs comparison feasibility-realised: Full budget was used. Cost comparison with traditional: Unfortunately no comparison was made. Project time: It took the project team 3 months to make the design and to prepare construction including all needed permits. Construction took 5 months. A traditional project would normally take about 12 to 14 months. Quality: n.a.(raising energy label was not a priority) Tenant satisfaction: above average. Defects: 2,6 defects per house. This is very low.

EMPIRICAL FINDINGS

In this section we explore the differences within and between the four cases using the framework of Eriksson as a guide. In our description we've tried to focus on elements that are not present in the framework or that might deepen our understanding on how to operationalise its dimensions.

Strength of integration

In all four cases the general contractor (GC) was selected by the client (see table 2). The selection of specialty contractors (SCs) is done by the client, the GC or they select SCs together. In the cases where the GC and the SCs are selected by the client directly, based on earlier experiences, we see that there is a basis of trust which has a positive effect on learning behaviour in the project team. Team members are more open to each other, questioning the client's goals, having productive discussions and helping each other in their search how to work together as a team. In case D where a specialty contractor HVAC (SC-HVAC) is selected unilateral by the contractor, we see that this partner shows less learning behaviour than the partners in the other cases. This might have to do with the more conventional relation that is set by the way this partner was selected.

In terms of project goals, we see that a client needs time to make sense of what he wants achieve on one side, and what can be delivered by the partners for the available budget on the other side. Using a design method that gives options to the client, like a set based design method in combination with target costing, can help the client in making sense of what he's aiming for in the project. In regard of joint objectives, we see that it is important not only to talk about the project goals, but also about how the partners want to work together in achieving these goals. Most partners hardly know each other and have never worked before in a project team setting from a very early phase. They simply need to learn how to work together in this setting.

In terms of contracting, we implemented similar contractual conditions in all four projects. We've seen that applying open book accounting (activity based costing) poses some problems. It takes most partners almost a whole project to really understand how the open book approach should be applied within the own organisation, between the partners and on the project. The same learning period is needed for pain/gain share mechanism in combination with the risk fund. Most construction partners in our cases are relatively small companies that are used to working with fixed price contracts. They hardly have experience with these type of arrangements. Therefore, the incentives are not really felt because the teams are busy understanding how the mechanism works and how to get it implemented. Incentives can also take a non-financial form. In our cases a non-financial incentive was set on the duration of the partnership. When the project would reach its goals, it was the client's intention to give the partnership a follow up project. We found this incentive to have a higher impact, because it is understood almost directly by the partners in the current economic conditions.

Next to contracting related mechanisms, all four projects used integrative activities and technologies. In general these activities are seen as effective, except for the use of joint IT tools. In project C we've seen the use of BIM was more of a hindrance than a help to making an integrated design. Most of the programs the partners were using did not communicate very well with the BIM program. Also, the BIM was seen as redundant. As put by one of the partners: *"the as-built-model is standing outside. We should be looking at building instead of an incomplete model"*.

Scope of integration

The structure of project teams in our cases is largely different from the team structure in conventional projects. In general, the general contractor and several specialty contractors become part of the project team from a very early design phase in which they participate in making the design. Because the general contractor and specialty

contractors take over part of the design work, we see the role of consultants being diminished. Only for very difficult design problems or tasks that require very specific knowledge, skills or artefacts a consultant is requested to join the project team.

The choice for a particular specialty contractor is mainly determined on the type of (specialists) works that need to be performed and the expert knowledge that is required to make the design or to identify and manage potential risks. An example is the asbestos abatement contractor. This specialty contractor is generally seen as a crucial partner in refurbishments projects with a high risk for asbestos.

A potential partner that is often forgotten in literature, but can be very crucial when it comes to making design related decisions are the authorities. In project A the building inspector for monuments was part of the project team. Although this partner was not part of the multi-partner agreement, he had a critical role in making a design that would be accepted by the commission for monuments of the municipality.

When we look at the level of internal integration (i.e. functions), we see that different departments of the client are represented in the project team. From the project department, the project manager and often a building supervisor take part in the project team. From the asset management department, which is the internal client (owner of the buildings), a property manager takes place in the team. We've seen that having the different departments of the HA in the project team is very important for the speed of the project. It takes time for a project team to understand what the client wants to achieve. Having the possibility to have a direct discussion with this client has a positive effect on this process. When we look at the supply side to the general and specialty contractors, we often see two internal departments (or functions) taking part in the project team. The first has to do with the planning function, the second with the construction function. Depending on the size of a company, these functions are divided between one or more people. Also, when the company gets larger, a project manager is appointed to manage the team of that particular partner.

When we look deeper into our cases we see that integrating too many specialty contractors can lead to problems. In project C there were three installation contractors taking part in the partnership. All three contractors were able to do all the installation works (i.e. mechanical, ventilation, plumbing and electrical). This led to discussions in task division in the project team. Also, during construction more coordination was needed than normally.

There is also a possible relation between the size of the different companies that take part in the partnership and the effectiveness of the project teams. In project C we worked with a relatively large HA. Also the specialty contractors that were involved in this project were large companies when we compare them to the companies that were involved in project A and B. We observed that in project C communication was more hampered due to the longer lines of communication when we compare this to project A and B.

Duration of integration

The project stage in which partners got involved was different per project (see table 2). In project D the client made a concept design with an architect before setting up the strategic partnership. What we've seen in project D, is that the partners ideas get framed by the concept design; the partners take the concept design as a given point that should be further developed into a detailed design. This more or less blocks the creative design process in which different design solutions are itemised, priced and

considered. In project C, we've seen the concept design made by the contractor and the client led to similar effects as in project D. The specialty contractors got into a sort of (traditional) "you tell us what to do"-mode instead of "we think you should do this and that"-mode. In project A and B the partners got involved directly after the client made a rough feasibility study. We see that involving specialty contractors in this early phase provides the opportunity for timely integration of their knowledge into design. It also helps in the early identification and solving of design problems. Involving these partners early, also makes concurrent engineering and prototyping possible; the partners can use one or more vacant houses to test their ideas. Altogether, we see this helps to build a common understanding of what needs to get done before construction commences.

Both the partnerships that delivered project A and B still exist today. We see these teams are working much more effective than in the first project. Team members know their role and are more aware of each other's capabilities. Also, the partners trust each other and each other's artefacts more. When we look at the organisational level, we see that overhead-staff in the project has been reduced. In the past, every partner had a project manager present in the project team. Now only the project managers of the contractor and the client are managing the team.

Depth of integration

In all four cases a management team (MT) and a project team (PT) are setup. The MT acts as the board of the strategic partnership. The PT manages the project on a daily basis. The MT comprises department managers of the HA and mainly directors of the supplying partners. In the early design phases, the PT comprises projectmanagers, planners, representatives of the clients' departments and in some cases end-user and building inspectors were also present in the team. When the design becomes more detailed, also site managers and foremen become part of the PT. We've seen that having this MT-PT organisational structure helps the project team. The directors are jointly informed about the project progress and important issues. Problems with regard of resources or issues between individuals can be discussed and decisions about how to deal with these issues are jointly taken. This MT-PT is also helpful in the change process that is going on. Strategic partnerships are uncommon in the Dutch construction industry. It takes time for the partners to learn how to work as one 'virtual' organisation. To aid these partners, coaches get involved on a MT and PT level. When there are problems between individuals in the PT, the coaches get in contact and, if needed, can inform the MT about the situation. Also, when a MT-member is not acting in the spirit of the partnership (i.e. following its own agenda instead), this is often felt in the PT.

An end-user (tenant representative) can take part in the project team or be closely involved. This representative can be someone that works for the HA (i.e. tenant consul) (project A), can come from a tenant (sounding) board (project A, C and D), or can be one of the tenants that lives in the buildings that are being refurbished (project A and D). The role of the end-user in this process has two sides. Where the tenant was part of the project team, we've seen that this helped the team in understanding their position and problems, but it also hampered the team in having open discussions about sensitive issues. In project A and D, this led to situations where other team members did not participate in certain discussions because they did not feel safe to share their sensitive knowledge on particular issues with a tenant sitting on the table. In project A, team members agreed that in the follow up project two different meetings should

be held: one technical meeting in which sensitive issues could also be discussed openly, and one meeting with the tenant in which tenant issues could be discussed and the tenant could be informed about project progress.

The input by the site manager and foremen on the design highly valued in the cases were they had to chance to make one or more prototypes when the design reached the phase of being detailed. Key in this process is (1) timing, i.e. the moment the prototypes are built, and (2) the ability and opportunity to draw lessons and translate them into the design. In case C the lessons learned from building a prototype led to a major change of the installation design which saved a few thousand euro's per apartment (189 apartments). However, the timing was too late. Due to a lack of unoccupied apartments, the prototypes were built just before construction commenced. This late change in the design affected the throughput time of the first 20 apartments.

CONCLUSION

In this study we observed four project teams working in a strategic partnering setting which could be seen as highly integrated on all four levels of integration. The levels of integration were based on the framework of integration in project based supply chains made by Eriksson (2015). This framework includes the four dimensions strength, scope, duration and depth of integration. The aim of this study was to further test the four levels of integration on their usefulness and to further elaborate on what could be added to the framework and how to operationalise its dimensions.

In general, the framework appeared to be very useful in describing the level of integration in project based supply chains. We feel that it is comprehensive with regard to critical elements that influence the performance of the partnership. However, we also found some elements that could be further deepened. When we look at elements that describe the strength of integration we see that team level factors that influence the performance are generally lacking in the framework. In terms of contracting, we would widen the concept of incentives from merely being financial to other forms of incentives. Looking at integrative activities, we have seen that the use of ICT tools in our cases was not always a success. Therefore the framework should not only measure if ICT tools are used by more than one partner, but also if these ICT tools are effective as a means for managing particular information in a multi user environment. Looking at the elements that describe the scope of integration we think that the framework should not only look at the nature and number of companies, but also to the size of these companies and their past experience. Further, although few parties are not considered to be part of the multi-partner agreement, stakeholders (e.g. building inspector) that can influence the project directly or indirectly, should be added to the framework, because they could prove to be critical in certain type of projects. In regard of the elements of duration of integration we expect a strong relationship between the moment a partner is involved and performance delivered. When we look at our cases, this affect will probably be the highest in between the concept phase and later design phases. What is critical in this regard, is the amount of influence a partner can have on the design. When we look at the depth of integration we found that end-user involvement can be a good, but also a negative factor depending on the way the end-user is involved, whether in the project team or more at a distance. We have also seen the positive effects of the involvement of production personnel in the design phase. However, timing and the ability to draw lessons of their involvement are very critical to squeeze every possible benefit out of this.

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THE IMPACT OF THE RECENT ECONOMIC RECESSION ON THE NEC CONTRACT IN NORTHERN IRELAND: A PRELIMINARY STUDY

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In comparison to the rest of the United Kingdom (UK) the Northern Irish Construction Industry was disproportionately affected by the recent economic recession. During this period, use of the New Engineering Contract (NEC) has proliferated in the public sector, however no study has been undertaken to examine the impact of the recession on this contract in Northern Ireland. The aim of this paper is to explore NEC contract implementation in Northern Ireland and the impact of the recession on its operation. A qualitative methodology is adopted using a literature review and semi structured interviews with six construction professionals. Qualitative analysis identifies themes and issues arising exploring connections between them using thematic coding. The initial findings are that the introduction of the NEC contract in Northern Ireland makes demands of contractors and consultants in terms of additional resources and training. Some consultants show a clear lack of understanding of the contract. Whilst there is general agreement that the contract does help to stimulate good project management, the interviewees find the contract time consuming and complicated to administer, describing it as *“unforgiving for the architect and unforgiving to the contractor.”* Due to the impact of the recession, both contractors and consultants are still reporting a drop in income from pre-recession levels. Project resourcing levels have dropped significantly since the onset of the recession. Adversarial and opportunistic behaviour has increased. Many consultants and contractors are struggling to adequately administer the NEC contract at current income levels. The introduction of the NEC contract and the economic recession have exerted opposing forces on the implementation of the contract, hindering its execution. As the pressures exerted by the economic recession abate and a greater understanding of the contract develops, these opposing forces will ease leading to a more consistent implementation of the contract.

Keywords: NEC, procurement, recession.

INTRODUCTION

The New Engineering Contract ('The NEC Contract') was originally drafted with a view to increasing the efficiency of the Construction Industry in the United Kingdom (UK) and promoting and delivering a new culture of cooperation and openness across the industry (Eggleston 2006). The NEC contract requires parties to act in a spirit of trust and mutual cooperation. In prosperous times this is difficult to achieve as often contractor and client want different project outcomes, but when profits are scarce and resources restricted, relationships can be impelled towards adversarial behaviour (Williamson 1975).

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In May 2006 the NEC contract was introduced as the public sector preferred contract in Northern Ireland, coinciding with a time of unprecedented economic growth (Verick and Islam 2010). This was followed shortly by the collapse of the US Subprime mortgage market in 2007, which in turn led to the 2007 - 2009 recession; the worst in six decades (Verick and Islam 2010). Since this economic downturn, Northern Ireland is slowly starting to emerge from recession. The results of the economic contraction have been particularly pronounced and impacted profoundly on the Construction Industry (Eadie *et al.* 2013). Although the negative impact of the immediate recession is receding in some areas, its effects are still being keenly felt in Northern Ireland (DFPNI 2014).

In light of this, this study aims to explore the effect of the economic recession on the operation of the NEC contract by exploring (1) early experience of the NEC contract in NI; (2) the contract's impact on resourcing, trust and cooperation; (3) experience of the recent economic recession; (4) the effect of the recession on resourcing, trust and cooperation.

This study will lead to a better understanding in academia and industry of situations where implementation of the NEC contract may be hindered, due to financial and resourcing constraints. Although only a preliminary study, this will form the basis for a future quantitative study, which is currently on going. Whilst some research has examined the impact of the recession on the construction Industry (Tansey *et al.* 2013; Eadie *et al.* 2013; Lowe and Moroke 2010) and others have looked at the implementation of the NEC contract (Broome 1997; Hughes and Maeda 2002; and Meng 2014), none have specifically examined the interaction of the two factors thereby creating a knowledge gap in the field. Although this study is based in Northern Ireland, it has wider applicability as the constraints imposed on resources by the economic recession were experienced across the UK and further afield.

THE NEC CONTRACT

The first NEC contract was published by the Institution of Civil Engineers (ICE) in 1993 with three aims: to have clarity and simplicity, flexibility of use and to act as a stimulus to good management (Gerrard 2012). It was intended to herald a new approach to construction contracts, discouraging adversarial behaviour and promoting cooperation (Eggleston 2006).

Writing in the aftermath of the early 1990s recession, Latham found that a lack of resources could lead to a dearth of trust (Latham 1994). He observed that the construction industry was inefficient, fragmented and held back by persistent problems. His recommendations to improve performance and teamwork included, among others, the use of the NEC contract, which most closely matched the principles he was espousing. He recommended the NEC contract be amended, stating that, in order to be effective, a modern contract should have “*a specific duty for all parties to deal fairly with each other...in an atmosphere of mutual cooperation*” (Latham 1994: 37). The NEC contract was duly amended and the second edition published in 1995.

In the early years of its use, studies, many funded by the ICE, observed that users found the contract easy to understand and agreed that its use encouraged greater cooperation (Broome 1997, Broome and Hayes 1997). However not all research was positive; Hughes and Maeda's study for the RICS (2002) called into question some of the founding principles of the contract, finding win-win contracts impractical and that reliance on trust introduces ambiguity. Members of the Law profession also found issue with the radically simplified language used (Eggleston 2006).

The NEC contract was amended a third time and published as the NEC3 suite of contracts in 2005. In this instance, the NEC3 contract was specifically endorsed by the UK Governmental Office of Government Commerce, for use in projects in the Public Sector. The delivery of the Olympic games facilities in 2012 using the NEC contract has been hailed as a success and held up as a precedent for its use; however not all NEC contracts have run as smoothly. Following the problems relating to the Cambridge guided busway project, Paul Blackburn in Stimpson (2011) argues that contract choice should be project specific. According to Doherty (2012) where the NEC contract fails, it does so in spectacular fashion. EC Harris (2013) and Doherty (2012) agree that failure to follow contract procedures, to provide resources to properly administer the contract and failure to understand the contract are major reasons why NEC contracts fail. In fact, the pro NEC lobby agrees broadly with this point, asserting that when NEC contracts fail, it tends to be due to the people operating it, not the contract itself (Gerrard 2012).

Bingham (2013) and Minogue (2013) criticise the incorporation of the requirement to work in a spirit of 'mutual trust and cooperation' as unenforceable; however Mason (2008: 4) argues that the 'good faith' clause in the NEC contract seeks to “*influence, rather than mandate*” behaviour. Without trust, it is difficult to achieve cooperation (Kadefors 2004). Trust is developed iteratively throughout a project (Smyth *et al.* 2010). 'Trust' has a different meaning to contractor and client groups and cannot be achieved through coercion or sanction (Pinto, *et al.* 2008). Good project 'chemistry' might lead to a reduction in the social distance between project participants, reducing the level of conflict, enhancing mutual understanding, motivation and morale (Nicollini 2002). The development of trust is dependent on the attitude of key individuals; it is difficult to build trust during one-off, short-term projects (Bresnen and Marshall 1998). Rooke and Seymour (1995: 2) describe the difficulty of building trusting relationships in a fragmented industry, illustrating it as fraught with “*mistrust suspicion and cynicism*”.

The socio economic environment has a large bearing on the development of trust within projects (Manu *et al* 2012). Rousseau *et al* (1998) linked trust with vulnerability, whilst Loosemore (1988) found during times of crisis, project participants attempt to minimise risk and reduce vulnerability. “*People do not perform well under prolonged conditions of insecurity and fear*” (Smyth *et al.* 2010) p120). Trust is undermined by socio economic conditions, which lead to adversarial, game- playing behaviour (Bresnen and Marshall 1998.) Khalfan *et al* (2007) found that, where the contract price does not relate equitably to the amount of work to be done, mistrust and suspicion are introduced to a contract. Taking a wider perspective, Tang and Koveos (2008: 1046) observed that societal cultural values are altered by prevailing economic conditions, finding that “*individualism, power distance and long term orientation*” have a relationship with GDP per capita on a national scale. These studies confirm Latham's hypothesis from 1994 that “*It is not easy to create teamwork in construction when everyone is struggling to avoid losses*” (Latham 1994: 9).

THE ECONOMIC RECESSION

The NEC 3 Contract was introduced as the public sector contract of choice in Northern Ireland in May 2006 during a historically high period of growth (Verick and Islam 2010). However, this was followed by a period of unprecedented volatility in the global and the UK economy.

On the 8th February 2007, the HSBC bank warned of losses incurred in the USA subprime mortgage market. Following a run on the bank, the Northern Rock received emergency support from the Bank of England in September 2007 and on the 15th September 2008, Lehman Brothers was declared bankrupt. The financial meltdown had spread from the US subprime market and led to the worst global recession in 60 years (Verick and Islam 2010)

In common with the rest of the UK, Northern Ireland experienced a sustained period of growth from 2002 to 2006. This period was followed by a prolonged period of contraction from 2007 to 2014. The quarterly construction statistics report released by the Office for National statistics in the third quarter of 2014 show that construction output in Northern Ireland peaked in 2007 and was 45.3% down on that level by late 2014. The number of jobs in construction fell by 37% between 2007 and the end of 2013. Construction Output in 2014 was at 86% of its average 2011 output, compared with 99% in Great Britain - thus reinforcing the point that Northern Ireland's construction industry experienced a longer lasting decline following the recession relative to the UK. Although there have been increases in output in some sectors, the decreases to other areas have outweighed the gains.

During previous recessions, the failure rate for construction companies has been double that of other types of company (Lowe and Moroke 2010). Insolvency lags behind economic recovery and Lowe and Moroke found that construction firm insolvency rates were still rising in 2010. Northern Irish construction companies tend to pursue cost leadership, leading to cost minimisation and cost reduction as a recession survival tactic (Tansey *et al* 2013).

Markets act imperfectly, not least because they are determined by human decisions, particularly in times of economic difficulty (Buchanan 2001.) Uncertainty in the marketplace, combined with bounded rationality, leads to opportunism and game playing (Williamson 1975). Opportunism - a lack of honesty and openness in transactions, springs from "*self-interest seeking with guile*" (Williamson 1975: 9). Due to bounded rationality and information impactedness decisions must be made using approximate information (Simon 1972: 170). Cousins *et al* (2008: 31) describes opportunism as "*achieving one's goals through calculated efforts of guile, lying, stealing, cheating, passing false information, distorting or disguising information and generally misleading the other party*". The main barrier to unfettered opportunistic behaviour which remains nevertheless lawful, is reputational damage.

Porter (1980) found that rivalry intensifies during periods of low economic growth and competitors are numerous. Competitors in a market are interdependent; in order to survive, price cuts by one company must be replicated by competitors leading to a race to the bottom. High exit barriers in the construction industry keeps firms trading when profitability is low, include reputation, history, reluctance to fold a family business and loyalty to an existing workforce. When a number of competitors 'hang on' in an industry where profitability is low, long term value in the entire industry can be driven down as a consequence (Porter 1980).

RESEARCH METHODOLOGY

In order to meet the aim of this research, it is necessary to identify and catalogue the required information, and thus lead to an informed discussion and conclusion. A qualitative approach is used in order to investigate the research aims identified by discussing the topic with those who have first-hand experience. This approach allows detailed exploration of the respondents' own experience in their natural context. It

permits complex factors to be probed and gives access to rich, deep data (Cresswell 2003) which can help to explain how the recession has affected the respondents, how they have reacted and why.

In order to gain grounding in the research area in focus, to ascertain a gap in knowledge and identify underlying literature and associated factors for consideration, a comprehensive desk based review of recent peer reviewed works is undertaken. Sources include peer reviewed journal publications, conference proceedings, books, web pages and articles regarding the NEC contract and economic theory. A review of published industry productivity statistics from 2005 to 2014 is combined with the literature review to inform questions asked during the semi-structured interviews and to support the data analysis.

To complement the literature and statistical review in addition to further explore the factors identified, in depth semi-structured explorative interviews are held. Semi structured interviews allow a focussed investigation of previously identified factors whilst permitting flexibility to explore issues arising from the respondents' experience which are not yet reflected in the literature. The interviews are carried out in person with six construction professionals in Northern Ireland between November 2013 and April 2014. Each interview lasts between 40 and 60 minutes. The prepared questions asked are developed from the literature and statistical review. The aim of the interviews is to probe issues relating to the respondents' experience of the recession, its impact on resourcing levels, competition and on the implementation of the NEC contract. The interviewees represent a broad cross section of the construction industry in Northern Ireland: an Architect, a Structural Engineer, a Contracts Manager, a Client who formerly worked for a large contractor, a Construction Adjudicator / Arbitrator and a representative of the Construction Employers Federation (CEF). This sample of convenience was formulated in an attempt to probe differing perspectives in the industry. The generalisability of the study is limited by the sample size and the qualitative approach used. Further research is ongoing using a mixed methods approach to substantiate the findings herein.

DATA ANALYSIS

To accurately catalogue the individual interviews, each is digitally recorded and transcribed verbatim. The transcribed interviews yield a total of 64 pages and 28,404 words of information which is analysed using NVivo version 10. The interviews are coded and sorted with emerging themes and relationships developed. Axial Coding (Strauss and Corbin 1998) is then used to relate codes to one another, to refine and develop categories and explore connections and links between them. These codes underline the main issues arising from the data.

Through the process of analysis and coding of the data, two main categories 'NEC Contract' and 'Recession' emerged, with nine sub categories and 34 further sub categories associated with the central themes.

DISCUSSION

The NEC Contract

Experience of the NEC Contract

Reception of the contract is balanced, with discussion of advantages and disadvantages. A single form of contract used across the public sector is hailed as a victory for consistency by the CEF representative, whereas the arbitrator feels that unsuitable projects were being 'shoehorned' into the NEC contract. Some contracts are

so heavily amended that the Z clauses are longer than the contract itself, and that the contracts are NEC in name only.

Several interviewees refer wistfully to the familiarity and comfort of old, familiar contracts and resistance to change to a contract where *“they don't know the intricacies, don't know which clauses are important...”* The Architect describes it a contract *“for painting lampposts”* whilst the arbitrator calls it *“an engineers' conceit.”*

Trust and cooperation

Most interviewees take the requirement to act in a spirit of trust and mutual cooperation with a pinch of salt, for example the arbitrator memorably describes it as *“absolute drivel.”* The Contracts Manager, Arbitrator, Architect and public sector client agree that trust and cooperation on a project depends more on the personalities involved in the contract than on the contract used (as also found by Bresnen and Marshall in 1998). The Contracts Manager finds that if you come across someone *“...who wants to be confrontational all the time well there's not much you can do about that.”* Regarding the stipulation to act in a spirit of trust and cooperation, he says *“It's very nice words but it means nothing. Means nothing at all.”*

Stimulation of good project management, more onerous contract administration

It is felt that the contract does encourage better project management across the board, with an appreciation of the value of early warning and compensation event mechanisms; however this leads to more onerous contract administration. The CEF representative feels that the NEC contract puts responsibility onto the client and consultants in terms of compliance with timescales, giving more power to contractors. The architect finds that the NEC is a very 'admin intensive' contract, describing it as *“unforgiving for the architect and unforgiving to the contractor.”* The Contracts Manager cites more frequent programme submissions and the architect dealing with early warning and compensation event claims as the main generators of additional paperwork in comparison to other contracts.

New contract, lack of understanding

The CEF representative describes a 'race' between contractors and consultants to train for the introduction of the contract, with a commercial advantage accruing to those who are better prepared. In the experience of several interviewees, there exists a significant minority of consultants who do not understand the contract nor operate it as it was intended. The maturity and depth of understanding of the contract in Great Britain is contrasted with that in Northern Ireland - as one interviewee puts it *“we're feeling like abused children because here contractors are getting mistreated by people abusing their role and authority...The consultants then aren't on top of it...”* The Contracts Manager describes a contract which *“...had absolutely no resemblance to NEC whatsoever it was run completely like a JCT contract, because none of the consultants had any idea about the NEC.”* This factor is troubling, as Gerrard (2012), EC Harris (2013) and Doherty (2012) agree that lack of knowledge of the NEC contract is a major contributory factor when it fails. Although this state is dissipating with time and experience, this indicates a need for more widespread NEC training particularly for consultants.

The recent economic recession

Experience of the recession

All of the interviewees are still suffering as a result of the recent economic recession. During the recession many clients became cost focussed *“when the market gets tighter*

and tighter and clients have the whip hand ...and they know they can squeeze the price down and that's all they're interested in." Some clients concentrated on price at the expense of long term value. This downward pressure, exerted by clients and contractors alike is described by the CEF representative as 'industrial suicide'. In 2014 a policy was introduced in Northern Ireland to exclude Abnormally Low Tenders on below EU threshold public sector tenders, however this was described as a legal 'grey area' (Golden, 2013) and after several legal challenges the wording of this policy has been watered down.

Reduction in income, resources and staff - consultants

Porter (1980) found that competition intensifies during periods of low economic growth, leading to income reduction and long term value suppression. In accordance with Porter's theory, the consultants report a drop in fee income. The fees on education projects are thought to be particularly low, with the combined team fee of a recent large school using the NEC contract rumoured to be as low as 2.5%. Over the last 7 years the Structural Engineer's fees have dropped by 30% and his staff have dropped from 17 in the office to 6, with the loss of his whole civil engineering department. Work in Great Britain and Africa is keeping his business afloat. The architect, working primarily in social housing, finds that fees have been squeezed yet at the same time clients have introduced stringent sustainability targets and the NEC contract. Exacerbating the problem, many individuals made redundant from large consultant firms have set up in business with very low overheads, competing for smaller scale projects and further driving down fees. This has led some consultants to cut corners - *"if consultants were to do the job properly they'd not be competitive – they'd never win the job."*

Reduction in income, resources and staff - contractors

Contractors fare no better. In 2013 several prominent contractors went out of business, having exhausted the last of their capital reserves. The CEF representative talks of the 'implosion' of the industry with members fighting for survival, with 'crazy' tender prices. Late payment is rife and fair payment charters seem to have little or no effect, with some of the biggest culprits being Public sector clients. This has led to a situation where *"prices are at an all-time low, profit margins are non-existent."*

Contractors maximising profit by any means as a survival tactic

Contractors will lose money if they have to stick to their tender figure. Corner cutting by consultants when assembling tender documentation has opened the door to claims by contractors. This situation has led contractors to aggressively squeeze contracts to gain profit as a survival tactic. The normal 'give and take' and 'letting mistakes go' in the interests of maintaining long term relationships has more or less stopped. Subcontractors are exploited and the consultants do not always have the resources to check or correct aggressive behaviour. The public sector client finds this means *"the spirit of trust of partnership is gone"* and that contractors are taking advantage of the contract and contract discrepancies *"by any means that you possibly have, because it's the survival of your business."* The arbitrator remarks that this had led to an increase in disputes. The interviewees' experience bears out the findings of Bresnen and Marshall (1998), Khalfan *et al* (2007) Loosemore (1988) and Manu *et al* (2012), that adversarial behaviour tends to increase and trust to decrease in times of economic difficulty.

Adversarial nature of the construction industry in Northern Ireland

All of the interviewees at some time mention the adversarial nature of the construction industry in Northern Ireland. Although Northern Ireland is a small market with much repeat business between project participants, it 'leads the way' in public sector procurement challenges. According to the public sector client: *“When we don't get our piece of the pie, we kick up a fight and scream. And that is inherent to this corner of the island.”*

These emerging themes can be amalgamated and summarised in the preliminary model shown in figure 1.

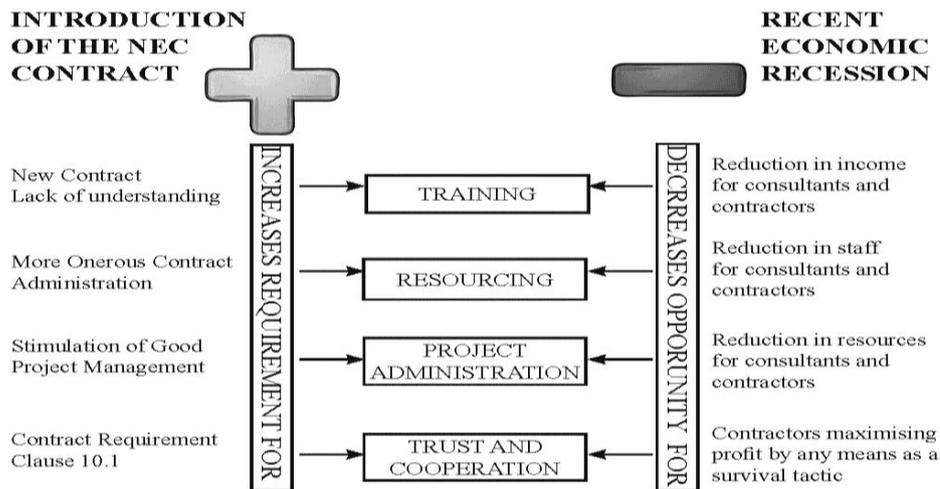


Figure 1: A preliminary model of the forces exerted by the introduction of the NEC contract and the recent economic recession

CONCLUSIONS

When they first designated the NEC contract as their contract of choice in Northern Ireland in 2006, the Northern Irish Central Procurement Directorate could not have known that the province was on the brink of the worst recession in living memory.

The aim of this research was to explore NEC contract implementation in Northern Ireland and the impact of the recession on its operation. The initial findings of this study, summarised in Figure 1, indicate that in the experience of those interviewed, the operation of the contract has been restricted by two counteracting forces. The introduction of the NEC contract to Northern Ireland increased the requirement for training, increased project administration, increased the requirement for project resourcing and introduced a contractual requirement to act in a spirit of trust and mutual cooperation. The onset of the recent economic recession exerted opposing pressures, reducing project resourcing, increasing adversarial behaviour and opportunism; thus hindering the implementation of the contract. This echoes Latham's hypothesis that a lack of resources will lead to a reduction in trust, a view endorsed by Williamson (1975) and Cousins *et al* (2008). These opposing pressures are dissipating with time as the economic situation improves and a greater understanding and experience of the contract develops.

Generalisable findings cannot be drawn from this size of sample; however it does give an insight into the experiences, perceptions and concerns of a number of construction professionals working with the NEC contract. Preliminary conclusions and implications for practice can be identified from the research whilst indicating the need

for further research. These findings will form the basis of a follow on quantitative analysis of the issues raised with a much larger sample using a questionnaire informed by this study. This will aim to test whether these findings can be applied more widely within the Northern Irish construction industry and further afield.

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A SUSTAINABLE INFRASTRUCTURE DELIVERY MODEL: VALUE ADDED STRATEGY IN THE NIGERIAN CONSTRUCTION INDUSTRY

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The current economy reforms strategy by the Nigerian government promotes competition among private contractors, which are comprised of local and foreign contractors, in order to achieve value added infrastructure delivery. Resulting competitive bidding processes between multinational construction corporations (MCC) and local construction contractors (LCC) has had mixed comments among stakeholders, with a need for a more sustainable and holistic value approach identified. The aim of this research is to develop a sustainable infrastructure delivery model (SID). The key research methodology is based on extensive literature review and questionnaire survey. SID is developed on the principles and philosophy of soft system methodology (SSM) and analytic network process (ANP). In order to evaluate the significance of MCC and LCC through SID model, questionnaire surveys were conducted. Feedback was collected from experts in the Nigerian construction sector who assessed the relative importance of formulated decision criteria, which were sought under 7 key factors. Data simulation revealed that, through competitive bidding, significant achievements have been made in the delivery of constructed facilities. It was also found that the policy lacked holistic value principles that integrated ethical stance and monetary returns on investment. In this study, SID framework has been presented, clearly showing needs for integration of economic and ethical stances in order to achieve a sustainable infrastructure delivery.

Keywords: economic reforms, infrastructure, stakeholders, value, soft system methodology.

INTRODUCTION

In order to accelerate procurement and maintenance of the national infrastructures, post 1999 Nigeria administration initiated the economic reforms agenda that embraced partnership with private construction corporations. During this period, interests were drawn to collaboration with multinationals due to their financial strength and global influences. This led to “*Look East policy*” blueprint (Babatunde and Low, 2013 pp. 19) with bilateral trade agreement with the Chinese construction firms that are being acknowledged as the largest and most competitive construction industry in the world. In theory, collaboration would promote economic growth that is instrumental to human development. More importantly, global partnership has been recommended as an instrument towards the actualisation of millennium development goals in developing countries (DC) (Du Plessis, 2007), with one of the goals to eradicate extreme poverty and hunger. Due to poor economic development, manifestation of poverty among millions of the population has soured. The severity is measured using national human development index that includes employment creation and social well-being (Ajufo, 2013).

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In spite of success of the construction sector through the reform policy (see ICRC, 2012), sustenance of the core objectives of the strategy and the guiding policy have had mixed reviews among stakeholders. For instance, Ozoigbo and Chukuezi (2011) and Idoro (2010) have argued there are significant inequalities between economic growth and subsequent development in the Nigerian construction sector. The reform policy is viewed to privilege multinationals with outsourcing of materials and human resources with no due justifications. Critics of the practice are concerned about the implications of continual marginalisation of local skills and manufacturing sectors. According to Ajufu (2013), the unemployment rate has reached a new level in Nigeria, with people aged between 18 and 35 being most affected. The group is the most active portion of the population and constitutes over 60% of the Nigerian populace. While 80% of this group are unemployed, the remaining 20% are under employed. The trend has been identified as the major cause of the high rate of poverty and subsequent social vices and insecurity in Nigeria. Values in the construction sector are, therefore, argued to be underutilised or mismanaged by the affected stakeholders. Thus, this paper is proposing a sustainable infrastructure delivery (SID) model for infrastructure procurement in the Nigerian construction industry.

TOWARDS VALUE FOR MONEY IN CONSTRUCTION INDUSTRY

In the global construction industry, Latham report (1994) is a milestone in the theory of value for money in the procurement strategy. It holds that, in construction procurement, values are best enhanced when there are synergies among stakeholders and they are willing to collectively share benefits while risks are managed together. In order to effectively manage values in the construction industry; knowledge of benefits that are associated with the process can be understood through study of the construction supply chain. Whilst project delivery remains a core value, PricewaterhouseCoopers (2011) *cited in* Babatunde and Low (2013, pp. 19) elucidates values enhancement for macro-economic development through the construction industry. Multiplier effects are achieved when employment opportunities are created for the local markets either through direct labour, sourcing of materials or services. Wider economic benefits are associated with the improvement in the human development index, such as skills acquisition, purchasing power and savings culture. At the higher quality construction is the capacity building among local contractors that promote internationalisation. Higher quality construction quality' requires trust, respect, transparency and knowledge sharing in the supply chain. Prospects of achieving this level in Nigeria through collaboration with the multinationals has been questioned (Trebilcock and Rosenstock, 2015; Loxley, 2013; Ozoigbo and Chukuezi, 2011). Reasons for the notion include the "*construct*" of construction value, whereby project finance is prioritised as value of the private sector involvement in infrastructure delivery.

Furthermore, a study by Loxley (2013) argued that partnership of multinationals in DC has shifted procurement towards privatisation in nature whereby the private sector takes charge of almost all fragments of the procurement process from design, construction, ownership finance operation and/or maintenance over a long term period. The study further revealed that, between 1990 and 2003, 70% of infrastructure deliveries in DC were procured through public private initiatives. While build-own-operate (BOO) accounted for 38.9%, build-own-transfer (BOT) and built-rehabilitate-operate-transfer (BROT) accounted for 17.9% and 13.2% respectively. These are the most common form of private finance in the Nigerian construction sector where

private sector is preoccupied by the multinationals (see ICRC, 2012). Most of the infrastructures that are procured through private investors are paid through sources that include user fees and tax. Interest rate is always considerably high (Trebilcock and Rosenstock, 2014).

STAKEHOLDERS ANALYSIS

Literature review reveals stakeholders in the Nigerian construction industry are broadly internal and external, and they form into 3 main categories; dominant, discretionary and dependent stakeholders. A dominant stakeholder is the Nigerian Government and its Ministries, Departments and Agencies (MDAs) (ICRC, 2012). With the power and authority that are bestowed on them, they commission projects for the wellbeing of the citizens. They are considered dominant because their actions are backed by the constitution of the state. ‘Discretionary’ is the second class of stakeholders, which are private construction corporations upon whom government and its MDAs entrust successful project implementations through financial resources. Studies show discretionary stakeholders are predominantly multinationals and they enjoy full support of the Government in order to achieve their business objectives. The third category of stakeholder is ‘Dependent’. In this category are private contractors that have little or no attributes to act as ‘Discretionary’. They are mostly local contractors. With the general public inclusive in this category, they refinance the cost of the infrastructure procurement through service payments over a period of up to 25 years or more. This stakeholder also enjoys limited privilege to be involved in the service provision of the construction process.

SUSTAINABLE INFRASTRUCTURE DELIVERY (SID) MODEL

Management of values among stakeholders has been identified as a missing gap in the Nigerian Construction sector. Primary goal of SID is to achieve maximum benefits in infrastructure delivery. The novel aspect of the proposed SID is the application of managerial style to construction values. The model aims to ensure cooperation, trust and transparency among stakeholders in the decision making process through a participatory approach. Whilst tangible values are enhanced, a cautious approach is also taken on the hard values that are most associated with value engineering aspects of a project. In any value construct, needs of the stakeholders must be clearly identified. The actualisations of these needs are directly affected by the resources that are required.

The proposed SID model is comprised of subjective and objective phase respectively. In the subjective phase the values among key stakeholders are structured, see Figure 1. The construct is based on extensive literature review and personal experience of the problematic situation. Noticeably, the current value structure in adversarial in nature.

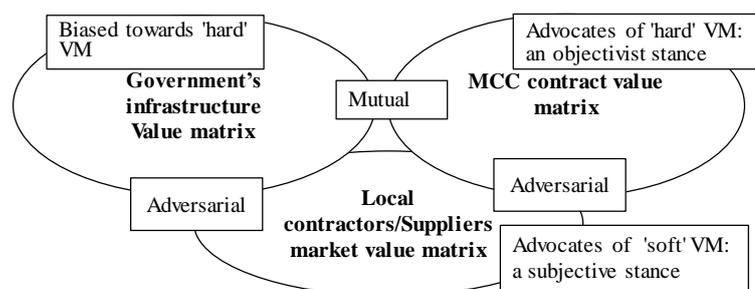


Figure 1: Current values structure in the Nigerian construction sector

Objective phase is where the logic of the integration of ‘hard’ and ‘soft’ value takes place. To achieve the aim, SID utilises merits of tested and proven multi-criteria decision making techniques (MCDM) to develop a hybrid decision model. Fundamentally, principles of modern MCDM are related to value analysis technique that was conceptualised by Miles *et al.* over 6 decades ago, in the 1940s. According to Cheng and Li (2004), multi-attribute utility theory (MAUT), multi-attribute analysis (MAA) and analytic hierarchy process (AHP) are very comparable methods in process and application. However, Analytic Network Process (ANP) technique by Saaty (2009), a generalised form of AHP, has been considered as the most suitable MCDM for SID model, following its successful application in diverse fields of study. An example is the research by Bayazit (2006) on the application of ANP in vendor selection decisions. In the study, three suppliers were studied and global priorities were derived from the synthesis of ten decision attributes (quality, on-time delivery, price, flexibility, delivery lead-time, top management capability, personnel capabilities, process capability, financial capability, and market share). The study highlights capability of ANP to input multiple variables and also consider their inter-dependent impacts. Two key MCDM in the SID model are soft system methodology (SSM) by Checkland and Scholes (1990) and ANP by Saaty (2009). SSM is a learning and meaning development tool. It is used to structure how values are perceived by the affected stakeholders and how it should be grasped in reality. To achieve an objective reality, philosophy of ANP is integrated into data collection and analysis.

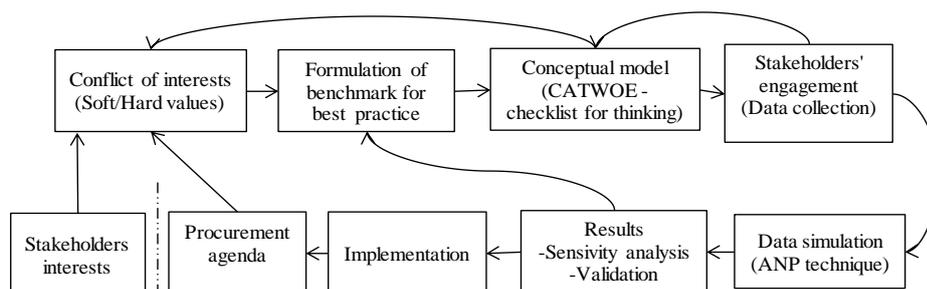


Figure 2: Formulated sustainable infrastructure delivery (SID) model

Application of SID model in Figure 2 starts with the preliminary findings in ‘subjective phase’. The findings are conflicts of interests among stakeholders on tangible and intangibles values. The next step is to review goal of the procurement agenda from stakeholders’ stances. Without prejudice, a functional and production system with reform policies is then identified as a benchmark for a best practice. Knowledge gained from the study is used for conceptualisation of transformation process that harmonise values among the affected parties.

SID engages stakeholders’ through a convenient sampling of experts in the Nigerian construction industry. They are asked about their opinions on the relative importance of the formulated decision factors to achieving delivery of both ‘hard’ and ‘soft’ values and choice between MCC and LCC. Data is simulated through Super Decisions: software that implements ANP. Once final decision is made, sensitivity analysis is carried out to establish significant of MCC and LCC in respect of each of the decision factors, which are money, material, method, machinery, manpower, society and environment. If the results are validated and accepted by the experts, implementation of action follows, or otherwise, further review of the underpinned benchmark is carried out as illustrated in Figure 2.

In this study, the conceptual model is based on reviews of private sector engagement in public procurement, as applicable in EU directives (2004/18/EC) and the Latham report (1994). Based on the reviews, 'CATWOE', part of SSM methodology, checklist of thinking, where the mnemonic stand for: C Customer; A-Actors; t-Transformation; W-Worldview; O-Owners; and E-Environment, is further applied in the design a world view of an ideal system. Details are presented in Figure 3.

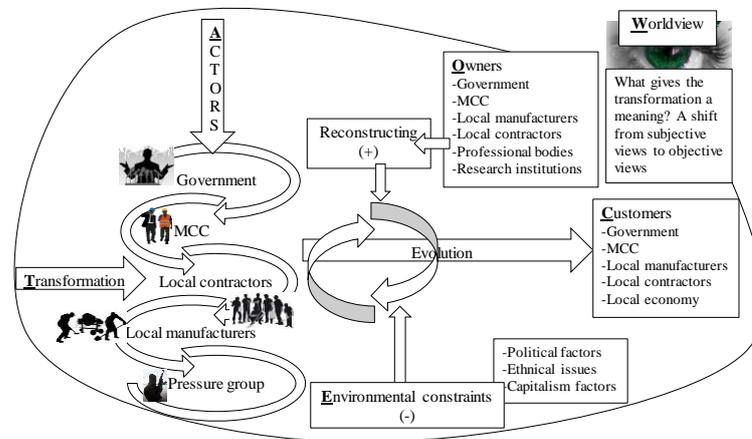


Figure 3: CATWOE model for a transformation in Nigeria construction sector

RESEARCH METHOD

Data was collected through literature review and survey. The web based questionnaire survey was administered to professionals in the Nigerian construction industry, with a total of 135 questionnaires sent and accompanied with a cover letter, detailing the purpose of the survey with assurance of confidentiality of feedback. The survey was administered to obtain experts' opinions on the relative importance of value criteria in order to generate relative vector. The logic of the pair comparison of criteria followed ANP methodology by Saaty (2009) proficiencies of respondents were judged based on their affiliate of professional membership and field of work. The survey was undertaken in 2015 for a period of 4 months, covering Academia, Government agencies, local construction companies, foreign construction companies and local manufacturing companies. The number of successfully completed questionnaires was 49, constituting an effective return rate of 36%. Respondents comprised of Engineers (n=12), Quantity surveyors (n=19), Architects (n=6) and Construction Project Managers (n=12). The data was analysed using 'Super decisions' software package and statistic analysis computed included priority vector and sensitivity analysis.

RESULTS

In order to test the validity of the survey questionnaire, awareness of respondents on the private initiative policy for infrastructure procurement were confirmed. 28 of the respondents acknowledged they were very aware of government economic reforms on infrastructure procurement through private finance initiatives and they represent 57% of the sample size. The remaining 43% were aware. Table 1 illustrates the number and percentage of the sample population that were received in relation to their field of work

Table 1: Field of work

Stakeholders	Field of work		
Government	Academia	8	16%
	Government agency	17	20%
Internal	Local construction company	10	35%
	Local manufacturing company	3	6%
External	Foreign construction company	11	22%
	Sum	49	100%

The highest response rate was recorded from Government agencies. The figures included respondents from Federal Ministry of Work and Housing, State Ministry of Work, teaching staff of Universities and researchers in built environment. This could be attributed to government being the largest employer. Experts were asked to assign relative importance to decision criteria that were based on pair comparison matrixes. Table 2 shows detailed sub-factors considered.

Table 2: Weighing factors for SID decision making process

Money	- Availability of funds - Cost of health and safety - Interest rate - Payback period - Welfare budget	Manpower	- Availability of manpower - Management and technical skills - Performance assessment standard - Availability
		Material	- Cost - Quality - Expertise for the application
Machinery	- Innovative machinery - Operating skills - Maintenance budget	Society	- Basic human needs - Empowerment of local contractor - Right and privilege - Affordability
		Environment	- Waste management - Carbon footprints
Method	- Construction method - Procurement route - Competitive bidding		

Figure 4 shows the outer relationships between Clusters. Loop symbol indicates interdependency among factors within Cluster. 70 pair wise comparison matrixes were considered (see Table 3).

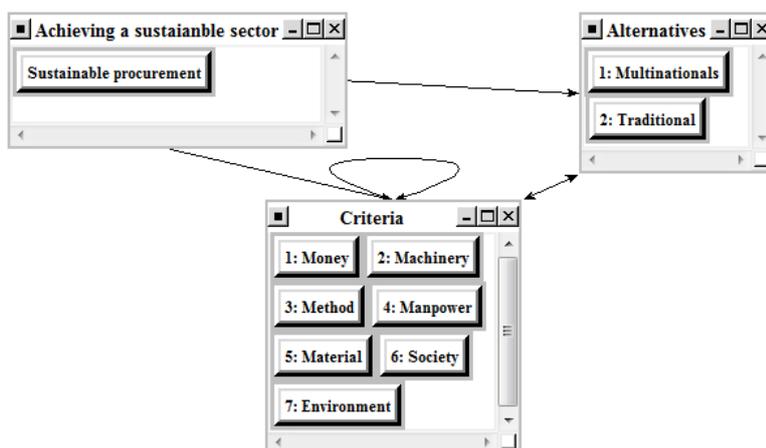


Figure 4: Clusters and nodes of decision network being capture in Super decisions software

Graphical illustration of are illustrated in Figure 4. It presents the structure that guided the number of judgement in the matrix. Line symbol shows there is outer relationship between Clusters. Loop symbol indicates interdependency among factors within Cluster. This has resulted in 70 pair wise comparison matrixes were considered (see Table 3).

Table 3: Number of comparison matrix

Sustainable procurement in respect of Criteria	21
Criteria in respect of MCC	21
Criteria in respect of LCC	21
MCC and LCC in respect of importance of each of the Criteria	7
Total	70

Altogether, 10 matrix based tables were developed. For each table with more than 2 variables for comparison, Consistency ratio (CR) was computed to validate consistency of judgements by respondents. CR is the measure of consistency in judgement that is being made by experts on decision factor. As a standard if $CR \leq 0.1$ (see Saaty 2009), the paired comparison matrix is considered to be consistent enough.

Table 4: Sustainable procurement in respect of Criteria

2. Node comparisons with respect to 1.1 Sustainable proc~							3. Results	
Graphical	Verbal	Matrix	Questionnaire	Direct			Normal	Hybrid
Comparisons wrt "1.1 Sustainable procurement" node in "2 Criteria" cluster							Inconsistency: 0.09845	
2.1 Money is 3.57 times more important than 2.2 Machinery							2.1 Money	0.21552
Inconsistency	2.2 Machin~	2.3 Method~	2.4 Manpow~	2.5 Materi~	2.6 Societ~	2.7 Enviro~	2.2 Machi~	0.10021
2.1 Money ~	← 3.57	↑ 1.0204	← 2.71	← 3	↑ 1.1235	↑ 1.1235	2.3 Method	0.19899
2.2 Machin~		↑ 1.2658	↑ 1.0204	← 1.08	↑ 1.0204	↑ 1.2987	2.4 Manpo~	0.09818
2.3 Method~			← 2.33	← 2.33	← 2.9	↑ 1.2658	2.5 Mater~	0.14296
2.4 Manpow~				← 1.08	↑ 1.3698	← 1.27	2.6 Socie~	0.11904
2.5 Materi~					← 3.45	← 1.76	2.7 Envir~	0.12510
2.6 Societ~						← 1.76		

For Table 4, CR is 0.0985 and that confirms that the decision is acceptable.

Table 5: Criteria in respect of MCC

2. Node comparisons with respect to 3.1 MCC							3. Results	
Graphical	Verbal	Matrix	Questionnaire	Direct			Normal	Hybrid
Comparisons wrt "3.1 MCC" node in "2 Criteria" cluster							Inconsistency: 0.08499	
2.1 Money is 3.86 times more important than 2.2 Machinery							2.1 Money	0.20372
Inconsistency	2.2 Machin~	2.3 Method~	2.4 Manpow~	2.5 Materi~	2.6 Societ~	2.7 Enviro~	2.2 Machi~	0.14133
2.1 Money ~	← 3.86	↑ 1.4925	↑ 1.25	← 1.36	← 2.33	← 2.33	2.3 Method	0.18285
2.2 Machin~		← 1.09	← 1.19	← 1.09	← 2.62	← 1.93	2.4 Manpo~	0.15530
2.3 Method~			← 2.62	← 1.08	← 1.36	← 1.36	2.5 Mater~	0.17303
2.4 Manpow~				← 1.19	← 2.71	← 2.71	2.6 Socie~	0.06132
2.5 Materi~					← 3.86	← 4.14	2.7 Envir~	0.08245
2.6 Societ~						↑ 2.5641		

For Table 5, CR is 0.0850 and that confirms that the decision is acceptable.

From Table 5, correspondent pairwise judgement shows that MCC demonstrates consistency in the management of the traditional five elements of project management by the multinationals: money-machinery-method-manpower-material. Priority vectors for Society and environment were significantly low.

Table 6: Criteria in respect of LCC

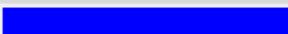
2. Node comparisons with respect to 3.2 LCC							3. Results	
Graphical	Verbal	Matrix	Questionnaire	Direct			Normal	Hybrid
Comparisons wrt "3.2 LCC" node in "2 Criteria" cluster							Inconsistency: 0.08667	
2.1 Money is 4.14 times more important than 2.2 Machinery							2.1 Money	0.38873
Inconsistency	2.2 Machin~	2.3 Method~	2.4 Manpow~	2.5 Materi~	2.6 Societ~	2.7 Enviro~	2.2 Machi~	0.08504
2.1 Money ~	← 4.14	← 3.57	← 4.71	← 3.86	← 4.71	← 4.71	2.3 Method	0.11078
2.2 Machin~		← 1.48	← 1.09	← 1.09	↑ 2.2222	↑ 2.8571	2.4 Manpo~	0.09146
2.3 Method~			← 1.48	↑ 1.4705	← 1.55	← 2.05	2.5 Mater~	0.11654
2.4 Manpow~				← 1.19	← 1.19	← 1.09	2.6 Socie~	0.12747
2.5 Materi~					↑ 1.4705	← 3.45	2.7 Envir~	0.07997
2.6 Societ~						← 3.29		

For Table 6, CR is 0.0867 and that confirms that the decision is acceptable.

In Table 6 are the results of judgement of LCC in respect of procurement criteria. The matrix result shows high disparity between priority for money and other decision factors. While priority vector for money is 39%, approximately 9.5% are scores for the remaining factors.

Further discussion that arose was what the money was being used for when it did not correlate to other decision criteria, especially material, method, manpower and machinery due to interdependency relationship among them. Finally, comparison of MCC and LCC in respect of importance of each of the Criteria was computed, with results generated serving as final input for the simulation of final assessment in Table 7.

Table 7: Global priority Vector

Name	Graphic	Ideals	Normals	Raw
3.1 MCC		1.000000	0.583818	0.194606
3.2 LCC		0.712862	0.416182	0.138727

DISCUSSIONS

In this paper, a suitability of proposed sustainable infrastructure delivery model for Nigerian construction sector was analysed. Final results favoured MCC = 57% over LCC = 43%, (see Table 7). This implies that procurement through MCC is more sustainable than LCC based on the decision criteria that were considered in the study. Sensitivity analysis was carried out to further highlight ranking of key factors to achieve the goal of the research and continual further improvement, Table 8 presents the final sensitivity analysis.

Table 8: Sensitivity analysis

Criteria	Priority Vector	Ranking of Criteria	MCC ranking	LCC ranking
Money	22%	1st	1st	2nd
Method	20%	2nd	1st	2nd
Material	14%	3rd	2nd	1st
Environment	13%	4th	1st	2nd
Society	12%	5th	1st	2nd
Machinery	10%	6th	1st	2nd
Manpower	10%	7th	2nd	1st
Total	100.00%			

From above Table, none of the two forms of private initiatives can deliver holistic values for achieving macro-economic development. Synergy in the supply chain has been considered to be a key success factor. There was a strong argument in favour of competent local skills for construction operations. Though previous study by Idoro (2010) found that local contractors are plagued with low productivity due to factors that include skills deficiency and shortage of funds for project finance, still local skills are considered to be underutilised, marginalised and evaluated with prejudice. Ilori, Nigerian Society of Engineers, has expressed similar views when he asserted there is abundance of technical skills at the national level (Alimi, 2014). However, there is no independent body that vets the quality and quantity of foreign workers that are employed by the multinationals. The major driver for the current development is government national and international policy on economic growth that are weak and non-coherent on the integration of social factors (Taylor (2007) From experts' opinions, it was deduced that local sourcing of materials and human resources remained key success factors for sustainable procurement. This would make a reality

of benefits associated with construction that were early discussed in Figure 1. The question on favourable conducive environment for local production, though, remains unanswered. High production cost resulting from lack of supporting facilities and security have been identified as drivers for closure in many local manufacturers companies (Taylor, 2007).

“It is important to emphasize that the performance of the Nigerian economy in the past four or more years has been remarkable, with a stable macro-economic environment and a growth rate averaging 6.3%....However, it is obvious that the associated benefits of growth were yet to trickle down to a large segment of our people....The challenges of poverty, growing inequality, coupled with increasing graduate unemployment remain worrisome....We cannot over flog the issue of infrastructural deficit that continues to becloud our investment climate” Campbel (2011). The citation in Enweremadu (2013, pp. 71) shows concern about disparity in the Nigerian economic growth and development. The growth could be attributed to more financial commitment of foreign corporations in the economy. Gross domestic product (GDP) growth at about 6.81% was achieved between 2003 and 2013, while average record in the period in other African countries was 3.6% (ICRC 2012). However, the trend in human development index is not the same, with youth unemployment and security threats on the rise (Ajufu, 2013). Lessons from EU directives (2004/18/EC) reiterate the importance of integrating economic and socio-environmental needs in the evaluation of private sector finance initiatives.

CONCLUSIONS AND RECOMMENDATIONS

The study highlights current value for money strategy in the Nigerian construction industry and justification for review of decision factors. Findings corroborated with the study by Babatunde and Low (2013) in which lack of standardised valued criteria was identified as the greatest challenge for value management in the Nigerian construction sector. Overall, MCC showed better competency in the management of project factors than LCC, though neither are fully committed to society and environment of pragmatic able to deliver holistic values. To achieve sustainable infrastructure model the collaboration is required among stakeholders, with objective structuring of interests, both economic and socio-environmental.

From the application of SID model, it is revealed that values in the Nigerian construction sector are underutilised and mismanaged. It is further revealed that economic reform policy lacks comprehensive sustainable decision criteria. SID model has presented a framework that effectively manages both tangible and intangible values in a more realistic and objective procedure in order to achieve a sustainable infrastructure delivery.

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CRITICAL SUCCESS FACTORS IN OBTAINING PROJECT FINANCING FOR PRIVATE FINANCE INITIATIVE PROJECTS IN MALAYSIA

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A continuing increase in demand for infrastructure, with the aim of realising Malaysia's developed nation status by 2020, has driven the government to seek smart partnerships with the private sector. In line with existing privatisation policies, the concept of Private Finance Initiative (PFI) was introduced to carry out public projects in the Ninth Malaysia Plan (2006-2010). Yet, there is a lack of participation by the private sector due to difficulties in obtaining project finance. Financial institutions are generally unwilling to provide long-term financing for PFI projects as they suffer from limited liquidity and visibility. Local financing bodies are still relatively inexperienced and doubtful about PFI project financing. Unclear guidelines and regulations, as well as lack of government initiatives to promote such schemes, have also compounded the problem. The objectives of this paper are to identify critical success factors (CSF) influencing the financing of PFI projects and propose a relationship framework between CSF and success criteria in obtaining finance for PFI projects in Malaysia. An exploratory research method which includes a comprehensive literature review, interviews and questionnaire survey was adopted to strengthen the research case proposed. Four experienced key players in PFI projects were interviewed and fifty two respondents with finance; construction and public agency backgrounds answered the questionnaire. The findings indicate four main dimensions of CSF in obtaining finance for PFI projects including project attributes; Special Purpose Vehicle (SPV) attributes; government attributes and financing attributes. An external environmental factor affecting PFI financing was the political and economic environment. The findings will provide guidelines to key players, i.e. SPV; financial institutions and government agencies in their financing strategies, particularly for Malaysian PFI projects.

Keywords: critical success factor, Malaysia, Private Finance Initiative.

INTRODUCTION

Private Finance Initiative (PFI) is an alternative way of procuring public infrastructure by getting the private sector to finance project implementation (Akintoye *et al.* 2003; Chiang and Cheng 2009). The PFI arrangement involves highly leveraged capital structure in which the private sector is responsible to design, build, operate, maintain and finance new infrastructure facilities for a long term concession period, exceeding 25 years (Engel *et al.* 2010). The long life cycle term contributes to high uncertainties and risks, making it difficult to attract investors and financiers (Engel *et al.* 2010). Schur *et al.* (2006) recorded that, between 1990 and 2004, approximately 160 infrastructure projects in developing countries suffered due to financing problems.

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In Malaysia, the government introduced PFI initiatives in the Ninth Malaysia Plan (2006-2010) to inspire smart partnerships with the private sector to implement infrastructure projects and public services. PFI initiatives have become a key modality for implementing Malaysia's development agenda under the Government Transformation Programme (GTP) (EPU 2010), an ambitious broad-based programme to transform Malaysia into a developed and high-income nation. Private investments in national development including PFI was expected to increase up to 12.8% per annum in the Tenth Malaysia Plan (2011-2015) (EPU 2010).

Yet, its implementation is hindered by difficulties in obtaining financing. Financial institutions are generally unwilling to provide long-term financing for PFI projects, as they suffer from both limited liquidity and visibility (Saidan Khaderi and Abdul Aziz 2009; Ismail 2012). Lack of experience also causes local financiers to doubt PFI project financing (Takim *et al.* 2008; Ismail 2012). Ismail (2012) added that unclear guidelines and regulations, and lack of government initiatives to promote the scheme also hindered PFI development. Initially, funding amounting to RM20 billion was raised from the Employees Provident Funds (EPF) in 2006 in the form of loans to the Ministry of Finance to kick start its implementation (Takim *et al.* 2008). The difficulties in obtaining financing for PFI projects need to be addressed. Hence, the purpose of this research is to examine the critical success factors (CSF) influencing success in obtaining financing for PFI projects. A proposed relationship framework between CSF and success criteria for PFI projects in Malaysia is derived.

LITERATURE REVIEW

Project financing for PFI projects

Obtaining finance refers to the ability to get funding from available sources to finance projects or any business development which includes expanding operations; investing in new staff or production facilities (Haron *et al.* 2013). There are a few financing options for PFI schemes, for instance, bank loans, equity, bonds and mezzanine finance. Duffield and Clifton (2009) and UN ESCAP (2011) describe financing options as follows: bank loans are funds lent by commercial banks and other financial institutions and usually securitized by the PFI project's underlying assets. Equity is long-term capital provided by an investor in exchange for shares representing ownership in the company or project. Bonds are typically long term (greater than 1 year), short term and potentially junk bonds (really a form of speculative investment). Mezzanine finance, is placed somewhere between equity and debt in the capital structure of a PFI project, sometimes referred to as non (or limited) recourse finance.

Typically, a capital structure that comprises of debt and equity is used in funding PFI projects with high ratio of debt to equity (Yescombe 2007). A project sponsor involved in a PFI project will contribute equity investments in an SPV company that usually covers 5 to 30 percent of the total project cost while the remaining 70 to 95 percent is covered by debt financing (Yescombe 2007). The demand for equity hinders small contractors from participating in PFI projects since their balance sheet is insufficiently strong to sustain such investment (Demirag *et al.* 2011).

Ability to obtain funding depends on fulfilling financing requirements and applicant eligibility (Riding *et al.* 2007). For example, finance institutions require a viable, future project cash flow for loan repayments (Yescombe 2007). The financiers need to have evidence of borrower's ability to pay because they face additional risks from highly leveraged projects, and there is no guarantee that the loan will be re-paid if the

project is a failure (Engel *et al.* 2014). The financiers are also concerned that the project will be implemented as a concession agreement after getting the loan. According to Painter and Gallo (2012), there is a risk that the project will not generate sufficient income for loan repayment, which may be caused by project delays or over budget; completed projects do not work properly as planned; revenue generated is less than projected and increased operational and maintenance costs.

Critical success factors influencing successful financing for PFI projects

Examination of existing studies led to the formulation of a list of critical success factors influencing the financing of PFI projects, as presented in Table 1. A total of 64 CSFs was identified and categorised into four groups; project attributes, SPV attributes, government attributes and financing attributes. Another external factor affecting PFI financing is the political and economic environment.

Project attributes

Project attributes are the characteristics and parameters of the project providing key project information. Scholars emphasised the economic viability of the project as the key factor in obtaining credit (Chiang and Cheng 2009; Singh and Kalidindi 2009; Asenova and Beck 2010; Hampl *et al.* 2011; Marco *et al.* 2012). Thus, profitable projects will ensure adequate cash flow to recover costs, service the debt besides ensuring a successful investment (Demirag *et al.* 2011). Likewise, it symbolises efficiency in project management and project completion, allowing the SPV to obtain the initial payment as well as to guarantee timeliness in monthly loan payment (Hampl *et al.* 2011; Demirag *et al.*, 2011; Engel *et al.* 2014). Concession agreements are also deemed important as a comprehensive concession agreement provides a regulatory framework to secure value for public money and cost effective services to the users (Singh and Kalidindi 2009; Marco *et al.* 2012; Gupta *et al.* 2013; Engel *et al.* 2014).

Special Purpose Vehicle attributes

Special Purpose Vehicle (SPV) attributes refer to SPV qualities in managing the project. A strong financial position with relevant management and technical expertise as well as previous successful experience will contribute to the quality of services and provide economic value to consumers (Singh and Kalidindi 2009; Meng and McKeivitt 2011; Hampl *et al.* 2011). The financier is intense in assessing the risk associated with the borrower and the potential success of project finance proposals when there is adequate collateral, future cash flow, and great chance of project success (Hampl *et al.* 2011; Demirag *et al.*, 2011; Engel *et al.* 2014). Furthermore, the SPV needs to deliver a high level of assurance that the project can be completed on time and on budget as well as functioning as designed, with sufficient cash flow for loan repayment. SPV with weak financial positions will have lesser opportunities to secure project financing as they are perceived as unable to bear cost overruns if the unexpected happens. Conversely, Chiang and Cheng (2009) highlighted that PFI company characteristics, size, type, governance and return on asset are not associated with the perception of financial institutions when considering financing PFI projects in Hong Kong.

Government attributes

Government attributes refer to the government characteristics including its role, power and management. Public sector agencies play a role in ensuring successful PFI development with updated regulations, policies and guidelines (Gupta *et al.* 2013). Government involvement should be enhanced by initiating engagement policies to ensure the success of the project which includes providing assurance on the project

Table 1: Matrix of success factors affecting financing for PFI

Factors	A	B	C	D	E	F	G	H	I	J	K
Project Attributes											
location of PFI project								X			
land title								X	X		
design and planning								X			
schedule of construction				X			X		X		
life cycle cost								X			
repayment period	X									X	
revenue			X					X	X	X	X
profitable and demand			X	X			X		X	X	
cost of project			X						X	X	
scope of project			X							X	
size of project			X							X	
technology		X			X				X		
construction period	X		X						X	X	X
concession period	X		X						X	X	X
on time completion					X						
project risk (minimisation of risk)		X								X	X
concession agreement	X	X					X		X		X
transparency in project selection		X							X		
termination provision				X		X			X		
insurance coverage				X			X		X		X
Special Purpose Vehicle (SPV) Attributes											
size of company			X		X					X	
type of company										X	
technical expertise	X								X		
resources					X						
year of company's establishment					X						
legal structure		X			X						
financial strength	X			X	X	X			X		X
return on asset										X	
cash flow	X	X		X	X	X			X		
contractor's liquidity					X						
outstanding loans					X						
debt level					X						
reputation	X		X	X				X	X		
experience in PFI project	X			X		X					X
strong commercial track record	X			X		X					
familiarity with industry and client				X							
quality of sub-contractor						X					
management skills					X						
governance			X		X					X	
financial management knowledge					X						
Government Attributes											
government guarantee		X				X				X	X
tax exemption or reduction											X
incentive of new market penetration											X
government permit and approval									X		X
government control on charges											X
government support for supply and distribution											X
government policies are stable		X									
government objectives are clear		X									
favourable legal framework		X									
committed public agency		X					X				
Financing Attributes											
inflation rate			X			X					
interest rate						X					
currency exchange rate			X								
high equity-debt ratio							X		X		X
payment mechanism								X	X		
internal rate of return				X							X
return on equity				X			X				
equity repayment period			X	X							
available financial market		X		X							
Political and Economic Environment											
political support									X	X	
social acceptability									X	X	
political and economic stability		X	X								
effective market enforcement	X								X		X

Note: A- Engel et al. (2014); B-Gupta et al. (2013); C- Marco et al. (2012); D-Demirag et al. (2011); E- Hampf et al. (2011); F- Meng & McKeivitt (2011); G-Kurniawan (2010); H- Asenova & Beck (2010); I- Singh & Kalidindi (2009); J- Chiang & Cheng (2009); K-Zhang (2005)

completion and refinancing plans over the long concession period (Chiang and Cheng 2009). Strong government support act as an important driver to raise financiers' confidence as PFI financing providers. Government support include various forms such as tax exemption, subsidies, equity participation, guaranteed revenue (Chiang and Cheng 2009; Meng and McKeivitt 2011; Gupta *et al.* 2013). In addition, the government should provide a clear, consistent and enforceable legal framework by means of comprehensive legislation and policies governing the PFI to attract private sector investor participation (Shendy *et al.* 2011).

Financing attributes

Financing attributes refer to the financing conditions and financier qualities. The financing conditions are the fundamental requirements in obtaining financing. According to Demirag *et al.* (2011), internal rate of return and return on equity are the most common financial decision-making criteria used by financiers in risk analysis. Marco *et al.* (2012) found that inflation rate is a significant factor influencing the equity share in build-operate-transfer projects. Additionally, financial institutions act as important stakeholders in PFI and they may have different thoughts on the risks and returns of PFI structure (Demirag *et al.* 2011). The available financial markets illustrate the participation of financiers in providing PFI project financing (Demirag *et al.* 2011; Gupta *et al.* 2013). However, their willingness to involve in PFI funding is low due to the high risks associated with long-term concession periods, large-scale and capital intensive projects (Chiang and Cheng 2009).

Political and economic environment

The political and economic environment represent significant factors affecting the involvement of financiers in any industry or business. According to Chiang and Cheng (2009), the risks in financial markets and political situations act as barriers to the financial institutions' participation in PFI project financing. Additionally, political instability leading to changes in government leadership affects policy and regulatory matters (Sundaraj and Eaton 2011). Social acceptability and social support also help to ensure project success and assure its benefit to the public (Chiang and Cheng 2009; Singh and Kalidindi 2009).

The critical success factors of prior research have a similar goal, that is to improve the lender's propensity to grant finance to PFI projects. The idea is to obtain financing from available sources. Identifying success factors could help the stakeholders to consider these key factors when preparing to participate in PFI projects and in funding applications (Singh and Kalidindi 2009; Chiang and Cheng 2009; Hampl *et al.* 2011; Meng and McKeivitt 2011).

RESEARCH METHODOLOGY

Initially, an exploratory research method was adopted to collect required data to support and confirm the proposed research case. This includes a comprehensive literature review, unstructured interviews and questionnaire survey. The literature review sought to establish the key issues in PFI project financing and CSFs in obtaining finance for PFI projects. Subsequently, unstructured interviews with four key players from public authorities; contractors and financial institutions were conducted. The objectives were to gain insight into current project finance issues and investigate the success factors for PFI project financing in Malaysia. Findings from the literature review and interviews were used to develop a questionnaire which aims to identify CSFs and derive a theoretical framework for further research.

The survey uses convenient sampling. The findings will be further examined once the research proposal is confirmed. A total of 180 questionnaires were distributed, generating 52 completed responses with a response rate of 28.9%. This comprised 22 (42.3%) contractors, followed by 21 (40.4) from public agencies, 7 (13.5%) consultants and 2 (3.8%) from financial institutions. The three-page questionnaire was distributed to the participants who attended the Public Private Partnership (PPP) Conference 2014 held in November 2014 in Johor Bahru, Malaysia. The participants of this conference whom consist of public agencies, contractors or developers, financiers, advisors and academicians were selected as they are assumed to have sound knowledge and experience in the construction industry including PFI or PPP projects. The respondents were required to rate 64 CSFs using a five point Likert scale ranging from 1 (not important) and 5 (extremely important). Before the actual distribution of the questionnaire, a pilot study was conducted on 3 respondents, specifically an academic, a colleague and a finance executive to avoid ambiguity and misunderstanding in the questionnaire. Content analysis and Statistical Package for the Social Sciences (SPSS) software were used for data analysis.

The survey managed to capture more than half (57.7%) of the respondents possessed more than 10 years of experience and 42.3% had less than 10 years of experience. Their experiences include experiences in the construction industry and PFI/PPP scheme. Although the sample size was relatively small, the quality of the responses was considered to be reliable due to relevant industry experience, knowledge and understanding of the PFI and PPP concepts.

DATA ANALYSIS AND FINDINGS

Unstructured interview

The interview seeks to explore the issues and problems related to project financing and examining the CSFs in obtaining project finance for PFI projects in the nation. The respondents revealed that difficulties in obtaining finance stems from the limited number of financial institutions offering financing for PFI projects. Besides the complex processes imposed for loan applications, the SPV is required to fulfil the requirements of the financial institution's lending policy, such as preparing PFI's life cycle costing and projecting cash flow for loan repayment. In addition, the long loan assessment process makes the negotiation more complex. The other issue in obtaining finance for PFI is the high-interest rate. The respondents revealed that among the CSFs in obtaining finance, the SPV has to ensure credibility to handle PFI projects through collaboration with smart partners and established sub-contractors and suppliers. The financiers are concerned about unresolved loans if the project is abandoned or delayed. Therefore, in order to mitigate construction risks, financiers engage Independent Checker Engineers (ICE) to ensure the project is viable and can be completed on time. A comprehensive concession agreement may also help to convince them to approve the loan. Financiers also consider the contractor's track record; financial strength and experience. The respondent highlighted the lack of PFI policy formulation in Malaysia, with no guidelines for PFI projects updates since its launch in 2009. However, guarantees provided by the government projects enable the contractors to get funding.

Questionnaire survey

The survey captured 52 responses to establish CSFs for PFI project financing. A reliability test was conducted using Cronbach's alpha coefficient and the reliability

value was 0.967, proving that the instrument was reliable. According to Pallant (2010), the reliability coefficient value is accepted if the Cronbach's alpha exceeds 0.7. A further analysis was carried out to measure the level of CSF importance and the mean scores and Relative Importance Index (RII) of responses for different factors were also calculated. As suggested by Chan and Kumaraswamy (1997), the mean and standard deviation of each individual variable are unreliable for assessing the overall rankings. RII was used to rank the success factors as it is more precise without transforming the linear five point Likert scale through the use of Doloi (2009) Relative Importance Index: $RII = \sum W/AxN$, where 'W' is the weight given to each factor by the respondents within the range of 1 to 5 using the same Likert scale, 'A' is the highest weight and 'N' is the total number of respondents. The analysis of the produced RII values for the 64 CSF range from 0.892 to 0.727. Table 2 indicates the ranking of the factors in a factor group based on their RII using the above equation. The analysis showed that all 64 factors were identified as having a high level effect on PFI project financing.

Table 2 displays the CSF level of importance in obtaining finance. As mentioned, there are five main variables measured i.e. project attributes, SPV attributes, government attributes, financing attributes and political and economic environment.

Table 2: CSF level of importance in obtaining financing in PFI

Factors	Mean	RII	Rank
Project Attributes			
location of PFI project	4.212	0.842	23
land title	3.981	0.796	53
design and planning	4.288	0.858	15
schedule of construction	3.962	0.792	55
life cycle cost	4.019	0.804	49
repayment period	4.327	0.865	11
revenue	4.365	0.873	5
profitable and demand	4.327	0.865	12
cost of project	4.269	0.854	18
scope of project	4.154	0.831	36
size of project	3.904	0.781	58
technology	4.038	0.808	47
construction period	4.096	0.819	43
concession period	4.058	0.812	46
on time completion	4.462	0.892	1
project risk (minimisation of risk)	4.346	0.869	9
concession agreement	4.442	0.888	2
transparency in project selection	4.192	0.838	30
termination of provision	4.077	0.815	45
insurance coverage	4.115	0.823	40
Special Purpose Vehicle (SPV) Attributes			
size of company	3.882	0.762	61
type of the company	3.769	0.754	63
technical expertise	4.294	0.842	24
resources	4.250	0.850	20
year of company's establishment	3.635	0.727	64
legal structure	4.038	0.808	48
financial strength	4.365	0.873	6
return on asset	4.154	0.831	37
cash flow	4.365	0.873	7
contractor's liquidity	4.192	0.838	31
outstanding loans	3.923	0.785	57
debt level	4.212	0.842	25
reputation	4.212	0.842	26
experience in PFI project	4.212	0.842	27
strong commercial track record	4.096	0.819	44
familiarity with industry and client	4.135	0.827	38
quality sub-contractor	4.173	0.835	33
management skills	4.231	0.846	22
governance	4.173	0.835	34
financial management knowledge	4.288	0.858	16
Government Attributes			
government guarantee	3.885	0.777	59
tax exemption or reduction	3.808	0.762	62
incentive of new market penetration	3.942	0.788	56
government permit and approval	4.327	0.865	13
government control on charges	4.000	0.800	51
government support in supply & distribution	4.000	0.800	52
government policies are stable	4.308	0.862	14
government objective are clear	4.404	0.881	3
favourable legal framework	4.269	0.854	19
committed public agency	4.192	0.838	32

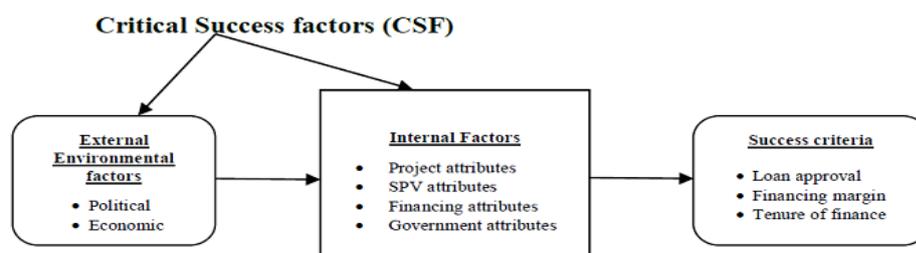
Table 2: CSF level of importance in obtaining financing in PFI (continued)

Factors	Mean	RII	Rank
Financial Attributes			
inflation rate	4.212	0.842	28
interest rate	4.365	0.873	8
currency exchange rate	3.865	0.773	60
high equity-debt ratio	4.115	0.823	41
payment mechanism	4.346	0.869	10
internal rate of return	4.255	0.835	35
return on equity	4.250	0.850	21
equity repayment period	4.288	0.858	17
available financial market	4.212	0.842	29
Political and Economic			
political support	4.135	0.827	39
social acceptability	4.115	0.823	42
political and economic stability	4.385	0.877	4
effective market	3.981	0.796	54
enforcement	4.019	0.804	50

Proposed PFI Project Financing Theoretical Framework

Figure 1 illustrates the proposed theoretical framework of the relationship between CSF and success criteria in obtaining finance in Malaysia. This has been developed based on the literature review, unstructured interviews and questionnaire survey.

Figure 1: Proposed theoretical framework: the relationship between critical success factors and success criteria in obtaining project finance



The theoretical framework comprises of three key components: External Environmental Factor, Internal Critical Success Factor and Success Criteria. The first component, External Environment Factors is the moderating variable. The 5 external environmental factors identified are: political support, social acceptability, political and economic stability, effective market and enforcement. These external factors embrace the macro factors of the political and economic environment based on the rationale that these factors will moderate the level of CSF. The second component, Internal Critical Success Factor, is the independent variable and comprises 59 CSF variables. They are categorised into 4 dimensions, namely project attributes; Special Purpose Vehicle (SPV) attributes; government attributes and financing attributes. The higher the level of CSFs, the higher the chances of obtaining financing for PFI projects. The third component is Success Criteria that measure level of success in obtaining financing, which is the dependent variable. Three success criteria used to measure success in getting funding for PFI include loan approval, financing margin and tenure of finance.

CONCLUSIONS

This conceptual paper sets out to examine the project financing issues for PFI projects and to identify its CSFs. Data collected found that difficulties in obtaining PFI finance are due to the limited involvement of financial institutions in offering financing, and a complex loan application process. Drawing on the literature review and questionnaire survey, 64 CSFs were identified as vital in obtaining project finance. These CSFs

encompass the issues of project viability, SPV credibility, financing aspect and governmental role as well as political and economic stability. A theoretical framework on the relationship between CSF and success criteria in obtaining finance for PFI projects in Malaysia is derived. This theoretical framework will form the basis for future research. The triangulation method using in-depth interviews and questionnaire survey techniques will be adopted as the research methodology. The research aims to develop an assessment framework for measuring the potential of obtaining project finance for PFI projects in Malaysia. The outcomes of the study will serve as guidelines to key players, i.e. SPV; financial institutions and government agencies in their financing strategies, specifically in Malaysian PFI projects. It is expected that the proposed framework will represent a tool for evaluating potential involvement in PFI projects and enable private companies to obtain funding. Also, the outcome will support public sector expectations to intensify the involvement of the private sector in providing infrastructure, as a catalyst for the nation's growth in tandem with the government's program to achieve Vision 2020.

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RENEGOTIATION OF PUBLIC PRIVATE PARTNERSHIP ROAD CONTRACTS: ISSUES AND OUTCOMES

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The renegotiation of road projects has been an important issue that has generated concerns in PPP procurement over the last decade. This has had serious policy implications for public procurement policy across countries because of its implications for the achievement of the objectives defined at the inception of PPP road contracts. This paper assesses the renegotiation of Public-Private Partnership (PPP) infrastructure projects in order to identify the issues involved in renegotiation and its outcomes. Data were collected through a literature review of selected studies on PPP infrastructure projects on a sectoral basis with particular emphasis on Latin America, Portugal and Spain. It was revealed that a high proportion of PPP contracts in the transport sector are renegotiated: Indeed, in the transport sector, more PPP road projects are renegotiated than other forms of transport projects. The main factors surrounding the renegotiation of road contracts are: lack of an adequate contract design, frequent opportunistic behaviour on the part of both public and private partners during the implementation of PPP road projects, changes in the conditions affecting revenue and costs beyond the reasonable assumptions accounted for in the original contract, corruption, and political and economic instability, all of which in most instances reduce the chance of the public partner achieving its objective of value for money (VfM). The paper concludes with a discussion of the need to develop a framework for integrating considerations of value for money into the renegotiation process of PPP road contracts.

Keywords: public-private partnership (PPP), renegotiation, road contracts, transport sector, value for money (VfM).

INTRODUCTION

The impact of transport infrastructure provision cannot be over-emphasised in the growth and development of any nation's economy. Gor and Gitau (2010) give credence to the role transport infrastructure plays in the enhancement of economic activities by identifying the road transport sub-sector as accounting for 90% of passenger and freight surface transport in Kenya. Because of the need to provide adequate and efficient transport infrastructure, governments of various countries have sought forms of procurement which ensure free and safe infrastructure on the most economical basis (Akintoye and Chinyio, 2005). However, the failures or inadequacies of some early forms of procurement have led most developed countries and some developing nations to adopt PPP for the delivery of transport infrastructure.

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PPP is a joint working relationship between the private sector and public bodies in which the two parties agree to pool their respective resources and share the risks of the proposed infrastructure project for mutual benefit and in the interest of members of the public or taxpayers. In spite of the numerous benefits of PPP to stakeholders, events usually occur during the implementation of projects that necessitate renegotiation of PPP contracts (Sarmiento, 2014, Acerete *et al.*, 2010). Though renegotiation may be necessary and expedient in order to align the contract to defined objectives and to keep it on track, most renegotiations of infrastructure projects have not addressed the VfM objectives and users' expectation. Instead, they have increased the costs to the public agencies, which is to the detriment of the users (Sarmiento, 2014). There is therefore a need to strategise ways to curb the negative impact of renegotiation.

This paper is based on the findings of the literature review of ongoing PhD research, targeted at developing a value-for-money framework for the renegotiation of PPP road projects. The renegotiation of PPP road contracts is assessed through a review of selected cases in the transport sector. This will be discussed with a focus on road projects in order to identify both the reasons for and the outcomes of contract renegotiation. The rationale for this focus is the high incidence of renegotiation in road projects when compared to other transport modes, coupled with their implications for the achievement of VfM. Thus the purpose of the paper will be fulfilled using literature published in journals and other sources. The authors have restricted the literature search to relevant up to date papers, i.e. those on the renegotiation of PPP transport projects within the last 10 years.

THE RENEGOTIATION IN PUBLIC-PRIVATE PARTNERSHIP CONTRACTS

Some of the definitions of renegotiation suggest that it is an un-anticipated change in the conditions or terms of a contract as a result of unexpected events which results in the amendment of the contract (Guasch *et al.* 2014 and Mackovsek *et al.* 2014). The extent of the work or the project scope could be impacted by an unexpected change. This change is not usually provided or defined in the original contract at the time of contract formation. However, there may be a clause in the contract, which provides that the contract may be subject to renegotiation.

Nikolaidis and Roumboutsos (2013) explicitly describe the process of renegotiation in PPP projects as a bargaining process, in which the parties involved seek to reach agreement on a particular option from a set of available alternatives. Renegotiation of contract has also been seen as procedure involving decision making in a collective manner (Sarmiento 2010). Thus, renegotiation is a decision making process which involves the choice or selection of a course of action from a list of alternatives or options in response to a specific need (Sarmiento and Renneboog 2014). However, the process of decision making is guided by the agreed procedure, which could differ between PPP projects and countries (Sarmiento 2014).

Renegotiations of contracts have been successful in some instances, but on other occasion they have resulted in delays and cost overruns during project implementation (Acerete *et al.* 2010). This conclusion is also supported by PPP studies conducted in Latin America (Bitran *et al.* 2013) and Spain (Acerete *et al.* 2010). The renegotiations discussed in both scientific and government reports in the past decade are thus considered in terms of their impact on the achievement of defined objectives (De Brux 2010). The reason for this is that the stakeholders in PPP contracts seek to fulfil their respective objectives during the renegotiation of PPP projects. However, the interest

of these stakeholders differ, and as a result synergy is required to achieve an outcome satisfactory to all parties while delivering the PPP project within contract provisions.

REASONS FOR THE RENEGOTIATION OF PUBLIC-PRIVATE PARTNERSHIP CONTRACTS

The driving factors for PPP contract renegotiations in Spain include: faulty contract design, defective regulation, over-estimation of traffic, inflexible contracts, changing construction risks and inadequate strategic network planning among others (Acerete *et al.* 2010). Nikolaidis and Roumboutsos (2013) also identify the inaccurate evaluation of the volume of traffic expected as a reason for major PPP contract renegotiations in Greece, which may result in a reduction or increase in the projected traffic. Gifford *et al.* (2014) notes that insufficient evidence exists with regards to drivers of renegotiation in the United States. Other reasons identified at the planning, construction and operation stage may require government to take over or provide subsidies to the project (Bi and Wang 2011). Also, Trebilcock and Rosenstock (2015) identify low-balling by private players in the competitive bidding stage, opportunism, lower than expected demand and unforeseen changes in the project environment as factors leading to major PPP renegotiations. This shows that there are many factors responsible for PPP contract renegotiations.

A comprehensive examination of all the factors associated with renegotiation reveals that opportunism is the bane of contract renegotiation (De Brux 2010). Under bidding, free riding, sitting on the job, poor quality of performance, hostile takeover, power misuse and social surplus capture have all been identified as manifestation of opportunism (Odoemena and Horita 2014). This list, along with the findings of several studies on renegotiation, has thus identified opportunism on the part of the private partner as more pronounced in transport projects (Bitran *et al.* 2013; Bi and Wang, 2011). However, governments use renegotiation as a means of evading budget scrutiny in order to increase PPP infrastructure spending (Engel *et al.* 2006), although recent studies reveal that opportunistic behaviour on the part the private partner is higher than that of public agencies in PPP infrastructure project procurement (Bitran *et al.* 2013, and Bi and Wang 2011).

RENEGOTIATION INCIDENCES IN PUBLIC-PRIVATE PARTNERSHIP ROAD CONTRACTS

An examination of renegotiation of PPP contracts around notable countries and regions of the world, including their frequency and outcomes, is necessary to advance the understanding of the subject. Recent studies have evaluated the instances of PPP contract renegotiations in Latin American and Caribbean countries (Guasch *et al.* 2014), Spain (Baeza and Vassallo 2010) and Portugal (Sarmiento 2014). These studies show that Portugal, Spain and Latin American/Caribbean countries have a long history of public service concessions that started in the late 1960s and early 1970s, initially in the transport and water sectors (Baeza and Vassallo 2010).

Specific studies have also been conducted in European countries such as Portugal (Sarmiento and Renneboog, 2014), Spain (Acerete *et al.* 2010), Greece (Nikolaidis and Roumboutsos 2013) and the UK (Bain 2010). Also, Engel *et al.* (2006) reveal that more than 1,000 PPP projects in Latin American from 1985-2000 were procured, 41.5% of which culminated on renegotiation. Evidence from some of these studies thus reinforces previous findings that toll motorway concession contracts are characterized by two features: significant traffic overestimations and frequent renegotiations (Baeza and Vassallo 2010, Acerete *et al.* 2010). In other words, road

projects have been found to be commonly renegotiated in the transport sector of most of these countries. Table 1 shows the respective incidences of renegotiations across sectors to support this conclusion.

Table 1: Incidence of Renegotiation across Selected Sector

Sectors	Guasch (2004) %	Our Sample (%)
Total	41.5	
Electricity	9.7	
Transport	54.7	
Railroads		32.2
Roads		57.3
Water & Sanitation		74.4

Source: Estache (2009)

The data presented in Table 1 supports the findings of the previous literature and puts road projects ahead of other modes of transport in terms of renegotiation. In all, it is calculated that 41.5% of projects overall were renegotiated, with the highest percentage being those in the water and sanitation sector. This was followed by the transport sector (54.7%), and within this sector road projects are the most renegotiated with 57.3%. Thus Table 2 supports these findings by showing the respective percentages of renegotiated contracts across countries and sectors.

Table 2: Incidences of renegotiations of PPP in selected regions of the world

Region/Country	Sector	% of Renegotiated Contracts	Source
Latin America & Caribbean	Total	68%	
	Electricity	41%	
	Transport	78%	Guasch et al. (2014)
	Water	92%	
Indian	All sectors	0%	Guasch et al. (2014)
US	Highways	40%	Engel et al. (2011)
France	Highways	50%	Athias & Saussier (2007)
	Parking	73%	Beuve et al. (2013)
UK (Scotland)	All Sectors	22%	NAO 2003
	All Sectors	51%	CEPA 2005

Source: Mackovsek et al. (2014)

Table 2 suggests that renegotiation of PPP road projects is common in Latin American & Caribbean countries. Contracts in the water and sanitation sector are the most often renegotiated, followed by those in the transport sector, as previously established. In the UK, no data is available with respect to the percentage of contracts renegotiation incidences on a sectoral basis, although generalised information, which cuts across all sectors is provided. However, Table 3 gives a vivid account of the frequency of renegotiation in developed countries with respect to both Portugal and Spain.

Table 3: Comparative analysis of PPP road projects renegotiation in Portugal and Spain

Road Projects		Concession & Award Period (Year)		No of Renegotiation		Year of 1 st Renegotiation	
Portugal	Spain	Portugal	Spain	Port	Spain	Port.	Spain
Lusoponte	Barcelona La Junguera	1995-2025	1967-2025	32	9	-	17
Norte	Mongat-Mataro	1999-2035	1967-1975	12	-	-	-
Oeste	Barcelona Tarragona	1999-2029	1967-1975	11	7	-	16
Brisa	Montmelo - El Papiuol	2000-2035	1967-1975	7	6	-	4
Litoral Centro	Zaragona-Mediterraneo	2004-2034	1967-1975	18	6	-	9
Scut da Beira Interior	Villalba- Villacastin	1999-2029	1967-1975	10	9	-	13
Scut da Costa de Prata	Villacastin- Adanero	2000-2030	1967-1975	12	8	-	9
Scut do Algarve	Bilbao- behobia	2000-2030	1967-1975	11	9	-	14
Scut Interior Norte	Burgos- Malzaga	2000-2030	1967-1975	5	9	-	15
Scut das Beiras Litoral Alta	Sevilla- Cadiz	2001-2031	1967-1975	7	7	-	18
Scut Norte Litoral	Tarragona- Valencia	2001-2031	1967-1975	19	9	-	10
Scut Grande Porto	Valencia Alicante	2002-2032	1967-1975	7	9	-	5
Grande Lisboa	El Ferro1-F. Portuguesa	2007-2037	1967-1975	10	14	-	1
Douro Litoral	Bilbao-Zaragoza	2007-2034	1967-1975	7	9	-	5
AE Transmontana	Leon- Campomanes	2008-2038	1967-1975	5	8	-	6
Douro Interior	Malaga-Estepona	2008-2038	1996-2008	5	1	-	4
Tunel do Marao	R-4 Madrid- Ocana	2008-2038	1996-2008	4	1	-	3
Baixo Alentejo		2009-2039		30		-	
Baixo Tejo		2009-2039		6		-	
Litoral Oeste		2009-2039		4		-	
Algarve Litoral		2009-2039		2		-	
Pinhal Interior		2010-2040		9		-	
Total Road Concession				233	121		

Source: Adopted from (Sarmiento & Renneboog 2014 and Baeza & Vassallo 2010)

Table 3 presents data for PPP contract renegotiation in Portugal and Spain. 22 PPP road projects in Portugal were investigated, while 17 road projects were investigated in Spain. The table shows the characteristics of these projects, their expected duration and the number of renegotiations per project for both countries. The figures indicate that more renegotiation occurs in the road projects of Portugal than in those of Spain, although to varying degrees: Lusoponte had the highest number of renegotiations in Portugal (32), while El Ferro F-Portuguesa was second with 14 renegotiations). A close comparison of these renegotiation incidences reveals that there are variations across countries and justifies the argument that road projects are commonly renegotiated with varying incidences in the transport sector.

THE OUTCOMES OF THE RENEGOTIATION OF ROAD PROJECTS IN SELECTED COUNTRIES

High repayment by the public sector for a long period in order to offset cost is one of the outcomes of the renegotiation of PPP transport project contracts in Portugal (Sarmiento and Renneboog 2014). In contrast, the outcomes of renegotiations in Spain and their respective percentages are: toll modification (50%), extension of the concession duration (24%), and other outcomes (26%) (Baeza and Vassallo 2010). Other studies have found the main outcomes of renegotiation in Latin America to include: tariff adjustments, revisions of cost components, adjustments of the annual fee paid by the operator to the government, changes in the asset base and extension of concession contracts (Guasch *et al.* 2014). This suggests that toll modification may be the most adopted and prominent outcome of the renegotiation of PPP concessions in Spain, which involves an alteration in the tariff or charges paid by users of the road. Furthermore, the renegotiation of road project contracts, according to Acerete *et al.*, 2010 have resulted in higher charges for Spanish road users. When there is a need for toll modification in Spain, the Spanish government has to step in to rescue the

situation. This is shown in the subsidies granted to the private sector in the case of eight old concessions in Spain in order to improve the viability of the scheme (Acerete *et al.*, 2010). Thus, the government usually steps in to rescue failing projects and those experiencing difficulties through subsidies, financial adjustments or rebalancing (Sarmiento, 2014, Xiong and Zhang, 2014).

For instances, an examination of 254 renegotiations in Portuguese infrastructure projects reveals that the road sector accounted for 233 cases which ended with compensation being paid to the private company (Sarmiento, 2014). In Latin America, experience reveals that 54.7% of transport concession contracts awarded were renegotiated and mostly benefited the concessionaires (Guasch, 2004). Furthermore, as Engel *et al.* (2009) notes, the Chilean experience reveals that firms lowball their offers, expecting to break even through renegotiation. Contrastingly, this paper also reports that governments use renegotiations to increase spending and shift the burden of payment to future administrations. Furthermore, renegotiation of these concessions thus results in increases in the future costs of service for users.

Moreover, according to Reside and Mendoza (2010), the Asian experience reveals that about 70% of PPPs are renegotiated due to currency risk, which in most instances results in increased subsidies and financial compensation for the concessionaire companies. Renegotiation of PPP projects also tends to be unfavourable to the public sector in United States of America (USA). However, the U.S. institutional framework have succeeded in protecting the public sector from private opportunism by guaranteeing service provision even in a situation where the private entity files for bankruptcy (Gifford *et al.* 2014). Thus, certain procedure or workable parameter could help in reducing public sector losses commonly experienced during renegotiation of PPP road projects.

The reason for the financial rescue and rebalancing of concession contracts by governments is based on the fact that government is a major party in the concession agreement, with a major interest in the project's completion (Nikolaidis and Roumboutsos, 2013). This is thus the main reason why public resources are usually devoted to covering private sector losses in PPP projects (Bi and Wang, 2011), which are mostly incurred as a result of the financial rescue of the projects. These losses, according to Sarmiento (2014), are then transferred to the users in the form of higher tariffs and charges. Xiong and Zhang (2014) support this view by stating concisely that "*international PPP practices have shown conflicting results in concession renegotiations*". Cases of contract renegotiation may therefore vary across countries and regions by virtue of the peculiarities and the prevailing situation. It is thus necessary to evaluate and assess renegotiation issues in the context of individual countries in order to ascertain the respective outcomes as they relate to the peculiarities and externalities of the prevailing environment.

The comprehensive review of the existing literature in the area of renegotiation of PPP road projects results in the following findings:

- Most PPP projects, and particularly road projects in the transport sector, are renegotiated;
- Analysis of the renegotiation of PPP road projects across notable countries revealed that VfM is not achieved for the public sector in most cases;
- Examination across countries, and particularly in Europe (including the UK), reveals scanty empirical data with respect to PPP road project renegotiations;
- The few studies of PPP renegotiation available show that the extent and implications of VfM achievement in road projects remains a subject of research and debate.

VALUE FOR MONEY AND THE RENEGOTIATION OF PUBLIC PRIVATE PARTNERSHIP ROAD PROJECTS

Recent academic studies on PPP/PFI have focused on VfM in PPP projects (Sarmiento and Renneboog 2014) because of its importance. Grimsey and Lewis (2005) define VfM as the optimum combination of whole life cycle costs, risks, completion time and quality in order to meet public requirements. VfM could therefore be viewed as a way of reducing the life cycle costs of PPP products through better risk allocation, faster implementation, improvement of the product and service quality and thus as a means of generating higher revenue for a public project. Based on this description, VfM is an important issue in infrastructure procurement, and has been considered the principal objective of any PPP project (Henjeweles *et al.* 2011).

It has been established from these studies that the achievement of VfM is an issue which has constituted a challenge in PPP procurement over the years. This indicates there is a need for further research, and motivated the present study. Few empirical studies have succeeded in exploring the ‘presumed’ relationships between renegotiation and VfM, which has been an issue in PPP procurement. Although these studies have established the importance of evaluating of renegotiation in terms of VfM achievement, few empirically assess the relationship between these two concepts in order to address the challenge of under- or non-achievement of VfM in PPP road project transactions.

The investigation of PPP road projects is in response to the factors militating against the achievement of VfM, which is relevant and germane in the contemporary world. Investigation of PPP renegotiation in the road sector will go a long way to ensuring that an approach which incorporates VfM thinking can be identified and embedded in the renegotiation process. Such an approach will involve the development of a framework that provides both a theoretical and a practical guide to stakeholders in the renegotiation of PPP road projects. The VfM framework proposed in this paper can be defined as one which seeks the reduction of whole life cycle costs through the development of workable parameters for the avoidance of cost and time overruns to facilitate implementation within budget and on time, improvement of service quality, and generation of appropriate and commensurate revenue for a public project without compromising profitable returns on the stakeholders’ investment. Fig 1 shows the conceptual classification of the research areas of the proposed PPP VfM renegotiation framework for road projects.

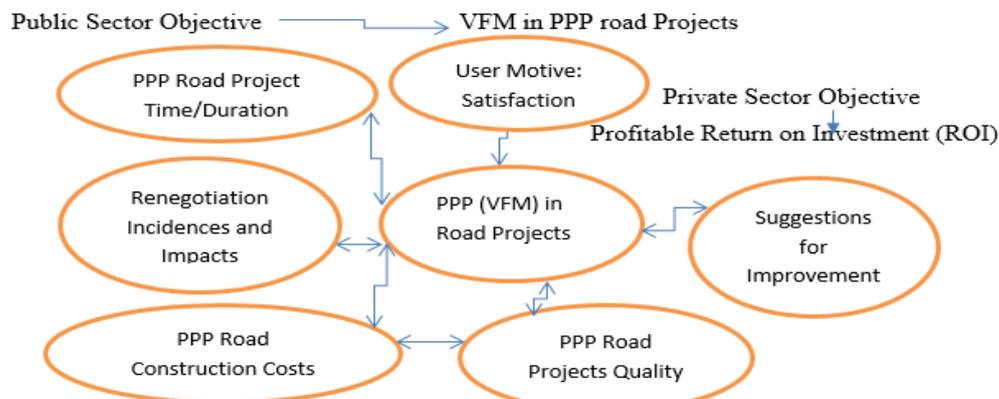


Fig 1: Conceptual Classification of the Research Areas of Proposed PPP VfM Renegotiation Framework for Road Projects

ONGOING RESEARCH TOWARDS THE DEVELOPMENT OF VALUE FOR MONEY FRAMEWORK

This review has significance in that it arises from ongoing PhD research, and its focus relates to the aim of that research, which is to investigate through empirical data collection the appropriate phases of PPP projects in order to ascertain renegotiation problems and issues that impact VfM implementation. Incidences and outcomes of renegotiation as well as the beneficiaries of the renegotiation process have been established for the following countries: Brazil, Chile, Colombia, Peru, Portugal, Spain and Greece, as well as Caribbean countries. However, not much work/research has been done in the context of the European Union (EU), and particularly of the UK. Mackovsek *et al.* (2014) claim that the paucity of research in the area of PPP renegotiation is due to a lack of data on renegotiations and the nature of renegotiations in PPP projects (including road projects).

This ongoing research therefore intends to investigate public agencies and concessionaires involved in PPP road projects in the UK. The reason for the adoption of the UK is that the UK has Europe's largest programme of PPPs, with 400 infrastructure projects in operation, which means that the UK constitutes around 25% of the overall EU PPP market (European Investment Bank 2004). In contrast, other countries such as Portugal, Spain and South Korea, all of which have adopted PPP for the delivery of road projects have initiated around 40 PPPs each (Baeza and Vassallo, 2010; Reside and Mendoza 2010) but which have been the subject of a handful of studies on PPP renegotiation. It is therefore surprising that in spite of the profile of the UK in terms of its adoption of PPP for infrastructure projects, few theoretical studies have investigated renegotiation to evaluate the issues surrounding its occurrence during PPP project implementation.

Indeed, studies conducted in the UK have not made available empirical data with respect to incidences of PPP renegotiation, the outcomes of PPP renegotiation or other issues inherent in implementation. This may be due to the fact that private firms rarely share information on such agreements and are even more unlikely to reveal information about renegotiation decisions and outcomes (Sarmiento 2014). This is one of the challenges the research intends to overcome through the collection of data. Moreover, most PPP road projects in the UK are currently in the operation stage, and few have been completed.

The study therefore investigates only long-standing PPP road projects and those which have been completed with the aim of remedying the dearth of empirical data on renegotiation in the UK. Thus, empirical data will be collected as a basis for appraising factors driving renegotiation, and the research will further assess the implications of value for money (VfM) achievement as a result of the renegotiation of road contracts as a basis for developing a workable framework for VfM implementation.

CONCLUSION

The findings of this review reveal that private concessionaires are mostly beneficiaries of the renegotiation process because of the frequent intervention of the government to financially rescue PPP road projects, which are failing or experiencing difficulties. In other words, the outcome of most incidences of renegotiation favour the private concessionaire. In contrast, the outcome of the renegotiation of road projects has not always been in the best interest of members of the public. In this situation, value for money has mostly eluded the public agency. This is evidenced in increases in tariffs

and user charges, and in cost and time overruns. On this note, this paper concludes that there is need for the assessment and evaluation of the renegotiation of road projects in consideration of the failure to achieve value for money for the public sector in most instances. The ongoing research seeks to address this gap in knowledge through the development of a value for money framework for managing the renegotiation of PPP road projects.

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RELATIONAL APPROACH OF VALUE CREATION FOR CONSTRUCTION PROJECT DELIVERY: A CONCEPTUAL FRAMEWORK

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In the current global and competitive business environment, the delivery of construction projects is a recognized challenge. However, the separation of design-construction-operation responsibilities has been a significant source of issues, resulting in poor 'triple constraint' project performance and negatively impacting long-term benefits realization. Stakeholder theory proposes that organizations can create value by improving stakeholder relationships and a substantial body of literature on strategic and project management proposes that project delivery models (PDM) that recognize and value these relationships better support value creation (VC). In consequence, this study undertakes a systematic review of extant literature and drawing mainly from the stakeholder theory, examines how PDM support the VC process (independently or co-created) in construction projects and their contribution to the project value. This study identifies three fundamental VC drivers for selecting a suitable PDM: early involvement, integration, and contractual agreements. A conceptual VC framework is proposed based on different forms of client-contractor relationships. Four environments called transactional, coordinative, cooperative, and collaborative are recognizable, each with its own characteristics attributable to the degree of interaction and trust between parties necessary to maximize long-term value within construction projects. The framework developed serves as a platform for future knowledge development and research into VC theory in the construction industry.

Keywords: project delivery model, project value, relationships, value creation.

INTRODUCTION

Construction project delivery has always been challenging (Ahola, Laitinen, Kujala, and Wikström, 2008; Forgues and Koskela, 2009; Oyetunji and Anderson, 2006). For example, typically under the schedule pressure commonly found is a major construction project many projects started construction prior to the project scope (i.e. requirements) being clearly defined (Abi-Karam, 2006; Eweje, Turner, and Müller, 2012). Where this happens, the contractor has the motive to behave opportunistically to demand higher than normal margins when accommodating scope change raising the overall cost of the project. Such scope changes are not normally subject to competitive bidding and therefore make it difficult for the client to argue against the variation costs demanded by the contractor. One way to avoid such opportunistic contractor

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behaviours is resulting from unclear scope definition is for the parties (client and the contractors) to cooperate and collaborate closely early in the project's inception (i.e. long before the tendering stage). However, such trusting relationships are rare and habitually designers (representing the client) and construction contractors work separately applying a traditional project delivery model (PDM) that keep the design and construction stages distinct. This model does not allow for requirements uncertainty and so increase project risks and impacts negatively on project value. Accordingly determining the appropriate PDM plays a critical role in ensuring a project creates long-term value for owners and others key stakeholders (Abi-Karam, 2006; Cheng and Carrillo, 2012; Crespín-Mazet and Portier, 2010; Hyvarinen, Huovila, and Porkka, 2012; Leiringer, Green, and Raja, 2009) and reduces the traditional fragmentation of design-construction-operation stages and interested parties (Dainty, 2007; Forgues and Koskela, 2009; Nawi, Nifa, and Ahmed, 2014).

The problem of uncertain requirements is not confined to construction and software/IT have increasingly looked to what are termed agile methods to more flexibly adapt or respond to scope changes. Indeed, some of these methods, such as Scrum, are a simplified form of PDM that is based around a tight-knit team that explicitly includes customer representatives that uses short, time-boxed release-cycles called sprints to regularly deliver value. While many of the characteristics of Scrum and other agile methods are based on the unique flexibility of the software medium, the high rate of adoption of these methods and their ability to reduce the contractual nature of the relationship between customers and developers suggest that similar relationships be explored in construction projects.

Stakeholder theory focuses the value creation (VC) process on maximizing benefits through relationships with stakeholders (Freeman, Harrison, Wicks, Parmar, and De Colle, 2010), where stakeholder engagement and stakeholder cooperation are two main principles that have been underlined. Although the traditional definition of VC is based on activities performed by the focal organization (Harrison and Wicks, 2013; Jensen, 2001), stakeholders may also collaborate closely to create mutual value (Aapaoja, Haapasalo, and Söderström, 2013; Chan, Chan, Chan, and Lam, 2012; Jacobsson and Roth, 2014). Hence, this paper studies the VC process in two dimensions: independent VC, and value co-creation.

Independent VC relates to the scenario where the project stakeholders have the knowledge, expertise and resources to solely deliver their specific part of a project's responsibilities without the need to seek contributions from other project partners. Examples of this type of VC include routine building construction projects where the parties know how to deliver their services or products without the need to help from other actors. In contrast, value co-creation refers to the scenario where stakeholders have to work closely together if they are to complete an activity or task. Examples can be found in infrastructure projects where significant risks exist and innovation is required to determine the design that meets the objectives. This necessitates that parties collaborate closely to maximize project value.

Specifically, this study investigates how PDMs support the VC process as independently as co-created in construction projects and what effects it can have on the project value delivered. Despite the importance of these questions, the prior literature is limited and ambiguous, consequently a systematic literature review was undertaken which aims to identify patterns and direct future research in this area.

RESEARCH METHODOLOGY

To answer the research questions, the current study was performed through a review of the literature on PDM and VC. The systematic method was applied within the project management field (e.g. Achterkamp and Vos (2008); Holzmann (2013)) in order to increase methodological rigour for synthesizing and producing reliable knowledge for both researchers and practitioners (Tranfield, Denyer, and Smart, 2003).

Firstly, to ensure high quality of the literature, this review was focussed on peer-reviewed publications (i.e. journal articles and international conference papers). The search criteria included three main parameters: period of publication, key terms, and ranking criterion were used in accessing the Scopus, ProQuest and Google Scholar academic databases. The period of publication for the literature search was the 15 years between 2000 and 2014 because the VC construct is a relative new concept in management literature and different PDMs have been proposed to deliver construction projects during this time. Search terms were defined a priori as: 'project delivery model OR project delivery method OR project procurement system AND value creation'. These main terms could be included in the title, abstract or keywords. Additionally, this review did not apply a high ranking journal criterion for seeking to ensure a broad range overview. Based on first criteria, 362 potential publications were obtained (including some duplications), however only 95 of them (26%) include some main terms in the title, abstract or keywords (second criteria).

Secondly, each article was reviewed with suitable publications were selected to form part of this study based on two considerations: context (i.e. construction/project management context), and relevance (i.e. both academic/research paper and direct relation between constructs: PDM and VC process). A total of 54 publications met the required criteria and formed the dataset for this study.

Lastly, capturing and analysing information of this dataset were realized using NVIVO 10. Information capturing started with a pre-codification scheme (e.g., definitions, factors and, types of VC and PDMs). Relevant information (i.e. sentences or paragraphs) was introduced in actual coding according to pre-code scheme. In the end, analysing information was realized through a descriptive and comprehensive understanding of the selected literature, checking redundancies and reporting.

The result derives in three significant drivers of VC from PDM which could be maximized through four types of stakeholder's relationships. In addition, a conceptual framework of VC in construction is proposed. Next sections explain it in details.

PDM AS PLATFORM TO CREATE VALUE

The fifteen years of strategic and project management literature reviewed has emphasized the relevance of VC from different perspectives, highlighting its critical role in a business model. According to Pekuri, Pekuri, and Haapasalo (2013), business models represent the manner in which organizations create value for clients and others key stakeholders, including benefits to themselves. More specifically, Magretta (2002) [cited in (Davies, Frederiksen, Dewulf, Taylor, and Chinowsky, 2010)] state that a business model describes how all of the components of an organization (i.e., resources, capabilities, strategy) fit together to create value for the firm and its clients. The focus of business models has been mostly on firm level. Meanwhile, project management research emphasises that business models cross intra and inter-organizational boundaries of firms and projects (Wikström, Artto, Kujala, and

Söderlund, 2010). Thus, project-based organizations (PBO) such as construction firms should consider understanding the VC process to different types of projects and developing business models that better meet the needs of specific clients or market segments while it also provide organizational competitiveness (Pekuri *et al.*, 2013). In consequence, a business model should be conceived to provide a source of sustainable competitive advantage (Davies *et al.*, 2010), representing a critical issue to better address the value created from the project level (Kujala, Arto, Aaltonen, and Turkulainen, 2010; Wikström *et al.*, 2010).

On the other hand specifically in construction, PDM is the process through which a project is designed and performed for a client (i.e. owner). This process traditionally includes project scope definition, organization of designers, constructors, sub-contractors, and consultants, design and construction phases sequence definition, execution and, closeout and operation start-up (Gransberg, Koch, and Molenaar, 2006). In the most of the cases, if one of these phases fails or is sub-optimal, the project success could be seriously affected in terms of the 'triple constraint' criteria; budget, schedule and quality. In addition, the PDM helps to define the nature of the relationships between project parties involved, to allocate the risks between them, and to identify which are the contract terms (Nawi *et al.*, 2014). However, the most relevant concern to the client and others parties is if the project will achieve the long-term, strategic objectives expressed as economic, environmental and societal goals. In consequence, the PDM is currently also considered as a core component to effectively support the VC process for client (Hyvarinen *et al.*, 2012) and others project stakeholders (Aapaoja, Haapasalo, *et al.*, 2013). Thus, the focus on construction project delivery is changing from the physical result and the triple-constraint toward a life-cycle VC process. This more holistic view ranges from the front-end (idea, selection, definition, financing) to the back-end (renovation, operation and maintenance) (Abi-Karam, 2006) necessary to achieve project value. The success of a PDM can therefore be measured in terms of both project efficiency (i.e. short-term objectives associated with cost, time and quality) and project effectiveness (i.e. long-term benefits to client, users and, the society).

Suitable PDMs and value creation drivers

If a business model is the means by which a firm creates value for its client and stakeholders, then to PBOs each project delivered is a particular value creation process that it is supported by the specific PDM selected. Indeed, the choice of an appropriate PDM, understanding it as source of value could significantly affect the value created and added for the owner (Ahola *et al.*, 2008) and others stakeholders. Table 1 describes three value creation drivers that could be performed for a suitable PDM to impact favourably on value creation process to maximize project value: early involvement; design-construction integration; and contractual agreements.

First, PDM can establish and maintain collaborative inter-organizational relationships (IORs) based on closely and joint interactions between partners (i.e. mainly client and contractor) during whole project lifecycle. Under this relational environment of collaboration main contractor and designer (led by client) can share same goals, processes and practices in order to support an effective and efficient communication, information exchange, risks/gains sharing, and continuous learning and improvement. Under this focus on close collaboration, PDM may engage in early project stages (from design) the contractor and others stakeholders. Early contractor involvement is fundamental to mitigate project risks and future disputes due to design and build differences through constructability, sharing knowledge and learning from and for the

contractor. Additionally, engaging stakeholders early could allow defining clearly users' needs and constraints to improve operability and maintainability.

Second, the integration of design and contraction stages through a suitable PDM eliminate the traditional construction project fragmentation, encouraging to knowledge and information sharing, improving lifecycle project costs and schedule and reducing design-construction issues with proactive solutions. This integration helps to shape a cohesive multiparty team (i.e. contractors, designers, sub-contractors, client and users) that work together from their stakes to successfully complete the project in an environment characterized by trust, respectful and 'no-flame' actions.

Table 1: Value creation drivers in construction projects

VC Driver, description and benefits	Researcher(s) and year
<p>Early (contractor or stakeholder) involvement: Maintaining close and strong collaborative relationships between partners and incorporating the contractor and key stakeholders in the entire project lifecycle.</p> <p>It could produce: clear definition of responsibilities; sharing of risks and rewards; effective informal control through mutual trust, flexibility and solidarity; reduction of possible risks; reducing negative effects on the behaviours of project actors (e.g. opportunism); resolving proactively disputes; understanding what clients want and how suppliers can help them achieve their goals; sharing vision; enhancing exploratory innovation; developing joint objectives with a win-win perspective; facilitating communication and information sharing; enduring continuous learning and improvement; enabling to cost and time savings and project quality; creating a no-blame culture and high levels of responsiveness; improving the design from the contractor's experience and knowledge; finding solutions that best meets the requirements and the constraints; mitigating risks; enhancing constructability; enabling a strong leadership and proactive contractor; increasing pain/gain sharing; sharing knowledge about the end-users enhancing product's function and usage; and, producing efficient operations according to the user's needs.</p>	<p>Aapaoja, Haapasalo, et al. (2013); Aapaoja, Herrala, Pekuri, and Haapasalo (2013); Abdirad and Pishdad-Bozorgi (2014); Abi-Karam (2006); Ahola et al. (2008); Caldwell, Roehrich, and Davies (2009); Chan et al. (2012); Cheng and Carrillo (2012); Crespin-Mazet and Portier (2010); Eriksson (2013); Errasti, Beach, Oyarbide, and Santos (2007); Kujala et al. (2010); Nawi et al. (2014); Ndoni and Elhag (2010); Tillmann, Ballard, Tzortzopolous, and Formosa (2012) Walker and Jacobsson (2014); Walker and Lloyd-Walker (2013); (Zimina, Ballard, & Pasquire, 2012)</p>
<p>Design-construction integration: System designed to allow the client, contractor and other parties may develop clearly defined and challenging mutual objectives through an effective project team.</p> <p>It could help: reducing traditional fragmentation; encouraging continuous improvements; better constructability and maintainability; resolving potential problems; allowing a focus on long term exploratory design issues and short term exploitation in efficient build activities; merging knowledge and information; sharing mutual interests and incentives; and, sharing expertise and responsibilities to join decision-making process.</p>	<p>Aapaoja, Haapasalo, et al. (2013); Aapaoja, Herrala, et al. (2013); Chan et al. (2012); Crespin-Mazet and Portier (2010); Eriksson (2013); Forgues and Koskela (2009); Leiringer et al. (2009); Nawi et al. (2014); Tillmann et al. (2012).</p>
<p>Contractual agreements: They are an essential part of projects which include patterns of formal relationships as well as informal.</p> <p>It could create: reducing hazards of opportunism behaviour; establishing formal controls to deploy safeguards through contractual enforcement and monitoring; reducing asymmetric information, promoting cooperative, long-term, trusting relations; providing legal enforceability; and, establishing mechanisms to relationship termination and conflict resolution issues.</p>	<p>Aapaoja, Haapasalo, et al. (2013); Caldwell et al. (2009); Chan et al. (2012); Forgues and Koskela (2009); Jacobsson and Roth (2014)</p>

Finally, although some empirical studies have demonstrated that contractual arrangements could be detrimental to foment close IORs, these agreements are an essential part of PDM as a platform to create value because includes mainly patterns of relationships between partners. Within formal agreements, contractors and owners may reduce opportunistic behaviour and asymmetric information through defined controls and often monitoring, as well as fomenting trust, cooperation and long-term win-win relationships by means of legal enforceability.

CREATING VALUE THROUGH RELATIONSHIPS

Stakeholder theory focuses on maximizing benefits through relationships with stakeholders (Freeman *et al.*, 2010). Although economic and financial viewpoint currently represents the main value measure of success to organizations, value maximization through stakeholder's satisfaction increases returns (i.e. benefits) in long-term (Harrison and Wicks, 2013). Justly, this study takes stakeholder theory as theoretical foundation because, as analysed above, the PDM configure a relevant platform to value creation considering close relationships and interactions between key stakeholders (mainly client-contractor dyads). According to a seminal research of Spekman, Kamauff, and Myhr (1998) and the extant literature reviewed, four types of client-contractor relationships, namely transactional, coordinative, cooperative and, collaborative are suggested as follows.

Transactional VC approach

Transactional relationship is the traditional way to deliver projects. It represents an exchange relationship based on short-term, limited and price-based interaction between actors where each transaction is becoming a new one (Pala, Edum-Fotwe, Ruikar, Doughty, and Peters, 2012). In this context, the projects are organized as a sequential process, where various actors participate only when their specific work is to be done (Zimina *et al.*, 2012), fomenting often adversarial relationships within a competitive context (Crespin-Mazet and Portier, 2010). The primary focus is on efficiency (Walker and Lloyd-Walker, 2013). In construction projects, a transactional mode is delivered when client receive what was specified through traditionally a design-bid-build (DBB) model (Walker and Jacobsson, 2014) where the owner (by means of designer or consultant team) leads the design process but no participates actively during construction process, maintaining almost none interaction with the contractor (Walker and Lloyd-Walker, 2013).

Accordingly, we propose that this transactional VC approach is performed to situations where parties do not need to interact with others to complete their tasks. It evidently represents an independent VC process where contractual agreements are the main source to create value. In this approach, the exchanged product adds value per se to the client and the impact on project value is only in terms of efficiency (i.e. on budget, on schedule, and on scope).

Coordinative VC approach

Coordinative relationship results when there are more mechanisms to interact between actors and processes, fundamentally through those related with monitoring and controlling (Pala *et al.*, 2012). This kind of interaction is based on information sharing to ensure project performance (Cheng and Carrillo, 2012), making that the relationship to be more systematic and structured than a transactional by means of administrative procedures (Pala *et al.*, 2012). The main focus of this relationship is on a fair process and common propose (Walker and Lloyd-Walker, 2013). An example of coordinative relationship is the construction management (CM) at risk model, where owner contracts separately designer and contractor but an overlapped design-construction sequence is performed to assure information sharing, frequent monitoring and anticipated problem resolution (Oyetunji and Anderson, 2006).

Thus, we propose that a coordinative VC approach is commonly delivered to situations where parties need clear interfaces to share or transfer information in order to control the progress and to complete theirs tasks. The VC process is independent

for each part. Contractual agreements are fundamental to define actions that fomenting interchange of relevant information. Constant monitoring between the parties adds value to client and it impacts positively on the project performance (i.e. efficiency).

Cooperative VC approach

The relationship based on cooperation integrates different actors and their activities under procurement procedures that encourage joint specification multi-criteria partner selection and incentive-based payment to more creative and innovative problem solving (Eriksson, 2013). In this type of relationships, there are more intensive interactions characterized by long duration, integration, early involvement, gain/pain sharing and focus on both project and client requirements (Pala *et al.*, 2012). Additionally, this cooperative work is facilitated through the alignment between the project process and information-sharing technologies (Sandhu and Gunasekaran, 2004). Integrated on common platforms is the main focus of this relationship (Walker and Lloyd-Walker, 2013). Design and construction (D&C), engineering-procurement-construction (EPC) or early contractor involvement (ECI) models are typically examples of cooperative arrangements in construction projects.

Hence, we propose that a cooperative VC approach appears within situations where parties need proactively to engage other parties in order to achieve goals within the terms of the contract. Main VC drivers are early contractor involvement during design, and design-construction integration. Actions of co-creation such as value management and/or building information modelling (BIM) are necessary to ensure project objectives and stakeholder's benefits. Early and innovative changes in design could provide some added value, impacting efficiency but mainly project effectiveness (e.g. client satisfaction, business success and beneficial usage).

Collaborative VC approach

Collaborative relationship demands that actors (called also partners) from different organizations jointly work as an integrated team towards common objectives and mutual benefits as well as sharing risks and gains (Aapaoja, Herrala, *et al.*, 2013). In addition, an environment of collaboration generates that partners find long-term relationships based on trust and 'no-blame' behaviours (Pala *et al.*, 2012). The value focus is on committed relationships (Walker and Jacobsson, 2014) to enable project performance through cost and time savings, and project quality (Errasti *et al.*, 2007; Ndoni and Elhag, 2010) but also to achieve tangible and intangible benefits for the client, contractor and others stakeholders (Ahola *et al.*, 2008; Tillmann *et al.*, 2012). Some collaborative PDMs have been proposed and applied in a construction context, for instance integrated project delivery (IPD) (Aapaoja, Herrala, *et al.*, 2013; Abdirad and Pishdad-Bozorgi, 2014; Tillmann *et al.*, 2012) and, project and strategic alliancing (Davis and Love, 2011; Walker and Jacobsson, 2014).

Consequently, we propose that this collaborative VC approach is applied to situations where close interaction, joint conflict resolution and risks/gains sharing are required to maximize value. Close client-contractor relationships and design-build integration are two drivers to create value for partners. Evidently, this approach is based on co-creation where client, contractor and others key stakeholders work together (alliance) during whole project lifecycle to achieve long-term benefits. For this reason, collaborative mode impact greatly on effectiveness.

Finally as shown in figure 1, a conceptual framework of VC in construction projects is proposed where VC process has been categorized as independent creation and co-

creation. Also, it is related with VC drivers and the four types of client-contractor relationships through a continuum from transactional (the lowest interaction) until collaborative (the highest interaction).

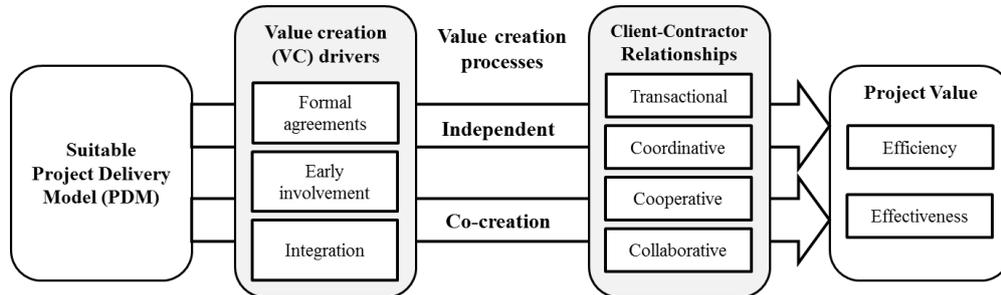


Figure 1: A conceptual framework of value creation in construction

CONCLUSIONS

Underpinned by stakeholder theory, organizations can create greater value from projects where client and others key stakeholders form close relationships. This statement is the foundation of this conceptual study. Supported by a systematic literature review within construction and project management contexts, this paper recognizes that PDMs support the process of VC during whole project lifecycle through three fundamental drivers: early contractor/stakeholder involvement, design-construction integration, and contractual agreements. Furthermore, it discriminates and clarifies four types of relationships between parties to more effective support that lifecycle, namely: transactional, coordinative, cooperative, and collaborative.

Each one of them has own characteristics that could be effective based on the degree of interaction necessary to maximize value from construction project to client and others stakeholders. Accordingly, a conceptual framework has been proposed which takes in account these types of relationships as a continuum starting from low interaction (i.e. more independent VC) to high interaction (i.e. more value co-creation). The effects of PDMs under each VC approach demonstrate that an independent VC process results from transactional or coordinative environments focussed mainly on project efficiency; while cooperative and collaboration relational approaches support co-creation between partners (e.g. client-contractor), contributing more significantly to project effectiveness.

Determining which PDM is best suited to a customer's requirement is extremely important to successful delivery of construction projects. Recognizing their different VC approaches taken by a PDM can reduce the project's risk of failure and help maximize project value. Little empirical analysis on the effects of the more relationship intensive PDMs on project value has been conducted and the efficiency and effectiveness of different PDMs needs further investigation. The conceptual framework presented in this paper will serve as a model for future theoretical and empirical knowledge development within the construction industry.

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RESEARCH METHODOLOGY AND METHODS

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RAPID ETHNOGRAPHY IN CONSTRUCTION GENDER RESEARCH

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In advancing the intellectual debate in gender equity and diversity in the construction industry, feminist institutionalism is being used as a new lens to understand the failure of formal policies to shift the intransigent gender imbalance. Feminist institutionalism allows new insights into how hidden informal organisational rules, practices and narratives operate in conjunction with formal rules in achieving gender diversity and equity. However, the adoption of feminist institutionalism as a conceptual framework raises new methodological questions. While formal rules are created, communicated and enforced through official and highly visible channels, informal rules, norms and procedures are created, communicated, and enforced outside officially sanctioned channels and are often 'hidden' from view. The power of ethnographic methods to reveal such 'under-the-surface' institutions is well established in the social and political sciences but not in construction. This paper makes a methodological contribution in response to the practical constraints of doing ethnography in the construction industry, by describing the merits of rapid ethnography within the context of feminist institutionalism. It concludes that while rapid ethnography has its limitations, it has significant potential as an unexplored methodology to tackle the persistent problem of gender equality in the construction industry and other social issues in construction management research.

Keywords: gender, policy, equity, diversity, feminist institutionalism, ethnography.

INTRODUCTION

In the last few years, ethnography has become an increasingly popular approach in construction management research. Recent research which has explored the application of ethnography to issues such as class, safety, intercultural communication and change management (see for example, Pink *et al* 2012; Shipton and Hughes 2013; Shipton 2012; Subbiah 2012; Tutt *et al.* 2013; Thiel 2012; Oswald *et al* 2014). This work follows the classic ethnographies of construction work conducted by authors such as Sykes (1969), Applebaum (1981), Mars (2005), Paap (2006) and Theil (2007), which has revealed something of the 'masculinity' within which construction practice seems so enmeshed. Despite arguing that ethnography holds considerable promise for construction researchers, the relatively small number of ethnographic studies is somewhat surprising (Pink *et al.* 2010), and there remains an overreliance on interviewing in construction social enquiry (Dainty 2008).

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The aim of this paper is to explore the challenges of classic ethnography in the construction sector and how alternative ethnographic practices might offer pragmatic ways of overcoming them. Specifically, this paper presents a case study of the Australian construction industry (Galea *et al* 2014) that explores the practical difficulties experienced in using ethnography in researching gender equity and diversity. It shows how ‘rapid’ ethnography was adopted as a viable alternative and how this might be suitable to other social research projects in the broader field of construction management.

EXAMINING GENDER EQUITY IN CONSTRUCTION USING A FEMINIST INSTITUTIONAL LENS

Recent statistics show the Australian construction industry remains Australia’s most male dominated sector despite many reforms to increase female representation (EOWWA 2012). Women have fallen from 17% of the Australian construction workforce in 2006 (ABS 2006) to just 11.6% in 2012 (EOWWA 2012). Countries like the UK have followed similar trends; early enthusiasm from women construction professionals about their own careers decreases with increased exposure to the construction workplace (Sang and Powell 2012; Dainty *et al.* 2000). In an effort to explain these discrepancies, researchers have turned to scholarship on gender in organisations. According to gender theorist Raewyn Connell (2005), gender is an embedded feature of all organisations. Organisations, including those in the construction industry, are not gender-neutral structures but institutionalise practices of femininity and masculinity into unequal gender hierarchies, gendered work practices and gender-specific jobs. In the construction sector, institutionalised gender practices play out through gender biases and discrimination in both formal policies and procedures that serve to uphold a masculine workplace culture, which emphasises presenteeism and long work hours (Powell *et al.* 2009; Watts 2007).

Research about the under-representation of women within and outside construction remains conceptually narrow. Dainty *et al.* (2007) note, construction management research is disconnected from theoretical developments in social and behavioural sciences and Terjesen *et al* (2009) has identified an urgent need for more scholarship in gender research. There is clearly a need to advance the intellectual debate in this area and to this end, new-institutionalist theories, especially its feminist institutionalist variant offers a valuable new lens (Chappell 2006; Waylen 2009; Mackay *et al* 2010; Krook and Mackay 2010). The basic premise of new institutionalism is that rules ‘matter’ (March and Olsen 1984, 747) as they structure social interaction and shape behaviour of people, organisations and government (Helmke and Levitsky 2004). Feminist institutionalism provides a lens to examine the gendered rules – formal and informal - operating in organisations and how these influence gender equality. According to new-institutionalism, formal rules are embedded in policies, strategies, constitutions, individual contracts and operational guidelines and enforced through channels widely accepted as official (Lowndes 2005). In contrast, informal rules, practices and narratives are unwritten socially shared rules which are created, communicated, and enforced outside of officially sanctioned channels (Helmke and Levitsky 2004). Chappell and Waylen (2013) and Azri and Smith (2012) argue that research using new-institutionalist theory has overly focussed on formal rules over informal. Yet as Krook and Mackay (2010) point out, the interplay of formal and informal rules may help explain the failure of formal policies to shift the gender imbalance in organisations. Examples of informal gender rules in the construction

industry which may undermine formal gender diversity policies include embedded views about the appropriate qualities necessary to be effective at work, expectations about presenteeism and time commitments, and the place and timing of meetings which often conflict with care-giving responsibilities. These accepted modes of behaviour, and many others, keep the industry's dominant culture intact (Dryburgh 1999) and as a consequence act as a barrier to women's recruitment, retention and progression.

METHODOLOGICAL IMPLICATIONS OF USING FEMINIST INSTITUTIONALIST THEORY

New theoretical approaches require new methodological thinking. The enforcement processes of formal rules can be more readily studied since they are written down and involve obvious actors such as managers, policy makers and committees. However, informal rules are much harder to research since they often take place through 'subtle, hidden, and even illegal channels' (Helmke and Levitsky 2004; Chappell 2006). Furthermore, analysing informal rules around gender practices raises practical issues since respondents may not even perceive or recognise the existence of informal gender rules because their normalisation and taken-for-granted nature may render them invisible.

Increasingly in the social and political sciences, these sorts of challenges are being addressed with the use of ethnographically-based research (Radnitz 2011). In simple terms, ethnography is a set of methods which involves the researcher participating in the daily lives of people for an extended period of time, observing what happens, listening to what is said, asking questions, undertaking follow up interviews and collecting any relevant that can throw light on issues of interest (Hammersley and Atkinson 1995). In ethnography, the researcher effectively acts as a translator between the group or culture under study and the reader (Millen 2000). In this sense they are both 'emic' (from the perspective of the participants) and 'etic' (from the perspective of the observer). Ethnographic research is typically more intensive than other forms of social research and is holistic, descriptive and reflective in nature (Ybema *et al* 2010). It tends to avoid causal relationships in favour of inductive explanations of explanatory theories and generally rely on a limited number of case studies that are investigated intensively in both a highly personalised and field-based context using primarily qualitative methods. This enables the researcher to capture the social meanings and ordinary activities of people in their natural settings. As such, ethnographic research must be seen as a reflexive and subjective practice within which the researcher is expected to contribute or participate (Pink *et al.* 2012).

The use of ethnography to reveal gendered dimensions of social life has a long history (Skeggs 2001; Visweswaran 1997), but as Chappell and Waylen (2013) note, ethnography has rarely been used in new-institutionalist research in specifically gendered ways, or as a gendered lens on informal institutions. Similarly, while ethnography's use in construction management is on the increase, its value in exploring gendered rules and practices in the sector has yet to be fully explored.

ORIGINAL ETHNOGRAPHIC RESEARCH DESIGN

Motivated by the need to address the narrow theoretical and methodological understandings of the intransigence of gender inequity in construction, we adopted an ethnographic approach to investigate the interplay of informal gendered rules and formal rules and policies in two multinational construction firms. We used two in-

depth case studies of multinational construction firms. One company (A) is a privately owned multinational contractor, which operates in the commercial, residential, engineering and infrastructure markets. The second company (B) is a publicly listed multinational contractor which operates in the commercial, residential, engineering and infrastructure markets. This research was phase 2 of a larger project, where phase 1 has focussed on the formal institutions that influence gender inequity (Galea *et al* 2014). Phase 2 use an ethnographic approach

However, despite close interaction with, and support from senior management among our industry partners, we encountered a number of problems to entering the field which challenged our approach. These are described below:

A key concern for the research team, entering phase one, was how to position the research. It became clear after phase 1 that, in both companies, *gender* tended to be understood as meaning ‘women’ (Galea *et al* 2014). We wanted to ensure that in this second phase we were able to observe ‘everyday’ interactions, processes and workplace practices, not just issues understood by the companies as explicitly related to gender, such as the provision of ‘family friendly’ work practices including parental leave and the provision of childcare facilities and women’s leadership training. This compounded management concerns that men in the companies may think we were trying to ‘catch them out’ or identify them as the main barrier to women’s recruitment, retention and progression. A further concern was that men might be disinclined to participate in research about gender because, in thinking it was really about women, they did not consider that it related to them.

Contracting is a highly competitive business, in building rapport and trust in the early stages of the research, the research team also had to overcome concerns that the research was seen by some respondents as potentially risky for their business or that trade secrets might be revealed to the other participating company.

Construction is a highly time pressured and resource intensive process where there is little time for people to engage with researchers in any detailed way. This meant the research team felt that many usual ethnographic methods such as spending extended periods of time on site or asking participants to complete diaries about their experiences was too great an imposition.

The project-based nature of construction activity, across multiple locations and for finite periods of time, mean in-depth traditional ethnography at one site or location was not appropriate to investigate how informal rules interact with formal rules across different site locations and teams. It was also not sufficient to spend an extended period of time only at head-office, where employees may be less likely to bend formal rules compared to employees on distant project sites. Accounting for the multiple temporalities which characterise construction practice has been acknowledged as representing a significant challenge for classic ethnographic approaches (Pink *et al* 2010).

Our access to companies was through the HR departments based at head office who often acted as gatekeepers in accessing potential respondents. Our gatekeepers, who were usually the champions of gender-related initiatives, were particularly concerned that project site teams, who were responsible for the day-to-day implementation of policies and initiatives, would be reluctant for us to observe and shadow them. However, our phase one interviews with business leaders, suggested that while this may be the case for some, there were others on site who would support our fieldwork.

These issues, which are not necessarily unique to researchers engaging with large construction contractors, forced us to reflect on the practicality of doing ethnography in the context of our research (see also Sage 2012 and Hartman 2012). As Pink (2005) identifies, obtaining a richness of knowledge within a limited time frame using ethnography is challenging for researchers. However, in order to uncover the informal rules at work in shaping gender policy in practice we were mindful of the need to maintain an ethnographic methodology. Our solution to this dilemma was to explore a 'rapid' ethnographic approach.

REVISED RESEARCH DESIGN: RAPID ETHNOGRAPHY

In contrast to the wide-angled, explorative and time-intensive approach of traditional ethnography, rapid ethnographers work in teams to undertake short, intensive and focused investigations using multiple and iterative methods to gain a deep understanding of the work setting they are studying (Millen 2000, Schultz *et al* 2009, Isaacs 2013). In rapid ethnography, open-ended interviews and explorative observations are replaced with condensed equivalents which are more focused on specific propositions and/or issues of interest which are identified from existing theory and literature before the research begins (Baines and Cunningham 2013).

Furthermore, broad conversations and interactions with numerous random informants are replaced with targeted and deliberative interviews with sampled respondents at key intervals and moments where data is the richest and most relevant to the questions of interest. Frequent interaction and communication with informants and the research team are essential through the iterative reflections on emerging results and the theoretical framework helping to focus the research even more and avoid time wasting in subsequent rounds of research. This requires careful up-front planning directed by research which has a strong theoretical focus and a systemically thought through method informed by specific research questions and propositions.

While rapid ethnography has been criticised by some for being a quick and dirty, second-rate approach to ethnography, arising from the commercial constraints of industry researchers who cannot afford to spend months in the field (Millen 2000, Isaacs 2013), it none-the-less provides some practical solutions to the challenges we encountered. As such we engaged a rapid ethnographic approach and incorporated targeted strategies to address some of the issues highlighted above. Our rapid ethnography approach comprised participant observation, shadowing and semi-structured interviews with a wide range of construction professionals from both case organisations. This allowed us to embrace both emic and etic approaches to our ethnographic work, allowing us to move from a position of an 'outsider' to a position of an 'insider' (and also simultaneously at times and in different places and contexts). This is always a challenge in any ethnographic research since there are contradictory issues that need to be worked through. For example, while our interviews very much positioned us as an outsider, the onsite shadowing and our regular participation in the events we observed allowed us to build relationships and fade into the background and see issues from the perspective of our respondents. As noted above participant observation was a critical component of the research that was necessary to reveal how informal rules and practices undermine formal strategies to improve gender equity and how both formal and informal rules and practices may differentially affect men and women's career experiences. To address some of the concerns of our partners, the ethnographic phase of the research was also rebadged, or repositioned, and ultimately

depoliticised by shifting the focus away from gender per se, towards a proxy: career pathways. While information provided to participants acknowledged our interest in gender, we foregrounded our focus on recruitment, progression and retention. This rebadging addressed concerns that telling people we were researching gender would limit our exposure to a broad range of people within the companies, particularly men. Gender therefore became an analytical concept, rather than the defining concept of our research for participants.

Given the challenges described above, the participant observation was designed as a staged process, beginning with less intrusion and demands on individuals, to allow the companies and participants to become familiar with the research and to see that it would not interfere with their work. This strategy was adopted to build relationships, rapport and trust between the researchers and respondents. The first part of the observation focused on pairs of researchers observing events or activities, including formal and informal meetings, diversity training, new employee inductions, graduate assessment centres, leadership training, mentoring initiatives, management 'road shows', and diversity-specific events. These observations noted room layout and seating arrangements, presenters, timing of events, who attended, who had 'voice', tone of conversation and participant involvement and engagement, practices (who does what) and group dynamics (how do people participate etc.) and narrative (what is the message being reinforced). Researchers also collected data such as handouts and invitations and took photos of people's positioning and presentation materials. Where appropriate the researchers also participated in these events and conducted informal conversation with attendees asking questions such as 'Is this event/activity typical?' 'Is it important to attend events like this?' Participants were also invited to take-part in an interview if the conversation became more personal. Interviews that formed part of the rapid ethnography were designed to complement the observations and explore how formal and informal rules interact, conflict or are reinforced in relation to recruitment, progression and retention. As such they explored narratives around career history and recruitment, mentoring and networks, what kind of people do well around here, promotion processes and work practices (such as hours and work-life balance).

The second part involved observation of a number of construction project sites, which involved two researchers spending 3-5 days (depending on the size of the project) on site, shadowing and interviewing professional employees in a range of positions. Observations on site focussed on work practices (what time people arrived and left the site), roles on site (who does what roles, whether roles are associated with particular work practices such as total availability or leadership), whether there is a demarcation between project site and site office, the composition of work practices during the day (formal and informal meetings and interactions), who had 'voice' within these meetings and the tone of engagement, group dynamics (how do people participate etc.) and narrative (what messages are being reinforced). Shadowing also provided an excellent opportunity for informal conversations with participants and included questions such as 'Was that a typical site meeting?' 'Is it important to arrive on site at this time?', 'Who is looked up to on this site, Why?'. If the conversation became more personal, participants were invited to take-part in an interview. To address concerns around confidentiality, we took care to emphasise the fact that we were observing process rather than content or individuals.

Where possible, the two-member research teams involved in the observations were twinned, with an 'insider' and an 'outsider'. The insiders were members of the research team with extensive experience and established relationships in the

construction sector, while the outsider researchers were gender experts from sociology and political science. This combination allowed the researchers to overcome challenges associated with being both an outsider – potentially not understanding issues – and an insider – missing important messages because they are taken-for-granted (Baines and Cunningham 2013; Bjarnegard 2013). As Pink *et al* (2012) observe, construction is a very masculine space and much of the ethnography work to date has been undertaken by male researchers. Our research team comprised of both men and women and while not always possible, we actively tried to maintain this mix throughout the research, in recognition that our gender may impact on our interpretation of data. The researchers reflected on their gender and acknowledge different self-reflexivity between researchers in post-observation debriefs.

After each observation the researchers debriefed and reflected, recording their conversation, which was later transcribed and formed the first stage of data analysis. A final obligation in any ethnographic research is to reflexively consider how empirical insights are kept in dialogue with theory throughout the research process (Pink *et al* 2013). To address this issue, researchers also kept notes and reflected in the debriefs on emerging findings, theoretical observations, and how their own perspectives (gender, previous experience, academic discipline, etc.) may have impacted on their interpretation of the data. These debriefs and analytical memos were important in addressing the challenges of analysis in a multi-researcher ethnography, where there are bound to perceptual differences and various points of agreement and disagreement.

CONCLUSION

This paper explored the practical difficulties experienced in using ethnography in researching gender and equity and diversity in the construction industry. Through a case study, it explored how rapid ethnography was adopted as an emerging and viable alternative which might be suitable to other social research projects in the broader field of construction management. As construction activity becomes ever more resource constrained, time pressured and risk adverse, the need for construction management researchers to innovate in finding new ways to undertake social research which fit with the cultural and real-life constraints of their informants will no doubt grow. In doing so, we identified many benefits in adopting a more telescoped and rapid approach to our ethnographic research that addressed the constraints presented in researching the organisational practices of large construction companies. These include less intrusiveness and avoiding the opportunity-cost of broad ranging unfocused investigations which would have resulted in the collection and analysis of a large amount of data which did not relate to the problem being addressed. However, rapid ethnography needs a strong theoretical context and systematic method to be thought out in advance. It also requires teamwork, close interaction with informants, focus, new technology, multiple methods, up-front planning, multi-tasking, time and informant sampling and the identification of clearer research questions and propositions in advance.

Is rapid ethnography always appropriate? The answer is obviously no. It may also be argued that the rapid ethnography approach (which is based on less intensive but more targeted research) is at odds with our initial argument that informal rules and practices underpinning gender discrimination cannot be accessed at the surface level, we have shown and argued here that this is possible in well-designed rapid ethnography research.

But when faced with a range of practical constraints, rapid ethnography represents an interesting and potentially viable alternative, which fits with the cultural and practical constraints on the construction industry and which can provide meaningful empirical insights into the important and persistent problem of gender diversity and equity. It might also be of significant wider interest and value to many other aspiring social researchers in the field of construction management.

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TRUST AND CONSTRUCTION PROJECTS - AN AUTO-ETHNOGRAPHIC EXPLORATION

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Associates, who use partnering as a form of cooperation, need to trust each other. However, even if one considers trust to be an expectation of good will, the partners will still need to have an understanding on the terms of their cooperation. How reflexivity and tactful action might enhance trust, cooperation and mutual understanding is here investigated in depth from a personal perspective. This auto-ethnographic study draws on the personal experiences of the author, who runs a construction business. The layered text account serves as a tool to explore multiple levels of reflection. An investigation is undertaken to consider the underlying patterns of judgements of trust, as well as the shifting nature of the context. Negotiators do not possess a sufficient understanding to effectively judge when to trust a partner. However, through the application of tactful action and reflexive investigation of one's self, one's partner and the context of the situation, a better understanding and better judgements of trust can be achieved. For those seeking partnerships in construction projects, one should not underestimate the importance of critically reflecting on their own practice and their own understanding of others.

Keywords: auto-ethnography, negotiation, partnering, reflexivity, trust.

INTRODUCTION

In the presented research, I seek to contribute to our understanding of the role that trust plays in negotiations. I use Baier's (1986) concept of trust in which the trustor relinquishes discretionary power over things valued to the trustee. The trustor expects the trustee to exercise goodwill and competence, without having complete knowledge of and control over the trustee (Baier 1986). Here, I will focus on the interplay of trust, cooperation and mutual understanding of negotiation partners.

"Trust is a matter of reflexivity" and it develops gradually (Möllering 2006: 102). I will show how active engagement in reflexivity supported my trust judgements. Therefore I applied concepts stemming from qualitative research to my managerial practice.

For more than 15 years, I have been running my own construction business with 38 employees, most of whom are bricklayers and carpenters. My job requires me to negotiate on a daily basis. I will investigate my experience in negotiating with business partners. I use the term *"negotiation"* to refer to most of my interactions in the business environment. This includes, of course, face-to-face negotiations, as well as all other means of communication such as phone calls, emails, letters, etc. Using this definition, each and every act of communication is an act of negotiating.

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The approach used is auto-ethnography. In general, ethnographers become part of the setting they attempt to study. They participate in activities in order to observe the communities first-hand and collect extensive field-notes about their observations and experiences (Hammersley and Atkinson 2007). As auto-ethnographer I am already part of the setting I study. I am native to the setting. In auto-ethnography, autobiography and ethnography merge (Reed-Danahay 1997). In auto-ethnography the research examines the relationship between the self and society by drawing on personal experiences (Ellington and Ellis 2008). I am both subject and object of the investigation process (Scott-Hoy and Ellis 2008).

Previous ethnographic work in construction industry dealt predominantly with topics around actual construction work (Pink, Tutt and Dainty 2013). Though, Sage (2013), for instance, investigated management practices but struggled to get access to building sites and Marshall and Bresnen (2013), sought to follow where action in construction management took place. I am native to the field and my daily business takes me naturally where the action is. I can, due to my job position, offer a “*long-term [18 months] engagement with a research context*” (Pink *et al.* 2010: 4). However, I may not maintain my “*ethnographic distance*” (Sage 2013) resulting in a more subjective account. Nevertheless, I may contribute to the knowledge of construction management since my auto-ethnographic approach enables me to explore “*issues from the perspectives of the individual level*” (Phua 2013: 168) and to “*tap into the ‘lived experience’ of partnering*” from within (Bresnen 2009: 932). I collected field-notes about my negotiations – usually written in the evenings after the event. These field-notes are my predominant source of data (Hammersley and Atkinson 2007).

The disinterested, omniscient voice of an objective researcher would surely jeopardize the authenticity of this research. Hence, I am going to use the first person or, as Ellis (2004) coined it, “*the ethnographic I*”. Here, I am telling my story “*as a narrator, a person with a point of view*” and so “*an embodied person responsible for [my] words*” (Richardson 1990: 27). Even my analysis is just another “*narrative, another point of [my personal] view*” (Richardson 1990: 27). Therefore, a departure from the narrative first person would suggest an objective view that would be misleading to the reader.

My experiences in my business environment are unique. Generalizations from such experiences need to be treated with a great level of suspicion (Van Manen 1990). However, my “*own experiences are also possible experiences of others*” (Van Manen 1990: 54). I want to produce a text “*in which readers can keep in their minds [...] the complexities of concrete moments of lived experience*” (Ellis 2004: 30). In order to write about my understanding of my negotiating relationships in my company I will highlight my experiences with field-notes in italics. These will be presented under a series of themed headings. In order to explore and analyse the meaning and connections of my experiences, I seek to reflect on them deeply. Apart from questioning causal assumptions, I need to uncover prescriptive and paradigmatic assumptions about my own judgments (Brookfield 1995). In order to effectively learn from my experiences I need to reflect in multiple ways, questioning the underlying patterns of my actions and thoughts (Brookfield 1995). Rambo Ronai (1995) provides an effective example of how such thought processes can be conveyed to the reader by using a layered text account. In this paper, I will use this technique. Three asterisks (***) will signal a shift in perspective and help the reader to understand the text.

THE EXPLORATION

In this section, I will analyse negotiations with an engineer about a single project.

The context

We made major alterations on a residential, mid-19th century building. The house was owned by a family. The architect had close connections to that family. He negotiated our contract on the family's behalf and also commissioned the other contractors, including the engineering firm. One of the goals in renovating the building was to enhance the load capacity of the foundation. The project engineer suggested deepening the foundations through the designated underpinnings. I thought a sole plate would suffice, at only a fraction of the cost. When I got the design from the civil engineer, I told the architect in charge of the project that I had a cheaper solution in mind and asked if I should propose it to the engineer. He supported my proposal.

*** Integrative negotiating

Both solutions would have worked for me – they would have been almost equally profitable. I assumed, that, like in most projects, the budget would be limited. The costlier solution would have put a great strain on the budget, and, in the long run, I may have faced with the consequences of that strain. Saving some money now might leave some room for concessions in later negotiations. Therefore, both the architect and I ultimately benefited from this economy.

My efforts to save some money now created a mutually beneficial situation for the future, when I was able to request something from the architect in return. That day, I saved money for my architect and at a later point I saw him somehow obliged to share it with me in form of a concession. I made a concession on a low priority issue in order to make future gains on an high priority issue (Thompson 2011) in an attempt to display a “*give and take attitude*” (Bresnen 2009: 928).

*** Trust relationship architect

In this situation, I gave the architect valuable information, which he could have exploited without honouring my efforts. I handed over some discretionary powers to the architect over things I valued, hence, I trusted the architect (Baier 1986). I expected some sort of reciprocity from the architect, although I did not know whether he would live up to my expectations (Pettit 1995). Hence, this situation contained elements which indicated a trust-based relationship, namely, to cede power over things valued, privileged knowledge, and positive expectations, while having limited ability to control or punish (Baier 1986).

Had I not trusted the architect, I would have kept my knowledge secret and we would not have started to cooperate to reduce costs. Therefore, trust was a prerequisite of cooperation (Baier 1986).

The first personal encounter

I called the engineer briefly and explained my proposal. We agreed to meet on the building site. We started analysing the situation and he explained to me how he arrived at his proposed solution. I tried to explain my approach to solving the underlying geotechnical problem. During the negotiation, I explained my proposal in detail it to him and suggested a design and what the construction details could look like. Simply put, he wanted to make the foundation deeper and I wanted to make it

wider. Both solutions would lead to an increased load capacity. We discussed the pros and cons of both solutions. At some point I struggled to explain my proposal sufficiently so that the engineer could understand it. However, we agreed to incorporate my proposal in the design. After some days of reflection and work, he arrived at nearly the same solution that I had.

*** Trust relationship engineer

In this meeting, I provided the engineer with even more information than the architect. In so doing, I also entrusted him with my knowledge. I expected him to incorporate this into his design. Furthermore, I hoped to achieve economies and, consequently, to build a working example of cooperation. Therefore, I was dependent on the outcome of this meeting.

Things worked out to my great satisfaction and my proposed plan was selected. The engineer lived up to my expectations. Hence, my initial trust was supported by a positive experience which strengthened my trust in the engineer (Child 2001). But the meeting had to provide more to our trust relationship than that.

Getting to know each other

Our conversation was not limited to discussing the technical details of the foundation, and eventually it turned personal. We talked about our time as students, where we studied, that we both earned civil engineering degrees and the major subjects of our studies.

During our talk, I sometimes got the impression that the engineer was well-trained but lacked some experience and, with it, the self-confidence of older engineers.

*** Context engineer

This personal information about the engineer helped me to put him – and his personality – into context. First, I assessed questions of his background – in this case his education. Second, I compared our common experience with my prior experiences with other engineers.

I was actually looking for parallels in the engineer's education and my own – I am civil engineer too. Consequently, I assumed that he may arrive at technical solutions similar to mine, and that he has enough technical knowledge to be open to an exchange between engineers. In other words, I expected him to understand what I am talking about and to think similarly about the discussed issues.

*** Trust relationship

Baier (1986: 236) asks, "*What do you trust to them?*" By incorporating his context into my judgement of trust, I sought to answer the question with 'what' should I trust to him. The 'what' in this case was that I expected him to understand the technical situation very close to my understanding. At that point, the 'what' had little to do with our personal values or attitudes. It was specific to that particular problem. I thought he assessed the foundation problem like I did.

*** My own context

This judgement is profoundly guided by my own experience with older, more confident engineers. They used to evaluate my proposals on the respective cases at a very high level. For them, it would have been easy to explain the technical advantages and disadvantages of my proposed solutions. I compared his responses to these

experiences, and attempted to judge his level of technical competence and self-confidence.

At that point, I thought he lacked some confidence. He is a couple of years younger than I am. But this is not the crucial point.

*** Inscription of my own context

There was the subtle consideration of how he came to choose the underpinnings, what he considered and what he did not consider. But more importantly, why did he not take my approach or something similar, in the first place. He could understand the geotechnical underpinnings of my solution, but he had not thought things through in the same way.

On different projects and with different engineers, I had already considered other engineers' solutions that were similar to mine, but disregarded them for various reasons. Next, we engaged in an advanced exchange over how to tackle the emerging technical disadvantages. Usually, such discussions are marked by at least some slightly defensive argumentation. Some sort of face-saving resolves these initial problems.

But here we were far from that stage. I considered this young engineer to be 'weaker' than the other engineers. It is not that he made a mistake, but for me, the strength of an engineer is his or her ability to contribute creative solutions and broaden the spectrum of possibilities. I want to build something I regard as good professional work, something that I can be proud of as an engineer. But at this moment, I felt obstructed from achieving this.

*** Connection between assessment and trust relation

This 'weakness' in engineering terms did not stop me from trusting him as he carried out his duties as engineer. I became more alert to look for alternative solutions myself. So I assess tacitly with 'what' to trust him. However, this perceived 'weakness' had a limiting effect because I did not consider him to be as powerful or competent as other engineers (Mayer, Davis and Schoorman 1995, Pettit 1995). Therefore, I could not trust him to the same extent and I became more vigilant about alternative solutions.

Second encounter

Later, when the construction process progressed, I had another negotiation about a possible technical solution for a special detail at this building site. This time, his boss was also present. We talked, sketched, calculated, and discussed for nearly two hours how to reinforce an old structure. The discussion unfolded around how it should be in theory and what is possible to apply in practice. However, this time the discussion was predominantly between me and his boss – the junior engineer was almost side-lined. The two engineers defended what the solution should ideally be, whereas I emphasised that their 'ideal' solution would cause more (collateral) damage than benefits. In the end, we agreed on a solution somewhere in the middle. However, what the engineer later designed and circulated differed significantly from what I perceived as the outcome of our meeting. At first sight, I thought, 'That's not what we came up with! I did not agree to this solution - not at all. How could he claim that this is the outcome of our discussion?' I felt betrayed. In my eyes, he was now lying about our meeting. Furthermore, I regarded this solution as a bad one.

Apart from my emotional reaction, I considered my judgement in trust to be misguided. At first, I did not understand what had happened. I was tempted to call him

and let off steam. But I did not do this, because I knew that that usually just makes such a situation worse.

*** Situated-ness and tact

This situation shows that reflecting on an event is often difficult because one “*cannot help but be 'unreflective'*” (Van Manen 1995: 35). This being absorbed by the course of action and reaction made it difficult for me to understand what happened to me and within me. I was too emotionally invested in the situation to be able to be reflective and to begin to understand (Van Manen 1995). My reaction – deciding to not call – was informed by some sort of tacit knowledge and a feeling that it would be inappropriate to call given the mood I was in. It was what Van Manen (1995) called tactful action. However, later on, once I had calmed down, I would need to deal with that issue – reflect and act on it.

*** Technical-personal dimension

Before that meeting, I regarded the negotiations as rather technical. In our first meeting we discussed geotechnical issues, how to design the plate. Only later, he mentioned that he would like to discuss it with his boss first. For me, this is a fair point because in engineering, the four-eye-principle is very common. I regarded his actions as technically-driven rather than related to power issues on his team.

Prior to our second meeting, I had already made up my mind about him. In our first meeting, I had not paid any attention to the power configurations on his team. So my initial image of him was shaped by our exchange over technical questions and the positive experience.

My limited knowledge at this point led me to conclude that I can trust him with the engineering issues. In this case, I thought I had a technically-driven engineer who was open to alternative solutions. Therefore, when it came time to solve the next problem, I thought I just needed to meet with him and explain my take on the issue. In so doing, we would have come up with, in my eyes, a good solution. But apparently this was not exactly the case.

Calm

Only the next day - in a calmer mood - I understood that he might have been under pressure by his boss - who may have favoured the proposal he presented.

*** Revision by context

That evening, and the next day, I sought to re-evaluate my judgment in trust and came to the conclusion that I had overlooked some important issues. I had only looked at who he is, but I missed the context in which he had acted.

Upon further reflection, I remembered that his boss was not that comfortable with my solution. The solution the engineer presented was more of a reflection of his boss's viewpoint than our agreement. It looked like he had yielded to the pressure from his boss. And I had not included the boss's influence in my judgement in trust evaluation.

*** Perspective taking

Next, I tried to see things from the engineer's point of view. If I were to amend my judgment appropriately, I would have to take the perspective of the other. Although, it felt unpleasant to admit being wrong, it was an easy and epiphanic exercise. What this example shows is that taking a reflexive position – questioning one's own assumptions inevitably leads to feeling uncomfortable about our own practice (Pillow 2003).

I had to revise my assessment. As in ethnography, I did not learn all at once, but rather in a continuous process, building new insights and understandings upon prior ones (Emerson, Fretz and Shaw 2011). I had to acknowledge the back and forth in the reflexive process of making sense. The perspective-taking enabled me to look at myself as well. I can only see myself when I see the other (Pillow 2003). The nature of this process is hermeneutic. Hence, using reflexivity not only contributes to research but also to trust judgements.

Of course, I sought to avoid misinterpretations. However, they cannot be avoided since the process of interpretation is inherently incomplete (Iser 2000). It is, unfortunately, an ongoing and never ending process (Iser 2000, Pillow 2003).

*** Applied perspective taking–seeing myself

Retrospectively, I must admit that I did not think or actively assess his encounters with other contractors. That would have given me more of an idea about how he might have seen me. It is not uncommon that contractors seek to endorse a cheap but inferior solution for the sake of reducing costs. This runs contrary to the interests of an engineer. First and foremost, the engineer must design a functioning building. Reducing costs is a secondary consideration for most engineers, at least in Germany. When it comes to litigation about defective engineering, the design is usually compared to highest technical standards. In case the design delivered by the engineering company falls short of these standards, that often poses a liability for the engineering companies. I did not investigate whether he anticipated that I wanted to respect these high standards or suspected me of departing from them.

Given that his boss suspected me of going for lower standards, it must have appeared necessary for him to push through his proposal. Therefore, for the engineers, the second negotiation was framed by lower standard solutions and not by possible collateral damages.

*** Trust assessment

The point here is not so much that I was wrong in my interpretation. That is inevitable, since all interpretation is incomplete (e.g.; Iser 2000). It was that I had to learn about two procedural mistakes. First, I did not anticipate the other engineers' perspective (Pillow 2003). And second, I took my interpretation too seriously. I assumed it to be 'right'. I did not investigate whether or not other interpretations were possible and perhaps more likely. I addressed my observation too fast to "conceptual boxes" (Weick 2006: 1727).

I should have somehow questioned the underlying assumptions (Reynolds 1998). In this case, that meant taking into consideration the constraints and pressures that the engineer might have experienced. I assumed that my freedom to act as a business owner applied to him as well. But the engineer was employed, he found himself in a completely different power hierarchy. In hindsight, it seems that the team he worked on respected a quite rigid hierarchy, leaving little room for individuals to act independently. I lead my team differently leaving them more space and giving them more responsibilities.

The side-lining of the engineer by his boss should have alerted me. There were power-relations involved that were not present in my company to such a degree. That begs the question, how could I disregard them, how could I have missed them.

*** Distance for reflection

I needed some distance from the event in order to begin to understand his behaviour. Seeing the pressure the engineer might have experienced helped me to regard his action not as a breach of trust but rather as yielding to a greater power, that of his boss. Once I saw things from his perspective, it became clear that he was acting quite naturally given his work situation, and that I would have acted the same if faced with similar circumstances.

As Chiseri-Strater (1996: 119) wrote, ‘turning upon ourselves [...] makes us look subjectively and reflexively at how we are positioned’. Once I could see things from his point of view, I was in a far better position to make a judgement of trust. By adopting his perspective, I was able to anticipate the constraints he faced and his ability to act.

*** Making sense

In the course of the interactions, I experienced being thrown into the situation (Weick 2003) only being able to reflect limited on the events. Therefore, my judgement had to be imperfect. The ongoing nature of life itself, with its inherent changes and my limited capacity makes it impossible to arrive at a comprehensive picture. However, I had to deal with such a situation this time and will undoubtedly do so again in the future. A way of coping with such situations is using what Van Manen (1995: 7) referred to as “*tactful action*” – acting intuitively and with consideration at the same time – as in the moment when I did not call the engineer.

Reconciliation

Later in the process we (the architect, my engineers and I) did find a solution that reconciled our proposals and limited collateral damages while getting close to the ideal solution. Repeated phone calls, meetings on the building site, and constructive and open exchanges about each other's concerns helped to forge this solution.

We arrived at the solution through a mix of mutual understanding. The engineers acknowledged our concerns about collateral damages and I could understand the issues they had with my solution. However, without tactful action, or worse, by seeking to push one solution through without regarding the concerns of the others, the situation would have certainly become tenser.

FINAL THOUGHTS

Considering this negotiation experience, I was able to explore how my judgements in trust evolved. I learned that I am able to refine my understanding of my negotiation partner more effectively if I can identify and acknowledge the different aspects of our relationship – namely technical exchange, power relations, education, and context. Through exploration of the meta-level, I was able to demonstrate how my own assumptions, experience and context influenced my judgement and expectations. Furthermore, by considering how others see me from their perspective, I developed a better understanding of the constraints my partner faced. I was able to later acknowledge that my emotional involvement might inhibit me temporarily from doing so. Tactful action helped to prevent an escalation of the conflict and gave me some space to reflect on the events.

However, my judgements were not and will never be comprehensive. They are by their very nature incomplete. I can never completely anticipate or understand another person. In this example, I learned that a third person’s action might have influenced

the decisions of a negotiation partner, leaving me disappointed. I misperceived this as breach of trust.

Though, I have shown above that my misjudgements about trust led to my disappointment. I expected the engineer to behave in a way that he did not and perhaps could not do. Seeing it from this perspective, I can conclude that the engineer did not act in an untrustworthy manner, but rather, my expectations were misguided and resulted from my misjudgement of him and his situation.

Knowing that our judgments will always be incomplete, trust, partnering and cooperation are subject to constant (perceived) disappointment. However, it is worthwhile promoting them given the alternatives of conflict and litigation.

Our partners, our selves, and the world we live in are constantly evolving. In other words, we, and our contexts, are always changing. In order to develop more trusting relationships, we need to constantly reassess what we should entrust to others.

The changing nature of our world calls upon us to act tactfully. In so doing, we can avoid entering vicious spirals of mutual misunderstanding and distrust. Tactful action allows us the space we need to reflect critically on how we understand the world around us. This space to retreat and reflect is, of course, not unlimited. Therefore, we may then come to still imperfect but far better judgements of whom to trust with what. I conclude that it might prove worthwhile to make more effort to investigate our relationships in a reflexive manner.

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METHODOLOGICAL APPROACH OF CONSTRUCTION BUSINESSES FAILURE PREDICTION STUDIES: A REVIEW

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In an attempt to stem the tide of mass failure of construction businesses, or support financiers and clients in identifying healthy construction firms for loans and contracts respectively, many researchers have developed construction industry bankruptcy prediction models (CI-BPMs). The effectiveness of such CI-BPMs is partly dependent on the methodology used in building it. Despite the usual claim of high accuracy by developers/authors, none of the CI-BPMs developed has gained wide acceptance in the construction industry, leading to development of new ones in succession. This study hence reviews the methodological positions in CI-BPM studies using the complete available population. After a critical content analysis of the features of CI-BPM studies, they all appeared to have used the positivism paradigm with realist ontology, objective epistemology and deductive approach. Although the main aim of CIBPM studies to ‘predict’ failure, an action (i.e. prediction) which is well ingrained in the positivism paradigm, makes the generally adopted positivism paradigm appear very appropriate, the aggressive dynamism of the construction industry and the experts’ criticism of the methodology clearly makes it inappropriate. This work proposes pragmatism, in the methodological pluralism form, as the best paradigm for CI-BPM research with realist ontology, combined subjective and objective epistemology, mixed-method research choice, case study, archival and survey strategies, and the deductive research approach. A complete research design framework for executing the proposed methodology is presented.

Keywords: construction business failure, bankruptcy prediction models.

INTRODUCTION

As vital as the construction sector is to most countries’ economy, construction businesses still fail in large numbers. The negative impact of such failures on economies, owners of failed businesses, financiers, clients and other stakeholders can be immense. One of the major ways of preventing construction business failures and ensuring financiers and client give loans and contracts respectively to only healthy firms is by using bankruptcy prediction models (BPMs) to reveal potential failure so that mitigation steps can be quickly taken. Many studies have thus justifiably attempted to build high performing BPMs. The performance of a BPM is however dependent on, among other factors, the methodological approach used to develop it.

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Because of the nature of enquiry and expected result, and the positivist approach adopted by pioneering works in the BPM research area, virtually all construction industry BPM (CI-BPM) studies have taken the positivism stance. The very first work on BPM was done by Beaver (1966), an accountant, who investigated how financial ratios can be used to predict failure of firms. Beaver's aim in itself readily side-lined the subjects i.e. firms' employees or owners, and had everything to do with the objects i.e. firms, since financial ratios of firms can be easily sourced from third parties. Altman (1968) built on Beaver's work by using a multivariate analysis of ratios to predict failure. The nature of these two pioneering works, i.e. to predict, had clearly set the studies closer to the positivism paradigm (Trochim and Donnelly, 2006).

Most, if not all, CI-BPM studies (Mason and Harris, 1979; Langford *et al.*; 1993; Abidali and Harris, 1995; Thomas *et al.*, 2011; Chen, 2012; Bal *et al.*, 2013; Horta and Camanho, 2013) that emerged arbitrarily used an approach similar to that of Altman (1968). In fact, no study made mention of its research paradigm or methodological positions *let alone* justify them. With no CI-BPM gaining wide acceptance, new CI-BPM studies have continued to spring up with concentration on choosing more effective financial ratios and/or better prediction techniques seen as the required means of bettering the models; the improvement, whenever there is any, has however been insignificant (Balcaen and Ooghe 2006). With little or no progress in CI-BPM performance, this work aims to review and critique the paradigm and methodological positions taken in CI-BPM studies to explore possible methodological improvements. The following are the objectives of this study:

- To identify, discuss and critique the methodological positions taken in CI-BPM studies
- To identify any deficiencies and propose possible improvement(s) to the methodology for developing a valid CI-BPM

The next section explains the methodology used to execute this review. Next is a discussion on positivism as the main paradigm used in CI-BPM studies, followed by ontology and epistemology of study area. Section 4 discusses the implication of the prevailing methodological positions while section 5 proposes improved paradigm and methodology, before conclusions are given.

METHODOLOGY

This study uses the review research strategy to analyse existing literature in order to critique their methodological positions for potential improvement. The studies were explored using content analysis, which examines papers to systematically quantify content in terms of anticipated or pre-known classes (Bryman and Bell, 2007); the classes in this case being paradigm, ontology, epistemology and sometimes other methodological positions. The paradigms of the CI-BPM studies are established by highlighting their research features such as research aim, data collection method, data type, form of analysis etc. and presenting the paradigms that conform to these features. The review of various existing knowledge is a recognised way of contributing to the progression and expansion of knowledge (Aveyard, 2007). This is why it has been widely used as methodology in various research areas including insolvency prediction (Balcaen and Ooghe 2006) and construction business failures (Edum-Fotwe *et al.*, 1996; Mahamid, 2012).

The unit of analysis in this paper are CI-BPM studies. The unit of analysis selected are unambiguous, abstruse and analysable knowledge according to the cognitive view (Akerhurst *et al.*, 2011) most of which exude from construction-specific publication

sources like ICE, ASCE, etc. and business and finance publications through publishers such as Elsevier, Taylor and Francis, Emerald and Springer.

POSITIVISM AS THE MAIN PARADIGM OF CONSTRUCTION INDUSTRY BPM STUDIES

Majority of CI-BPM studies over the years (Mason and Harris, 1979; Langford *et al.*; 1993; Abidali and Harris, 1995; Thomas *et al.*, 2011; Chen, 2012; Bal *et al.*, 2013; Horta and Camanho, 2013) seem to have used the positivism paradigm, though the selection is barely expressly stated and/or justified in any of the papers. In positivism, research is “*seen as the way to get at truth, to understand the world well enough so that we might predict and control it*” (Trochim and Donnelly, 2006, p.18). This is exactly what CI-BPM studies are usually about. In the studies, an attempt is made to understand construction business failures and to identify failure indicators; then there is effort to predict potential failure in order to aid control of the situation by owners taking mitigating steps, or financiers and client avoiding giving loans and contracts respectively to potentially failing construction firms. The aim of CI-BPM studies thus, to an extent, lend them to positivism.

Positivists believe that research can mainly be done by observations and measurements (Trochim and Donnelly, 2006). A positivist researcher whose approach “*is rooted in the tradition of sociological positivism*”, is normally independent (of the subject) as an observer, reduces a phenomenon to simpler measurable factors/elements, explains the elements in terms of how they affect the phenomenon (cause and effect) and usually uses large samples (Burrell and Morgan, 1979, p.26; Saunders *et al.* 2009). All these features are normally exhibited in CI-BPM studies (Mason and Harris, 1979; Langford *et al.*; 1993; Thomas *et al.*, 2011; Chen, 2012; Bal *et al.*, 2013). In these studies, a large number of construction firms are selected as sample, usually the larger the better; the complex failure process (phenomenon) is reduced to measurable variables, usually financial ratios (simpler elements); the ratios and the factors they measure are described; the financial ratios are finally analysed with a statistical technique which uses the measurement of the ratios of the firms to predict their potential failure/survival. A few indicative quotes from some of the studies are given in the next two paragraphs.

Abidali and Harris (1995, p.189) “*combines financial ratio analysis and the statistical technique known as multivariate discriminant analysis, to produce a predictive model made up of seven variables*”. The ratio of turnover to net assets “*measure of how well a company has used its productive capacity*” (Abidali and Harris 1995, p.191)

“*Using financial ratios and the Altman Z-score modelling methodology, an insolvency warning model is developed in order to evaluate the performance of construction contractors in China*” (Thomas *et al.*, 2011, p.599). The Activity ratio measures “*how well a company has been using its resources*” (Thomas *et al.*, 2011, p.601).

According to Burrell and Morgan (1979) the functionalist is always seeking to find implementable solutions to real problems and is more concerned with controlling social affairs. This is well in line with the aim of CI-BPM studies which try to provide BPM as a solution to the real problem of either high rate of construction businesses failure or to the problem of identifying healthy companies for loans or contract. CI-BPM studies have used mainly quantitative data, in form of financial ratios, which is common with positivists (Mukherji and Albon, 2009). Further, positivist tend to use

statistical analysis so as to aid generalization (Alvesson and Sköldbberg, 2009; Mukherji and Albon, 2009); this is typical of CI-BPM studies as shown in the quotes.

From all the evidences given in this section, it appears that the positivism/functionalism paradigm is predominant in the CI-BPM literature. This is well understandable since prediction, the main aim of the studies, is a main feature of positivism. Although critical realism also supports quantitative data and analysis, and possess some features similar to those of positivism, it is not used mainly for prediction. A critical realist is also not an independent observer, i.e. an objectivist, as is with CI-BPM researchers (see epistemology below). A brief look at the ontology and epistemology of the reviewed studies can shed more light on the discussion.

Ontology and Epistemology of Construction Industry BPM Studies

Ontology deals with the assumption researchers have on how knowledge exists i.e. 'nature of reality' (Saunders *et al.*, 2009, p.110) while epistemology deals with how to learn that reality (Krauss, 2005). The realist ontology and objective epistemology are features of positivism (Saunders *et al.*, 2009) and are thus the adopted forms in the positivism aligned CI-BPM studies. Realism "*assumes that social and natural reality exist independently of our cognitive structure: an extra-mental reality exists whether or not human beings can actually gain cognitive access to it*" (Johnson and Duberley, 2000, p.67). The realism ontology is in itself quite embedded in the nature of CI-BPM enquiries since the statistics of mass failure of construction businesses is repeatedly available in many financial and government reports; the failure is real whether or not human beings can access, assess, prevent or hasten it, or whether human beings know about it at all or not. This is pretty much the opposite of idealism ontology which "*assumes that what we take to be external social and natural reality is merely a creation of our consciousness and cognitions*" (Johnson and Duberley, 2000, p.67).

Epistemology wise, objectivism is the widely used option in CI-BPM studies. Objectivism accepts that reality and its meaning exists independent of any awareness or recognition and can be learned (Crotty, 1998); it focuses on the object with absolutely no regards for the subjects (Saunders and Paul, 2013). CI-BPM studies are generally directly concerned with only the object i.e. the construction firms. Developing the CI-BPMs is done, in virtually all cases, with absolutely no contact with the subject i.e. any representative of the sample construction firms (e.g. owner, employee, firm's lawyer etc.) The information used to develop the CI-BPMs is usually in form of financial variables that can be gotten from financial firms independent of the sample construction firms. In the very rare cases where non-financial variables are used, questionnaires are used to get the variables. The exclusive use of the objective approach in CI-BPM studies has however been an area where improvement can be made since it has always been an area of contention between experts, plus the construction industry is quite dynamic (see next section).

IMPLICATION OF THE NARROW METHODOLOGICAL POSITIONS IN CI-BPM STUDIES

The restricted use of the positivist approach to CI-BPM studies has led to the continuous exclusive use of the objective epistemology, through the use of multivariate analysis of financial ratios. Unfortunately, this restricted approach does not fully represent the insolvency situation of construction firms as highlighted in various studies, also, due to the dynamism of the construction industry.

On facts highlighted in various studies, countless number of non-financial indications of insolvency, such as management mistakes, do come up a lot earlier than financial distress (Abidali and Harris, 1995). Financial distress only tends to be noticeable when the failure process is almost complete, around the last two years of failure according to Abidali and Harris (1995). In fact it is adverse managerial actions and other qualitative factors that lead to poor financial standings and in turn cause insolvency. Accordingly, many experts have reiterated that financial ratios alone are insufficient for early depiction of disastrous factors like shambolic management, acquisition of a failing construction firm, economic decline etc. (Abidali and Harris, 1995). Edmister (1972) and Argenti (1980) also stressed that financial ratio models are not enough to predict insolvency of construction firms until they are used with other economical, 'managerial and social factors'. Further, the tendency of accountants to amend important financial ratios, known as window dressing or creative accounting, reduces the reliability of financial ratios as factors influencing insolvency (Arditi *et al.*, 2000).

On the dynamism of the construction industry, the dynamic nature of the industry with constantly changing trends (Chang, 2001; Odusami *et al.*, 2003; Dai and Wells, 2004; Navon, 2005; Navon, 2007; Razak Bin Ibrahim *et al.*, 2010) means the main causes of failure of construction firms will vary from time to time. This implies that subjects will have to be spoken to in order to identify key reasons behind failure construction firms. Although it is not impossible for all the identified reasons to be observable objectively as done CI-BPM studies, the fact remains that this will not always be feasible due to the dynamism of the industry. Ultimately, leaving out the subjects appears no to be a wise choice if a valid CI-BPM is to be built.

The need to involve social factors, which can mainly be considered through subjectivism, and the need to talk to subjects to understand the dynamism of the construction industry, both call strongly for the adoption of the subjective epistemology in CI-BPM studies. Subjectivism emphasizes on "*understanding the meanings that individuals attach to social phenomena*" (Saunders *et al.*, 2009, p.111).

PROPOSED METHODOLOGICAL POSITIONS FOR DEVELOPING A ROBUST CI-BPM

Proposed Paradigm, Ontology and Epistemology

Having reviewed numerous CI-BPM studies, the authors propose that the best paradigm for developing a CI-BPM is pragmatism. "*Pragmatism argues that the most important determinant of the epistemology, ontology and axiology you adopt is the research question – one may be more appropriate than the other for answering particular questions*" (Saunders *et al.*, 2009, p.109). Pragmatists are more concerned with the "*practical consequences*" of the research findings and as such believe that one standpoint can never be suitable for answering all types of research questions and there "*may be multiple realities*" (Saunders and Paul, 2013, p.58). This is the maximalist view noted by Callon (2006) which argues that nothing in a research phenomenon can escape pragmatics. Pragmatists neither agree with positivists in that demands of a research cannot be fully satisfied by a theory (falsify-ability, objectivity, etc.), nor with interpretivists in that demands of a research can be satisfied (at least partly) by almost any theory (Powell, 2001). This is in similarity to the Actor-network theory (ANT) which "*privileges neither natural (realism) nor cultural (social constructivism) accounts of scientific production, asserting instead that science is a process of heterogeneous engineering in which the social, technical, conceptual, and textual are puzzled together (or juxtaposed) and transformed (or translated)*" (Ritzer,

2004, p.1). Pragmatism thus allows the use of any, or a mix of multiple methods, approaches, choices, techniques etc. as long as they will help to answer the research questions properly (Saunders *et al.*, 2009). It allows the researcher to “*study what interests you and is of value to you, study in the different ways in which you deem appropriate, and use the results in ways that can bring about positive consequences within your value system*” (Tashakkori and Teddlie, 1998, p.30)

The authors believe the relative rigidity of other paradigms as to the methodological positions that fit a research can limit steps needed to be taken to complete quality research, just as confirmed by Saunders *et al.* (2009, p.109) that “*the practical reality is that a particular research question rarely falls neatly into only one philosophical domain*”. Further, a good CI-BPM study should focus on failure of construction firms (a problem) experienced by construction business owners (people) and the effect of developing a BPM which will allow timely intervention that can prevent potential failure (consequence of inquiry). Such focus is synonymous with pragmatism which “*emphasizes the practical problems experienced by people, the research questions posited, and the consequences of inquiry*” (Giacobbi Jr. *et al.*, 2005, p.18).

The realist ontology used for BPM studies is very appropriate and is consequently proposed here. There is only one reality and that is ‘construction firms do fail and failing construction firms have certain similar attributes’. Finding the most effective attributes to develop a CI-BPM is what is tricky. This is why there are many BPM studies, each trying to prove certain attributes are more effective than others.

Although the objective epistemological stance is suitable for developing a BPM, a combined subjective and objective approach in a facilitation manner (see later) is proposed here. While the objective approach will aid the use of existing factors and variables, the subjective approach can be used to identify temporal factors and variables that can be used to develop a robust CI-BPM; this would have taken the dynamism of the construction industry into consideration. The subjective approach can also help identify important social and managerial factors that contribute to insolvency of the construction industry. This has long been advocated by many construction management (CM) authors (Seymour *et al.*, 1997; Dainty, 2008) who queried the focus on objects, when at the centre of most CM research is people (subjects), justifying need for greater emphasis on qualitative enquiry. Management level staff and/or owners of failed and existing construction firms can use their practical experience to contribute vital information in terms of factors that affect insolvency and survival of construction firms. Since both the objective and subjective epistemology are vital for CI-BPM studies, the integration of quantitative and qualitative research approach is proposed here. This is in line with the much advocated methodological pluralism (Seymour *et al.*, 1997; Mingers and Gill, 1997) which combines methodologies from varying paradigms to provide richer insights into relationships and their interconnectivities (between factors and firm failure in this case); this is the best approach to solving research problems (Mingers and Gill, 1997)

In this vein, the proposed methodology agrees with the popular Seymour and Rooke's (1995) work which clearly argued that different researches require different methods and no methods should be ruled out a priori. However, it does not support their opposition to the multi-paradigm (see Rooke *et al.*, 1997) approach which pragmatism allows if it is what will bring about a valid methodology. In fact, such an opposition is tantamount to nullifying some methods a priori since selecting a particular paradigm readily nullifies some methods; an act Rooke *et al.* themselves preach against.

Proposed Research Strategy and Approach

The subjective epistemology aspect of the work should be executed with the case study strategy. Case study is defined as a research strategy involving empirical examination of a specific incident using multiple sources of evidence (Robson, 2002). The reason for proposing case study is to allow a comprehensive study of some failed construction firms in order to identify these questions: what are the common factors that lead to insolvency and how do these factors affect insolvency? This reason goes down well with case study’s superb capability of obtaining answers to the ‘what?’ and ‘why?’ questions (Saunders *et al.*, 2009). The case studies can be accomplished using unstructured interviews and maybe focus group discussions. The factors gotten should be analysed to identify befitting measuring variables which can then be measured with a survey research strategy. Survey can be executed with a Likert scale questionnaire, allowing respondents to rate the extent to which each variable applies to them.

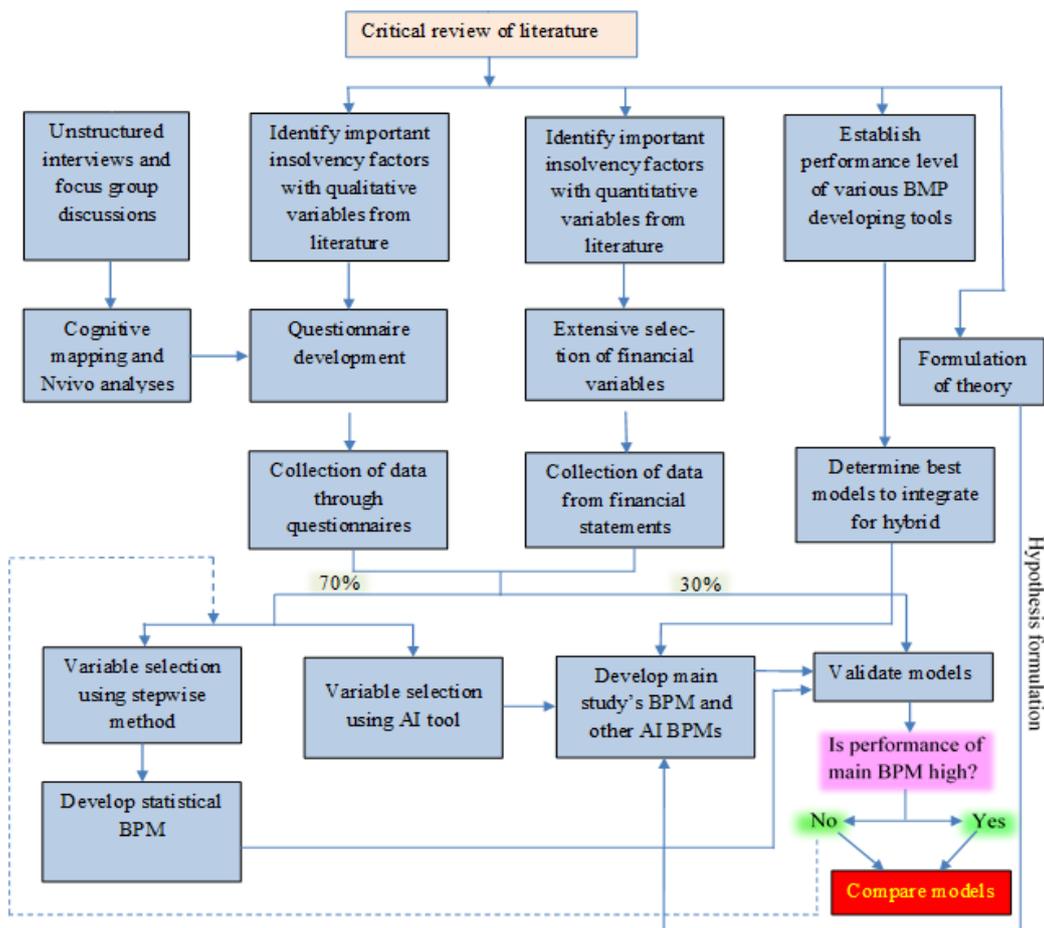


Figure 1: An improved research design for developing CI-BPMs (AI: artificial intelligence)

Archival research strategy, which involves collecting data from companies’ administrative documents (Saunders *et al.*, 2009), is generally required in most BPM studies as it is used to access the financial information of sample firms. The term ‘archival’ in this strategy does not directly mean ‘old’ in anyway as pointed out by Saunders *et al.* (2009) hence using recent financial statements also fall under this category. Financial ratios from these statements are normally directly used as variables for developing CI-BPMs. Archives of financial data can be gotten from financial firms or third parties like Dun and Bradstreet, Company House, etc. Both archival and survey research strategies represent objective epistemology.

This proposed strategy culminates in facilitation which involves the “*use of one data collection method or research strategy to aid research using another data collection method or research strategy within a study*” (Saunders and Paul, 2013, p.154). Here the case study strategy aids the survey strategy. The proposed strategy also shows the intended mixed method approach (qualitative and quantitative data and analysis) which is a very good approach since it ensures an all-round effectiveness of research (Creswell and Clark 2007) and is well in line with the proposed pragmatism philosophical stance (Giacobbi Jr. *et al.*, 2005). Figure one shows the research design for the proposed methodology.

The research approach used in virtually all these CI-BPM studies is deduction which is quite common with the positivism paradigm (Easterby-Smith, 1991; Saunders *et al.*, 2009). Basically, most of the studies test and confirm the theory that financial ratios, or some other commonly known variables, can be used to predict potential failure of construction firms; theory testing is a feature of deduction (Saunders *et al.*, 2009). This approach is okay for CI-BPM studies since there is abundance of literature in the research area; according to Saunders *et al.* (2009) abundance of literature in an area of study easily lends new studies to the deductive approach. However the theory does not always have to be the same as financial ratios alone are not sufficient for predicting the insolvency of construction firms

CONCLUSION

Positivism is about the only paradigm used in CI-BPM studies. This is not surprising since BPMs are all about large data size, statistical analysis, operationalization, prediction, generalization, etc. The deductive approach used in BPM studies is quite appropriate since there is abundant literature on the subject area and there is always a theory to be tested. The ease of getting financial ratios from third parties, or getting other variables through questionnaires explains why the objective epistemology is the common position taken by CI-BPM researchers. Although most methodological positions taken by CI-BPM researchers look appropriate, the methodology as a whole can be improved if better CI-BPM are to be developed. The key area of improvement would be to first use a subjective approach, through case studies for example, to identify temporal factors affecting failure of construction firms. These factors can then be analysed to establish measuring variables which can be used, along with other known variables, to build a robust CI-BPM

There is no doubt that the readily available nature of financial ratios is a major contributor to the reasons researchers use the objective approach to building CI-BPMs. It is hoped that the implication of this study on practice is that future CI-BPM developers will take the more demanding step of combining the subjective approach to the more popular objective approach. CI-BPM built with such an approach is bound to be of a higher performance, more valid and have wider acceptability.

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