FOREWORD

Welcome to ARCOM 2018 at Queen’s University Belfast.

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

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

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

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

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

The single quality that sets ARCOM aside from other academic conferences is a spirit of community, which is friendly, warm and supportive. ARCOM researchers are also resilient. Our papers are double blind reviewed, with two out of three submissions not making publication. Those papers that are accepted come with critical comments,
where the authors mindfully respond, attempting to retain their preferred direction while respecting the reviewers’ comments. Having hit all of the deadlines, many of us require a visa to join the conference. The barriers that face us and the high standards that ARCOM continue to uphold have been overcome and now we are here, we should be proud and must embrace everything that our community and Belfast has to offer.

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

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

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

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

Chris Gorse
Conference Chair, ARCOM 2018

August
**ARCOM COMMITTEE 2017/18**

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

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A SPECIAL THANK YOU FROM CHRIS GORSE

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

**Track 1: Failure and Learning from Failure**
Convenor: Simon Smith, University of Edinburgh

**Track 2: Theoretically Informed Research on Digitalization in Construction**
Convenors: Henrik Linderoth, Jönköping University; Mattias Jacobsson, Jönköping University; Christop Merschbrok, Jönköping University; Amany Elbanna, Royal Holloway University London; Martin Löwstedt, Chalmers University

**Track 3: Reconceiving Multidisciplinary Collaboration for Managing Design in Construction: Moving Forward from the Fragmentation-Integration Dichotomy**
Convenors: Mustafa Çıdık, London South Bank University; David Boyd, Birmingham City University; Vedran Zerjav, University College London

**Track 4: Integration and Collaboration for a Sustainable Built Environment**
Convenor: Esra Kurul, Oxford Brookes University

**Track 5: Keeping Up with the Digital Age: How Construction Companies Use Digital Communication Tools to Build Up Management Processes**
Convenors: Tugce Ercan, Yildiz Technical University; Fusun Cizmeci, Yildiz Technical University

**Track 6: Mental Health, Stress and Wellbeing in the Construction Industry**
Convenor: Dingayo Mzyece

**Track 7: Institutionalising Construction Management Research?**
Convenors: Paul W Chan, The University of Manchester; Sonja Dragojlovic-Oliveira, University of West of England

**Track 8: Infrastructure Investment through Public-Private Partnerships**
Convenors: Sharon McClements, Ulster University; Andrew McErlane, Ulster University; Des McKibbon, Northern Ireland Assembly

**Track 9: Procurement for Sustainable Innovation in the Built Environment**
Convenors: Professor Pernilla Gluch, Chalmers University of Technology; Professor Anna Kadefors, KTH Royal Institute of Technology; Associate Professor Leentje Volker, TU Delft.

**Track 10: Walking the Talk: Moving beyond words to create productive communication between academia and industry**
Convenors: Professor Christine Räisänen, Chalmers University of Technology; Dr. Paul W Chan, The University of Manchester
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Failure And Learning From Failure
LEARNING FROM FAILURE: PROCESSES AND ATTITUDES IN THE CONSTRUCTION INDUSTRY

Henrietta Baker¹, Simon D Smith, Milena Velikova, Gordon Masterton and Bill Hewlett

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Learning from failure is an instinctive part of an individual’s learning from childhood; however, translating this into a corporate or industrial environment is problematic. While, on some level, failure is encountered on an almost daily basis, the word ‘failure’ still connotes intense negative feelings and discussing mistakes feels taboo in many areas of business. In the construction industry, where failure can have significant repercussions such as loss of life, it is critical that learning from failure is effective and best mobilised as part of everyday operations on both individual and organisational levels. Developing an understanding of the underlying processes, both engineering and social, behind ‘learning from failure’ will allow industry leaders to more effectively exploit these learning opportunities and advance industry-wide learning. To better understand learning from failure in practice, 19 semi-structured interviews were held with members of the construction community across various levels and aspects of the business. The aim was to explore the processes currently employed by the construction industry to capture, understand and extract learning from these events. This is supplemented by an exploration of the perceived attitudes towards failure, and if such attitudes are barriers or aids to effective learning in practice. Findings show that different types of failure within the construction industry, e.g. time, safety, quality, manifest as separate and individually developed learning cycles. Thematic analysis also revealed that attitudes towards failure impact the learning process. In particular, the two pairs of attitude stimuli were discussed: Ownership and Blame; Acceptance and Leadership.

Keywords: failure, learning, Health and Safety, organisational culture, blame

INTRODUCTION

“No one wants to learn by mistakes”

This quote, from Henry Petroski's ‘To Engineer Is Human’ (1985: 62), is as applicable in the construction industry today as it was over 30 years ago. While learning from failure is almost universally exhorted as a 'good idea', the practice of implementing systematic learning from failure within organisations is problematic (Cannon and Edmondson 2005). On an instinctive level, learning from past experiences should be natural. This type of experiential learning is observed throughout the learning cycle of children and adults alike and, as noted by Kolb (2015), is defined as lessons extracted from the ordinary course of life. However, converting this learning to an organisation or industry is notoriously difficult and learning has been historically limited to large public civil engineering failures, such as that of the Tacoma Narrows Bridge or Hyatt Regency Hotel.

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walkway. This difficulty can be attributed to a combination of the technical complexity with implementing continuous learning in an organisational context coupled with negative social and psychological reactions which most people exhibit when faced with the reality of failure (Cannon and Edmondson 2005). Evidence of the difficulties of learning from failure, even large failures, can be observed in the recurrence of similar failure types.

By developing a deep understanding of established learning processes and attitudes towards learning from failure, the construction industry can begin to pick apart individual barriers and address them to facilitate learning on both individual and organisational levels. The research presented here explores, using in-depth semi-structured interview with members of the construction industry, the different processes currently employed by the construction industry to feedback learning from failure and investigates the perceived attitudes towards learning from failure.

**PREVIOUS WORK**

Research, such as Drupsteen and Guldenmund (2014) and Stemn et al., (2018), has shown limited implementation of learning from failure within industry where failure can be described as undesirable or unintended outcomes. This learning relies on individuals identifying what they believe to be significant cases of failure on their project, either for their general applicability or potential consequences, and then disseminating this information to a wider audience. Communication of this failure often takes the form of an alert or storytelling, either to an individual via IT or by forums such as SCOSS, the Standing Committee for Structural Safety (Soane 2015). Lampel et al., (2009) dub this learning about failure rather than learning from failure, which highlights a key distinction in the level of engagement involved.

Silva and Lima (2005) also identified two further intervention strategies used to implement learning, in addition to diffusion and discussion highlighted above. Training refers to the use of incident information to improve or introduce employees’ training, while change describes the adjustment of a procedure or standard in response to an incident. These are both top-down approaches instigated by leadership.

From information aggregated by Drupsteen and Guldenmund (2014), a generic stepwise learning cycle can be defined. This typical single-loop learning cycle is identical to the one described by Argyris and Schön (1996), illustrated in Figure 1. This focuses on correction of procedure or actions to prevent recurrence but does not examine the underlying values. Argyris and Schön use the example of adjusting the temperature instruction given to a thermostat to correct the failing of a cold room. The instruction is corrected to prevent failure; however, the values and culture behind the process are not questioned, e.g. they did not ask if donning a jacket would achieve the same job more efficiently. If this extra loop is included, Argyris and Schön refer to this as double-loop learning (Figure 2). Double-loop learning is often referred to as a superior method; with Stemn et al., (2018) suggesting that classification of whether an implemented learning system included and/or encouraged double-loop learning could help define the effectiveness and maturity of the cycle.

Identification of barriers to learning from failure, either in general organisations or engineering projects, has been the subject of multiple investigations (e.g. Cannon and Edmondson 2005, Drupsteen and Guldenmund 2014, Stemn et al., 2018).
However, while identification of barriers to learning from failure has taken place in wider context, specific examination of the construction setting is lacking, especially in regards to how established processes interact with the attitudes of employees. Therefore, the intention of this paper is to reveal the learning processes which stem from different failure types in the construction industry including an examination of any attitudes the interviewees present towards these processes.

**METHOD**

What systematic processes for learning from failure exist in the construction industry? Are there identifiable attitudes surrounding learning from failure?

In response to these research questions, an in-depth examination of the features behind learning processes from failure and associated attitudes was required. 19 semi-structured interviews were conducted with members of the construction industry across several infrastructure sectors at different levels of business. Semi-structured interviews allow a fluid format to the discussions including clarifying questions meanwhile ensuring the relevant topic areas are covered (Harreveld *et al.*, 2016). The interviewees were approached through mutual professional acquaintances and Table 1 shows a demographic summary of the interviewees.

The role of the researcher is often discussed in relation to his or her impact on the research being carried out, and is especially poignant in qualitative research (Silverman 2007). In designing the research and interview prompts, neutral language was aimed at to avoid bias or leading questions. A downfall is that the interviewers' preconception of what is and isn't important/relevant will have encouraged the conversation on certain routes of enquiry and possibly neglected others. In order to avoid unconscious bias in this
area, close examination of the literature was withheld until after completion of the interviews themselves. However, it is impossible to eliminate bias from any interview situation.

Table 1: Interviewees

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<td>45-55</td>
<td>Male</td>
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<td>Commercial Director</td>
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</table>

*No transcript of interview

Data were acquired from the interviews via thematic analysis, aided by NVivo software, of both interview notes and transcripts, which were typed verbatim but did not include indication of pauses and intonations. Thematic analysis is a standard method used by social scientists for qualitative research and is an iterative method used to draw out underlying themes (Silverman 2007). When properly implemented, it can be powerful at identifying key factors within context, and correlations which aid the formation of hypotheses. It should be noted that analysis in this way cannot prove causality, which would be better shown in a more experimental or action research method. For the research question posited here, namely what processes and attitudes exist and identifying suspected interplay, thematic analysis is a suitable method of analysis. Analysis was initially developed by examining the data for key pre-identifiable theme areas, such as failure type, and developed further as new themes emerged. Manipulation using NVivo also shows co-occurrence of themes which were then examined to form hypotheses of causality.

THE NARRATIVE AND DISCUSSION

Process Identification

To open the discussion, interviewees were asked what would constitute a failure either to them or their colleagues at work and how this would then be dealt with.

This resulted in the identification of several project 'failure modes' which form the inputs to the learning process. Three core modes, consistently identified in discussion were: time, money and H&S. Other commonly cited failure modes, such as quality and problems with setting out requirements, were sub-categories of these as one interviewee
said, 'the others all feed into these three'. The only mode, identified by two separate interviewees, which does not directly feed to one of the 'top' three is 'public perception'. These identified failure modes are all well documented consequences of risk in engineering project management (Munier 2014).

For each of these failure modes, it became clear that there were defined stages of learning from an individual failure which matched the generic stepwise learning cycle set out by Drupsteen and Guldenmund (2014). This single-loop learning cycle was characterised by an initial information gathering phase following an incident followed by a period of initial remedial action and alerts. Some of these incidents then progressed to a long-term change or formal learning implementation.

Additionally, while the different learning processes identified in this analysis were consistent across different companies and engineering specialities, the maturity of some aspects varied depending on sector. For example, Interviewee 2 noted that working in rail, he expected engagement with reporting NCRs to be less than the nuclear industry, but ahead of general building construction.

**Safety**

Safety was the most mentioned failure with all the interviewees, except the two client representatives, stating that it was a potential form of failure within the industry. Moreover, 12 of the 19 interviewees identified H&S failures, such as incidents involving injury, as the focal form of failure in the construction industry.

Of the identified failure modes, interviewees recognised safety as mature in respect to the paperwork and formal process. One interviewee stated that:

Safety legislation is there, [...] I think for me dealing with safety and minimising failure, it's a state of mind and it's a culture

This was reinforced by other interviewees who were pleased by the current system and referred to the process as industry standard, although several acknowledged that there were still steps to be made to improve the uptake and personal buy-in of certain learning stages. Additionally, there is a wide belief that more needs to be done to drive these processes down to contractors and SMEs.

Overall, the safety learning cycle was presented as a closed, well-standardised single-loop learning cycle where information is collected, analysed, distributed and then stored. Interviewees tended to be content with this learning cycle for larger incidents; however, felt that it was insufficient for smaller events as there was a weak link in the learning cycle which would fail. For example, the small incident was not recorded or it would prove too costly in terms of time and/or resources to investigate it.

The buzzword on people's lips seems to be behavioural science or developing a positive safety culture which was mentioned explicitly by 7/19 interviewees. The inclusion of values and culture into the learning cycle marks the migration from single-loop to double-loop learning. This type of learning could tackle underlying issues which are currently inhibiting learning. However, Bye et al., (2015) note that the attention given to culture could be a 'two-edged sword' as the use of 'poor safety culture' as a reason for incidents might lead to premature closure of an investigation into root causes which are key to efficiently reducing reoccurring failures (Haslam et al., 2005).
Quality

Non-compliance and poor build quality was identified by half the interviewees as a specific failure. While the initial learning process presented by interviewees is extremely similar to that in place for H&S, there were more concerns over under-reporting, lack of analysis and inadequate feedback. Several interviewees were keen to point out that there were systematic quality checks in place to avoid non-compliance reports (NCRs) including managerial reviews requisite under ISO 9001. Interviewee 10 stated:

Generally quality is quite well-managed, we use quite tight process to ensure we use the correct products and the correct stuff and that it’s all approved.

However, this active management generally refers to managing quality prior to failures or implementing remedial action to ensure the quality of the end-product, not implementing systematic learning from failure. The majority of interviewees were pleased with the level of immediate response of an investigation and remedial action; however, they found that long-term trends and learning opportunity lost into the blame game. The general message was that NCRs were used actively on projects for firefighting and remedial action; however, there was far less engagement with analysis than H&S. Interviewee 1, a technical director, stated that they probably do nothing with the reports, acknowledging that there should be some kind of statistical analysis to identify trends similar to H&S data.

Reporting engineering non-compliance (NCRs) was referred to as a little bit scary and it was indicated several times that people were more willing to put in snag or improvement reports as the personal consequences were seen as less severe. The exception to this rule was when the potential safety consequences were judged to be serious or life-threatening.

Discussion of new technology for reporting presented an interesting conflicting view where a younger interviewee remarked that it made reporting quicker and easier to store, while an older interviewee stated that it made reporting more opaque and less assessable to those on site.

In comparison to safety, therefore, quality had a far less complete single-loop learning cycle as, while information is captured, very little analysis and extremely sparse distribution occurs. Equally, while the information is generally electronically stored, this tends to be siloed by project, rather than in a central data repository, and access is limited both by permissions and opaque search tools. Nevertheless, it should be noted that interviewees gave good examples of informal feedback and team discussion to analyse or learn from serious examples of these events. These unformatted lessons learnt exercises were occasionally captured for future learning but interviewees were very sceptical as to their worth.

Time and Money

Time and money were also identified as key factors in defining project failure; however, learning from incidents of overrun or exceeding budget were less well defined and varied greatly between levels of the business. These failure modes refer to more commercially sensitive root causes and are not as easily captured.

Tacit learning was, therefore, the only identified method of on-job learning along with some mention of generic formal training courses. Consequently, innovations within this section of business are kept within a very small community. Executive groups or small communities tend to share their internal learning using discussion such as informal lessons learnt sessions. Interviewees working in these areas did not feel it inhibited their
individual learning on project as the teams are small; however, they acknowledged that staff turnover and lack of formal capture restricted learning outside each project.

While accounting records and schedules should record changes and why these events occurred, there is no systematic cyclic assessment and feedback/distribution of information within (or outside) the business. Although 'notice to delay' exists, its use is misconstrued and therefore not used properly. The lack of systems approach for cost overrun has been explored by Ahiaga-Dagbui et al., (2016), however no robust methods have been suggested for improving capture and analysis of this failure type.

**Attitudes to Failure**

An attitude is an enduring pattern of evaluative responses towards an issue (Colman 2008). While failure as a whole could be taken as the input here, there are several separate issues that stem from failure which were found to drive certain behavioural responses. These are subsequently referred to as attitude stimuli.

During analysis of the interview data, key attitude stimuli were identified with their corresponding responses. Two pairs of these stimuli will be discussed here: blame and ownership; leadership and acceptance.

**Ownership and Blame**

A theme which emerged was reluctance to take ownership of the failure. Multiple interviewees alluded to this with a few citing reasons such as: not good for your CV, if I knew my job wasn't on the line and it's very painful, it's embarrassing. One interviewee pointed out that directly employed members of staff or those employed by the main contractor were more likely to raise an issue as he put it they feel ownership because they are part of a larger group. There was also mention that by specifically referring to job security and the length of work during inductions, the site workers tended to be more involved in the job, rather than just carrying out the assigned task. This concurs with recent emphasis in research, such as Sanne (2008), on increasing employee ownership to cultivate a productive reporting procedure.

On the other hand, for failures where there existed an overwhelming sense of moral obligation to take ownership, interviewees expressed increased satisfaction at the learning process. For example, H&S failures have a moral imperative to help preserve life and quality of life to others. This was expressed by one interviewee succinctly:

> Everyone is very open-minded about sharing lessons learnt from safety incidents because of the overarching moral obligations

Perhaps due to the different amount of perceived moral obligation, different failure modes seemed to elicit different levels of personal or company ownership. In comparison to H&S as already outlined, discussion on quality failures led more to blame and legal consequences, for example contractual conflicts. Additionally, if quality processes can be improved by a certain action, it is in the interest of the company to keep it undisclosed as a Unique Selling Point. Such reasoning overlooks the interdependent nature of quality and safety in construction where investigations have indicated mutual causality, where each performance type positively impacts the other (Wanberg et al., 2013, Love et al., 2015). Given this, the industry should ask itself, "is it morally justified to keep back significant quality information?"

Reluctance to take ownership had significant co-occurrence with the theme of personal blame or consequences. Some of the many quotes on the subject were:

> We live in a world of blame culture. Whether you like it or not.
People always worried about being the one at fault
You got your battle lines drawn very quickly
This discourse of blame and fault is at odds with recent research and policy to foster a no-blame culture, especially within H&S, to not only address learning but also encourage collaboration and innovation (for example, Lloyd-Walker et al., 2014).

An interesting finding was the role interviewees perceived HSE to take in regards to H&S learning within industry. Several times, it was hinted that inclusion of an independent body within the learning cycle shifted the internal focus from blame and personal culpability to learning and fair distribution of information. The legal obligations also gave professionals within the H&S industry an external scapegoat to avoid internal conflict as Interviewee 7, a H&S advisor, noted he was able to say to site staff in relation to enforcing H&S that it’s not just me once or twice a month, HSE could come up here any time.

Acceptance and Leadership
Acceptance of failure, or rather the lack of acceptance, emerged as an important attitude stimulus within the discussions with interviewees.

They go: […] "It will never happened to me"
People […] think "oh, we'd never do that on our project"
I wouldn’t say we had any failures.

This topic co-occurred with discussion of the role of leadership and top-down incentives for encouraging learning from failure. It was explicitly stated that increasing incentives and the acceptance of failure will aid prevention of failure:

I think people should be incentivised to produce these things and to accept the fact that we’ve got something wrong. Because, if you don’t accept the fact that you’ve got something wrong, you’re never going to prevent those things happening.

It was indicated by several interviewees that learning from failure is not incentivised. Several interviewees noted that leadership are often given financial incentives for productivity or profit which is in direct conflict with the acceptance of failure. Also on a personal level, one interviewee notes that a project which was considered a failure is bad on your job record. However, projects are an amalgamation of the work and effort of a (sometimes huge) number of people and the overall success or failure of a project rarely reflects on the specific value you brought to the job or the valuable learning gained from this. This observation can also be scaled up to the company as, when bidding for work, successes are emphasised, and failures unheeded. One interviewee explained the situation nicely:

When you tender for work, clients will ask you what you got right, never ask you what you got wrong and what you learn from it. […] I find that’s an interesting way of just ignoring it basically.

CONCLUSIONS
Having identified the perceived failure modes in construction projects, the research presented here explored the different systematic learning processes undertaken in the construction industry and the attitudes towards learning from failure.

Analysis of the interview data showed different stages of maturity in the learning cycle applied to different failure modes within a construction project. While safety showed mature single-loop systematic learning and some migration towards double-loop thinking,
quality presented an undeveloped single-loop process. Meanwhile, time and money failures gave no indication of any systematic learning process; nevertheless, there was strong evidence of informal learning and discussion.

Given these different stages of maturity, development of learning from failure in the construction industry cannot be tackled by a singular approach, but rather by developing different aspects of the process for each failure mode.

Within discussion of attitude to failure, two pairs of attitude stimuli were discussed: Ownership and Blame; Acceptance and Leadership.

Discussion on ownership and blame highlighted three outcomes:

- Blame suppresses learning;
- Increased ownership of failure cultivates a learning environment;
- Inclusion of an independent organisation within cycle aids failure analysis and distribution i.e. HSE for safety failure.

Meanwhile, dialogue on acceptance and leadership revealed the need for introducing incentives for learning from failure and emphasised the impact of individual and company leadership on acceptance of failure as a possible concept.

The messages delivered here can help focus future work on developing specific methods for learning from failure in construction that address the individual barriers identified by interviewees and wider literature.

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THEORETICALLY INFORMED RESEARCH ON DIGITALISATION
IS CONSTRUCTION RIPE FOR DISRUPTION?

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The notion of ‘disruption’ and particularly that of ‘disruptive innovation’ is now widely used by researchers as well as management practitioners, and the construction industry is being described as ‘ripe for disruption’. By comparing this industry to healthcare (another massive, societally important industry also considered ripe for disruption), this paper applies the lens of disruption theory to analyse the current and anticipated status of the construction industry. To do so, we ask and answer three central questions: Why should construction be ripe for disruption? When will disruption potentially occur? How will disruption likely manifest? We find that both industries share a number of challenges, including a fragmented stakeholder network, complex incentive structures and a sense of being in a deadlock that makes change difficult. Furthermore, we find that in both industries the term ‘ripe for disruption’ describes a process rather than prescribe when disruption will occur. By applying central notions from disruption theory (disruptive technologies, low-end disruption, new-market disruption, and a focus on value creation), we identify several potential disruptors of the construction industry. To conclude, we discuss the benefits and limitations of applying disruption theory to the construction industry.

Keywords: disruption theory, disruptive innovation, healthcare, industry comparison

INTRODUCTION

“Disrupt - or be disrupted” has become a common catchphrase of today. Managers and scholars alike seek to understand the nature and potential impact of disruptive innovation. In 2003, Charitou and Markides (2003) identified 14 examples of industries having experienced disruptive strategic innovations. The list included industries as diverse as the steel industry, the airline industry and the life insurance industry - and since then, more industries could arguably qualify for the list.

Observing how disruptive innovation has upended competition in other industries, the notion of disruption has also reached the construction industry. In recent years, two comprehensive analysis reports have described the construction industry as being ripe for disruption (World Economic Forum, 2016; McKinsey Global Institute, 2017). Similar conclusions are found in other recent grey literature such as Fortune (Tobak, 2016) and Disruptor Daily (Rands, 2017), both listing construction as one of three to six industries which soon will be disrupted. Arguably, disruption has become a popular buzzword that attracts the attention of business managers. However, the term also form the basis of scholarly theory (Christensen, 1997; Christensen and Raynor, 2003). In this paper, we
Is Construction Ripe for Disruption?

will take the point of departure in the theory of disruption while seeking to answer the main research question: Is the construction industry indeed ripe for disruption?

Previous research has compared the construction industry's development, innovation and productivity to that of the manufacturing industry, as this industry has accomplished to benefit from several transformations during the last 100 years (Slaughter, 1998; Winch, 2003). However, this comparison is limited due to the distinctive features of construction, including a comprehensive regulatory environment, the need for on-site assembly, and long life expectancy requiring long-time testing (Slaughter, 1998). Consequently, Winch (2003) suggests learning from other industries that similarly to construction has a complex system production model, and Concept-to-Order (CtO) or Design-to-Order (DtO) production strategies.

The U.S healthcare sector is an example of such an industry. As we will show, this sector shares a number of characteristics with the construction industry - including a recent label of being 'ripe for disruption' (Christensen, Waldeck and Fogg, 2017). Seeking to understand whether construction is indeed ripe for disruption, we compare the two industries. The industry comparison is guided by three sub-questions:

- What makes us believe an industry is ripe for disruption - and in particular, why should construction be ripe for disruption?
- When will disruption potentially occur?
- How will disruption likely manifest?

We begin by reviewing the most important aspects of disruption theory. Next, we present the two industries and describe our method. The main body of the paper is shaped by the three questions above. For each question, we describe the status of the two industries separately, and identify similarities, differences and opportunities for learning. Finally, we discuss how disruption theory may contribute to construction and to which extent the construction industry can be characterised as ripe for disruption.

DISRUPTION THEORY

The notion of disruption has intrigued business managers and scholars, since it was coined by Bower and Christensen in 1995. Disruption occurs as new innovations “bring to market a very different value proposition than had been available previously” (Christensen, 1997, xv), hereby changing the bases of competition in a market (Danneels, 2004). The theory on disruption is based on multiple case studies of technological development in e.g. the disk drive industry and the steel mill market. In these cases, disruption occurred because well-managed, established companies failed to recognise the disruptive characteristics of new technologies before it was too late. Dealing with disruptive technologies, the theory thus emphasizes the importance of first mover advantage and recommends incumbent to invest in disruptive technologies while they are still relatively immature (Christensen, 1997). Christensen and Raynor (2003) differentiate between low-end and new-market disruption. Low-end disruption happens when a low-cost and low-performance disruptive offering enters an existing market, and eventually overtake mainstream customer segments, as the performance of the disruptive offering improves. Opposed to this, new-market disruption targets current non-consumers and creates a new value-network.

Reviewing disruption theory, Danneels (2004) and Markides (2006) emphasised the lack of a clear-cut definition of disruptive technology and disruptive innovation and question the theory's ability to make ex-ante predictions. Nonetheless, the notion of disruption has been used increasingly often in the last few decades (Christensen, Raynor and McDonald,
Ernstsen, Maier, Larsen and Thuesen

leading to a rather diluted understanding of the term. Correspondingly, much research has investigated how disruption should be defined, and if and how disruption may be predicted (e.g. Danneels, 2004; Markides, 2006; Yu and Hang, 2010).

The term "ripe for disruption" is not as often found in research literature. However, according to Yu and Hang (2010), Schmidt (2004) proposed that a market is ripe for disruption if it is characterised by customers that are overserved according to traditional attributes, and underserved according to secondary attributes. Analysing the U.S healthcare sector, Christensen et al., (2017, 4) state that "High costs and uneven levels of access are typical hallmarks for an industry that is ripe for disruption". Consequently, we argue that to predict disruption we need to analyse the current status of an industry. Rather than focusing on specific technologies or a company setting, we will here apply the disruption lens in an industry context.

METHODOLOGY

The construction and healthcare are of course two very different industries. The main offerings of the healthcare system include diagnosing and treating patients, whereas the main offerings of construction are centred on designing and constructing physical structures. Where the primary outcome of healthcare is healthy people, the primary outcome of construction is a built environment. Despite their vast differences in offerings, the healthcare and construction industries share a number of characteristics. Both are quite large industries, given that each constitute 9-10 % of EU’s gross domestic product (European Commission, 2016; Eurostat, 2016). The industries are of societal importance, depend on public investment, and have a complex ecosystem of actors with different roles, agendas and mandates. And perhaps most importantly, although both industries have been proclaimed ripe for disruption, both struggle with implementing disruptive changes at the same speed as other industries (World Economic Forum, 2016; Christensen, Waldeck and Fogg, 2017). The healthcare sector and the construction industry both score among the lowest when comparing the degree of digitalisation to other industries (Gandhi, Khanna and Ramaswamy, 2016), indicating that they experience a need for embracing the opportunities provided by new technologies and digital innovations.

We base the description of healthcare disruption on research material from the Christensen Institute (Christensen, Bohmer and Kenagy, 2000; Christensen, Waldeck and Fogg, 2017) as well as other academic articles on anticipated disruptive changes in the healthcare sector (e.g. Patou and Maier, 2017). The Christensen Institute analyses how disruption is happening in various industries with a special focus on the U.S healthcare sector. We will keep in mind that healthcare, like construction, is a very diverse industry on a global scale - and all the inherent mechanisms of the U.S healthcare sector may not be present in e.g. European equivalents.

The description on construction disruption is based on two rather recent industry analysis reports from McKinsey Global Institute (2017) and World Economic Forum (2016), and supplemented by academic articles on anticipated disruption of construction and construction innovation (e.g. Winch, 1998; Bock, 2015). We will consider construction as a global industry although we acknowledge that there are very large regional differences. We recognise that consultancy reports may be biased since consultancies arguably may benefit from claiming that an industry is ripe for disruption. However, the comprehensiveness of the analysis behind the reports as well as the anticipation of construction disruption from other, purely academic sources (e.g. Bock, 2015), make us include the reports as relevant sources.
Is Construction Ripe for Disruption?

Why Should Construction Be Ripe for Disruption?
Already in 2000, Christensen et al., proclaimed that the U.S healthcare sector was ripe for disruption. This conclusion is based on a description of the sector as highly expensive, resistant to innovation, competing fiercely on price and delivering low-quality offerings. Further describing the challenges of healthcare, Christensen et al., (2017) emphasized the high cost and uneven access to offerings as key reasons for why disruption should be anticipated.

McKinsey Global Institute (2017) describes construction as ripe for disruption based on a global analysis of the challenges and productivity of the industry. Based on studies of productivity in more than 30 industries, they argue that the productivity of construction is "remarkably poor" and could be improved by 50-60 percent. World Economic Forum (2016) argue that the large societal, economic and environmental impact of the construction industry makes the potential of digitally transforming the industry significant. They both point towards the opportunities in e.g. standardizing processes, rethinking contractual structures, changing regulations and adopting new technologies.

Although both industries have identified the need for change, they are described as in a sort of deadlock that makes change difficult. In both industries, a large barrier to change stems from the complex network of actors with different objectives. Moreover, fierce competition makes it challenging for a single actor to break the deadlock - at least not without close coordination with others. The challenges that are used to characterise the industries as ripe for disruption are summarized in Table 1.

Table 1: Challenges used to characterise construction and healthcare as ripe for disruption

<table>
<thead>
<tr>
<th>Stakeholder network</th>
<th>Industry opaque and highly fragmented.</th>
<th>Powerful stakeholders interested in maintaining status-quo.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incentive structures</td>
<td>Tenders or invoices according to time spent. Contractual structures and incentives misaligned.</td>
<td>Fee-for-service model. Difficult to calculate profitability per procedure. Focus on utilisation of assets.</td>
</tr>
<tr>
<td>Market dynamics</td>
<td>Fierce competition, slim margins. Sub-optimal owner requirements.</td>
<td>Fierce competition between old institutions on price and accessibility. Uneven access to healthcare.</td>
</tr>
<tr>
<td>Quality of offerings</td>
<td>Poor project management and execution. Megaprojects surpass time and budget.</td>
<td>Reduced quality due to time pressure. This is dissatisfaction to patients.</td>
</tr>
<tr>
<td>Skills vs. tasks</td>
<td>Low skill-level of workers. Need for training workers to use the latest equipment and digital tools.</td>
<td>High skill-level of doctors surpass most patients' needs.</td>
</tr>
<tr>
<td>Investment</td>
<td>Low degree of investment in digitalization and innovation.</td>
<td>Investments focus on treating difficult high-end diseases.</td>
</tr>
</tbody>
</table>

Although disruption theory does not provide specific parameters for assessing whether an industry is ripe for disruption, our comparison suggests six parameters that may characterise an industry as ripe for disruption. Moreover, it is shown that construction and healthcare experience quite similar challenges according to most parameters. The only major difference is the skill-level of professionals, which is claimed to be too low in construction and too high in healthcare.

Besides having similar challenges, both industries report that they experience that other industries have succeeded in benefiting more from a digital transformation, than they have (World Economic Forum, 2016; Christensen, Waldeck and Fogg, 2017; McKinsey Global Institute, 2017). Thus, disruption is anticipated due to an experience of missed opportunities rather than because current challenges constitute a burning platform.
When Will Disruption Potentially Occur?

The proclamation of a need for change in the construction industry is not new. Already in the late 1930s, Schumpeter argued that prefabricated housing would bring a “gale of creative destruction” to the construction industry, in the same way as mass production changed other industries (Winch, 1998). Winch (1998) argues that Schumpeter was wrong and that the industry has not yet experienced the cost reduction and quality improvements seen in other industries in last 100 years. So why should disruption occur in the construction industry just now?

A similar question is asked in the healthcare sector, where 17 years have passed since the sector was first described as ripe for disruption. Christensen et al., (2017) suggest that characteristics of U.S healthcare make the sector impervious to change: End-users (i.e. patients) lack control of the design and buying decisions, new competitors experience high barriers to entry, and the fee-for-service reimbursement system fails to consider the quality of the care. Despite these forces repelling disruption, they persist in concluding that healthcare will be disrupted, although slower than initially expected.

In theory, disruption occurs at that exact point in time when the performance of a disruptive innovation surpasses the performance of mainstream offerings (Christensen, 1997). Thus, by mapping the performance trajectory of an expected disruptive innovation as well as mainstream offerings, one should be able to anticipate when disruption will occur. In practice, however, it is challenging to determine the disruption point before disruption has actually occurred (Danneels, 2004). One reason for this is that performance may be measured according to many different parameters - and that choosing the right parameter is not trivial. For example, for a group of customers in the construction industry the most important performance parameter could be "time from idea to finished building" or "life-time cost" or (most likely) something else. Even if one has identified the most important performance parameter for mainstream customers today, one should keep in mind that disruption may imply that this parameter is not the most important for customers tomorrow.

Thus, seeking to predict when disruption will occur in construction and healthcare is challenging. However, assuming that disruption will occur at some point, the challenge may be worth undertaking for construction companies to avoid being surprised by disruptors. Acknowledging the limitations of predicting the future, we believe companies in the construction industry may benefit from using e.g. foresight methods to identify potential disruptors. In the following, we identify some of the potentially disruptive technologies and innovations that should be analysed to be able to estimate when disruption could occur in construction.

How Will Disruption Likely Manifest?

To understand how disruption may be anticipated in construction, we will take point of departure in four recommendations found in disruption theory:

- Disruptive technologies: Invest early as a first mover advantage is essential
- Low-end disruption: Identify overserved customers
- New-market disruption: Identify current non-consumers
- Focus on creating value for the customer
Disruptive technologies: Invest early as a first mover advantage is essential

Technological progress is often brought forward as a reason to anticipate disruption. However, in the analyses of healthcare disruption, new technologies are merely mentioned as an enabler of disruption, alongside with new innovative business models and a changed value network (Christensen, Waldeck and Fogg, 2017).

According to McKinsey Global Institute (2017), the largest potential for productivity improvement of the construction industry stem from the implementation of new technologies. Especially the anticipated disruptive potential of Building Information Modelling (BIM) has long been studied by construction researchers (e.g. Morgan, 2017). World Economic Forum (2016) conducted a survey about the perceived potential of construction technologies among industry experts, and here integrated BIM was rated as extremely likely and anticipated to have an extremely high impact. BIM is arguably a critical driver of disruption in construction since digitalisation of data makes several other new value propositions possible. Another important group of potentially disruptive technologies is found in automated construction technologies such as 3D printing and construction robotics (Bock, 2015). Bock (2015) argues that automated construction technologies will speed up construction processes, change the way buildings are designed, and eventually pervasive robotics (e.g. service robots) will be an integrated part of the built environment. Considering these examples of technological progress in both the virtual and physical dimensions of construction, we expect disruptive changes to affect the entire value-chain of construction.

When companies have identified supposedly disruptive technologies, they should, according to theory, act as first movers in maturing the technologies to avoid being disrupted. This recommendation, however, contrasts the description of construction and healthcare as being in a deadlock where stakeholders need to act simultaneous for change to occur. In construction, for example, multiple companies have invested heavily in BIM to gain a first mover advantage. However, BIM seems to gain grounds through a coordinated effort (including legislative action) rather than through a strategic first move. As disruption theory focuses on the actions of a single company, it does not provide recommendations for coordinating disruptive initiatives across an industry.

Low-end disruption: Identifying over-served customers

According to disruption theory, incumbent companies may prepare for disruption by identifying current customers that are currently over-served. Christensen et al., (2017) argue that on one hand, the U.S healthcare system delivers dissatisfying services to patients due to e.g. time constraints on consultations. On the other hand, the healthcare offerings overshoot the needs of the majority of patients, as highly educated doctors attend all patients without differentiating between minor and major health issues. Thus, the recommendations for healthcare include creating a system where the skill level of the health professional corresponds to the difficulty of the medical issue (Christensen, Bohmer and Kenagy, 2000).

Translating this line of thoughts to construction, we find that construction, like healthcare, defines its offerings based on professional disciplines rather than complexity of the offerings. For example, larger companies in the construction industry are typically differentiated by profession (e.g. architect or engineer) rather than by the nature of assignments (e.g. school building or landscape planning). In this regard, disruption theory recommends taking the point of departure in the customers' jobs to be done and look for over-served customers. Over-served customers may be customers that currently buy relatively low-cost offerings (e.g. expansions of an office building) without actually
needing the high-end offerings that the company is capable of providing (e.g. specialised knowledge used for designing hospitals).

An example of a low-end disruptor of construction is Altan.dk, a specialized company that delivers customized balconies including customer service, installation and life-time support (Kudsk *et al*., 2013). Altan.dk has succeeded in identifying a customer group that needs "only" the services related to designing and establishing balconies on existing buildings. Although the balconies are customized, they are designed using a product configuration system of standardised components, enabling Altan.dk to deliver a low-cost product that is valuable to a specific group of customers.

As the case of Altan.dk demonstrates, low-end disruption of construction does happen. Disruption theory may therefore contribute to construction through its emphasis on the (often over-looked) potential of low-cost, low-performance offerings that improve over time. Correspondingly, construction companies may benefit from identifying low complexity tasks that 1) could be bundled as a low-cost offering, and 2) may develop to a high-end product over time as technology improves.

**New-market disruption: Identifying current non-consumers**

Another type of disruption, which might be anticipated in construction, is new-market disruption. According to theory, this kind of disruption may be found by identifying current non-consumers. An example from healthcare is that of doctors prescribing patients to change their lifestyle, e.g. exercising more, losing weight and/or eating healthier to prevent e.g. diabetes or depression (Christensen, Waldeck and Fogg, 2017). These patients can be seen as non-consumers since they are expected to make lifestyle changes between the occasional doctor's appointments without the support from health professionals. Identifying this gap in the market, a pilot study in Boston, successfully introduced non-clinically trained health coaches. The health coaches meet with the patients before and after clinical consultations, act as the patients' advocate and support the patients in their health journey. Since the focus is on prevention rather than treatment, the investment in health coaches is shown to pay off.

Correspondingly, we may identify current non-consumers in construction to anticipate how new-market disruption may manifest here. Although a lot of stakeholders are generally involved in construction projects, there are also rather significant groups of stakeholders that are typically not involved. This may for example include the expected users of a new bike path, the neighbours of a new subway station or the future cleaning personnel of a new school. New technologies such as virtual and augmented reality make it easier to involve users in the construction design at an early stage of the project. Likewise, new-market disruption may be expected to empower the users. Perhaps crowdfunding platforms can involve users in prioritizing new construction projects, or allow the future users to vote about design-related decisions during the project.

Today, many construction companies deliver a customized solution for each customer i.e. they deal with markets of one (Gilmore and Pine, 2000; Thuesen, Jensen and Gottlieb, 2009). In contrast, disruption theory presupposes a mass market where companies target customer segments with different offerings. This discrepancy between practice and theory challenges the relevance of speaking of new-market disruption in construction. Supposing that a market consists of one customer, identifying new-market disruption in construction would mean identifying just one new customer. Supposing, in contrast, that construction may be a mass market, new-market disruption entails developing standardised solutions for construction.
Focusing on Creating Customer Value

Describing how disruption will occur in U.S healthcare, Christensen et al., (2017) argue for changing the incentive structures from a fee-for-service to a value-based system. Healthcare practitioners could for example be reimbursed on account of the general health of their community opposed to on account of number of consultations. Furthermore, a value-based incentive system would entail an increased focus on prevention rather than treatment. Technological progress could support this focus on the preventive value of healthcare, as it enables continuous monitoring of peoples' health, behaviour and environment (Patou and Maier, 2017).

In construction, focusing on long-term value may mean measuring the indoor work environment and its effect on the users of the building, or utilizing measures of life-time environmental impact in the design of new structures. If companies in the construction industry start focusing on prevention rather than "treatment", facility management may likely play a bigger role in the design and construction phases. Furthermore, an increased focus on value would entail rethinking the contractual structures to align risk and reward and forming e.g. strategic collaborations.

In both healthcare and construction, it is difficult to change incentive structures and value networks. Especially because shifting to an incentive system that is based on long-term value typically will induce bad financial performance in the short run. Christensen et al., (2017) prescribe that legislators, providers and payers need to coordinate their actions in order to create sustaining changes. Although this is highly difficult, the benefits of disrupting the industry appear to be worth it.

DISCUSSION AND CONCLUDING REMARKS

Comparing healthcare and construction, a number of similar challenges and opportunities were identified. Both industries are characterised by a complex stakeholder network, misaligned incentive structures, improvement potential in the quality of offerings and limited investments in disruptive innovations. Assuming that the healthcare sector is indeed ripe for disruption, this comparison would suggest that construction is similarly ripe for disruption.

However, the identified similarities between healthcare and construction may also support another conclusion: that the construction industry, just like healthcare, is "impervious to even the strongest forces of disruption" (Christensen, Waldeck and Fogg, 2017, 4). Or perhaps more likely: disruption theory may not be the most appropriate theory for explaining the complex industrial dynamics of construction and healthcare.

This view is supported by Geels (2018) who has analysed the transformation of energy-related sectors to low-carbon energy systems. He argues that disruption theory's focus on single (conquering) innovations and price/performance competition makes the theory less suitable for studying system transitions, where e.g. social and political dimensions play a large role in creating change.

Correspondingly, we find that the strengths of disruption theory does not lie in its ability to predict when disruption will occur, but rather in its recommendations for envisaging how disruption could likely manifest. Taking point of departure in four recommendations from disruption theory, we have shown to which extent the lens of disruption may aid construction companies in anticipating changes.

As for the question of when disruption might occur, disruption theory falls short of an answer. Different industries have different trajectories of technological development,
meaning, for example, that it took 40 years before mini mills had disrupted the steel industry (Christensen, Raynor and McDonald, 2015). Arguably, this may deflate the prescriptive value of speaking of ripeness for disruption. Although the industry is claimed to be ripe for disruption today, the lack of a specified timeframe makes it possible that the industry is still (or again) ripe for disruption in 15 years from now. Not knowing when disruption will occur in construction (and assuming that it will), construction companies may benefit from following both market and technology development closely. Foresight methods may be helpful for imagining possible future, and technology management methods may aid the companies in identifying and assessing the potential of new technologies. As a part of our future research, we aim to combine the advantages of foresight and technology management and investigate new ways of assessing the disruptive potential of new technologies.

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THE VALUE OF BIM IN A HEALTHCARE CONSTRUCTION PROJECT: A MULTI-ACTOR PERSPECTIVE

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Construction projects constitute a highly complex and fragmented project environment where a variety of stakeholders are forced to interact and collaborate during the various phases of the project process. In enhancing collaboration and communication among project stakeholders Building Information Modelling (BIM) has been identified as an important tool, however the implementation and use of BIM as a collaborative tool has been more difficult and time-consuming than anticipated. The aim of the study is to investigate how various project stakeholders perceive the value of BIM in a large construction project by using and applying the Industrial Network Approach (INA). An in-depth case study of a Swedish healthcare project was performed through interviews with main stakeholders of the project. The results indicate that each stakeholder perceives the value of BIM from their own perspective and role in the project. The perceived value of BIM is closely connected to the changes and adjustments that each stakeholder have to do in order to use BIM; for some stakeholders BIM cause an increased work load, while for others’ BIM facilitated their work processes. The diverging perspectives of the value of BIM and the associated changes among the various project stakeholders provide a deeper understanding to why the implementation and use of BIM is challenging.

Keywords: BIM, projects, value, multi-actors, industrial network approach

INTRODUCTION

During a long period of time the construction sector have been imbued by escalating costs and low productivity (Egan 1998). In addition to this construction projects are increasingly complex and challenging to manage. One way of managing increasingly complex inefficient construction projects is to use various ICT-tools. Several scholars reveal the increased use of Building Information Management (BIM) in the construction sector and conclude that the use of BIM cause changes of how construction activities are organized and how actors relate to each other (Boland \textit{et al.,} 2007; Whyte and Levitt 2011; Succar \textit{et al.,} 2009), hence the use of BIM influences existing practices and also the involved actors. Sebastian (2011) mentions the changing actor roles due to the use of BIM, while Davies and Harty (2013) emphasize the need for informal relationships between actors on site when implementing and adopting BIM. Existing studies of using BIM hence reflect one main characteristic of construction projects, the involvement of various actors with various perspectives of the project or as Heravi \textit{et al.,} (2015: 985) put it: "Many stakeholders, individuals, and groups are involved in the provision and delivery of..."
of construction projects and each has their own role, requirements and objectives”. However this also indicates that different actors may have different opinions on the use of BIM and its specific benefits and values. Scholars have revealed several benefits due to the use of BIM, for instance cost reductions can be achieved (Fox and Hietanen 2007; Bryde et al., 2013), increased innovation and better coordination (Gillian and Krunz 2007). Studies of the use of BIM have been limited to the perspective of one particular actor, often the contractor or the client, while few studies include a multi-actor perspective. Hence the following paper focus on investigating the value of BIM from a multi-actor perspective. More specifically the paper aims to answer the following research questions: How do various project actors perceive the value of BIM? What different values can be identified? How do the different values relate to the interaction processes between stakeholders?

The questions are investigated through a case study of a specific construction project - a new healthcare facility providing radiation treatment. The case mainly relies on data retrieved through in-depth interviews with main stakeholders (the developer, the construction company, the radiation supplier, the tenant, the planning coordinator, the architect etc.). In order to understand the project context and its development the authors also performed on-sites visits. The authors only used the project as a study object and had no influence over the projects’ execution. The paper contributes to the construction management literature by providing a multi-actor perspective on the use of BIM and its value(s). In the following section a short review of the value of using BIM is presented, thereafter the characteristics of construction projects and its involved actors is presented followed by a presentation of the resource interaction model. Thereafter the case is described followed by a concluding discussion.

LITERATURE REVIEW

Use of BIM - Benefits and Values

Several scholars have investigated the use of BIM as well as the value and benefits of BIM. Grilo and Jardim-Goncalves (2010: 530) focus on the interoperability of BIM models and information systems on the organizational level and they conclude that: “If higher levels of interactions between participants emerge (e.g. through full 3D BIM cooperation), companies in buildings projects will likely obtain differentiation value levels, where higher cost benefits and less risk are likely to be the outcome”. While Gu and London (2010) focus on understanding the changes required in order to use BIM and the authors emphasise that expectations on BIM as well as value of BIM differs across disciplines which causes problems when adopting BIM. Sebastian (2011) also focuses on the changes and re-organizing due to BIM. The author especially highlights the changing roles of construction actors as well as the formation of a new professional role in construction - model managers. Linderoth (2010) on the other hand point out the possibility to enhance the value of BIM by using the same actor network for several construction projects, where not only human actors are important but also non-human actors. Linderoth (2010) point out that the use of BIM can result in both immediate benefits (such as installation clash analysis) but also related to more long-term and indirect benefits (in relation to scheduling and planning). Bryde et al., (2013) concludes that most prominent values of BIM are cost reductions and increased control through the project life cycle. The study also revealed that BIM can create time savings as well as communication, coordination improvement and enhanced quality. Fox and Hietanen (2007) conclude that the use of BIM result in different business values and effects. Automational effects refer to BIM as substituting for labour resulting in productivity
improvement and cost reductions. Informational effects refers to BIM as a tool to store, collect and disseminate information which can result in increased quality and more efficiently use of resources etc. Transformational effects refer to how BIM contribute to innovation and transformation, such as improved service. Demain and Walters (2013) focused on how BIM can be used as a medium for communication within a construction team. The use of BIM resulted in benefits such as more accurate and on-time information exchange among construction teams. Gillian and Krunz (2007) present a survey of how stakeholders actually perceived value of using BIM. The majority of users of BIM saw a value of BIM throughout all phases of design and construction. The authors divide value into three main value groups: benefits, unintended consequences and benefit impediments. The authors also mention the use of BIM as a possible to engage project stakeholders in actually understanding the projects scope.

Construction Projects: A Multi-Actor Constellation

Main activities in the construction sector are performed within time-bound projects. Hence projects play an important part of the construction sector and projects can be seen as multi-actor constellations (Kolltveit and Grønhaug 2004; Brady and Davies 2011). In any construction project a number of stakeholders come together to execute a particular task with a particular function to a particular cost (Bakker 2010). However these actors may have radically different views and perceptions of the project at hand which can cause conflicts and problems in projects (Rauska et al., 2011). It is also argued that the way actors interact and relate to each other influence the outcome of the project (Olander 2007). Winch (2010) divides actors into internal stakeholders including actors representing the demand side such as the client and its employees and customers and the supply side with architects, engineers, suppliers etc. External stakeholders are actors outside of the project including regulatory agencies, as well as NGOs etc.

Within the Industrial Network Approach (INA) the basic notion is that any company or organization (being construction related or not) is dependent on other actors to access resources and activities in order to develop its business (Håkansson and Snehota 1995). INA is inspired by Penrose (1959) where the notion of resource heterogeneity is put in the fore. As a consequence the value of any product (for instance BIM) is not given instead it is dependent on how it is connected to other resources (Håkansson and Waluszewski 2002). Hence the value of a product is dependent on resource interaction processed of a network of actors combining resources. This means that resource interaction is a key process in giving value to a particular product, but it also means that the value can be rather different depending on what actor perspective you address. The resource interaction model (Håkansson and Waluszewski 2002) divides resources into two types of resources; technical (products and facilities) or organizational (relationships and units). Products as resources can be goods or services such as components, raw materials, services etc., while facilities refer to equipment or tools used to produce particular products. Organizational units refer to a company, a division within a company, or an individual which develop skills, knowledge, experiences and routines etc. over time. Organizational relationships emerge when two or more organizational units interact and organizational units mobilize and develop products and facilities through interactive relationships. By using the resource interaction model it is possible to investigate the value of BIM and how the value of BIM is related to the network of resources (products, facilities, organizational units and organizational relationships). Moreover it is also possible to identify what value it brings to the focal construction project and main project stakeholders in the project network.
THE CASE: SKANDION CLINIC

The Skandion clinic is the first clinic in Northern Europe to provide cancer treatment using proton therapy. The cost of the new clinic is estimated to around US$ 104 million; US$ 52 million for the construction of the clinic, while the remaining US$ 52 million constitutes the cost for the radiation equipment. The construction of Skandion Clinic was complex and uncertain due to the challenge to create a 'radiation safe' environment. Six main project stakeholders involved in the construction of the Skandion Clinic can be identified; 1) Kommunförbundet Avancerad Strålbehandling (KAS) - the main tenant of the new clinic and responsible for the cancer treatment. 2) Akademiska Hus (AH) - the developer and the main owner of the new clinic. 3) NCC Construction - the construction company in charge of coordinate the construction of the clinic. 4) Link Arkitektur - the architect firm responsible for developing the design of the clinic along with coordinating the BIM-model. 5) Sweco - the design and planning coordinator of the design and planning organization. 6) IBA - the radiation equipment supplier.

Establishing Skandion as a BIM-Pilot Project

Akademiska Hus (AH) was appointed to set up and manage the new clinic and AH signed a partnering agreement with NCC concerning its construction. The choice to engage in partnering is closely related to the use of BIM in the project. AH and NCC had both prior experiences from BIM but mainly used is a 3D tool for visualizations. The partnering agreement opened up for using BIM on a higher level. The Skandion Clinic project was decided to be a BIM-pilot project for AH with the aim to result in a written BIM-manual to be used for future projects. In order to be able to use building information structurally AH and NCC needed to jointly develop a basic BIM instruction for the project. It was not enough to combine resources from AH and NCC, instead the two parties realized the need to include the architect and the planning coordinator in specify the instruction for Skandion. Through a number of BIM-meetings and a specific BIM workshop AH, NCC, Link and Sweco scrutinized the collected BIM documents from prior experiences and projects in order to define a BIM instruction for Skandion. This way of jointly setting the frames of BIM in Skandion was reflected on by the main architect from Link as:

A lot of collaboration was between us and the partnering actors. Together we did an instruction from the beginning on what to use the models to and how to work with the models. So we did an instruction from the very beginning that we have followed

The planning coordinator from Sweco comment on the benefits of the intense work with AH, NCC and Link as: “For my work it means that it will be a smooth coordination since we have reached consensus in what to achieve at an early stage. This is unique and something that we have not done before. Early on decide what to model and why”.

BIM-tools in design and planning - the tenants' lack of construction knowledge becomes obvious

The early design model developed by the architect was the point of departure for the design and planning organization. AH has a special requirement concerning the room functioning software, hence it was important to choose a software based on an open IFC-system, hence the architect decided to use Solibri as main BIM tool. Use of BIM in design and planning meant that the specialized technical consultants should provide their information into the model while the BIM-coordinator should update and synchronize the information from all consultant groups into one model. In specifically discussing the BIM-models a new type of meeting area was introduced the BIM-meeting.
In being able to do the basic design work Link was dependent on the tenant to deliver necessary information such as number of sockets, material on the walls and sizes of windows etc. Normally tenants have their own organization with construction expertise such as a building unit but this was not the case within KAS as the organization only consisted of 2-3 individuals with expertise in cancer treatment and efficient patient flow. To handle construction related issues KAS appointed a consultant firm, however with little experience from large complex healthcare projects. Due to this the other stakeholders needed to determine the information on behalf of KAS. This was reflected on by the architect as the following: “...the tenant did not have an organization. Instead it is a new established organization and during a long long time it only consisted of two people...everyone [Link, Akademiska Hus, NCC] tried to make the tenant to organize and deal with the questions but we did not succeed in time.” Hence the lack of construction knowledge at KAS resulted in that the wrong information was inserted in the BIM-model. Moreover the lack of construction knowledge is also visible in how KAS perceives the use of BIM in Skandion. KAS had little understanding about how cost can arise due to work with the BIM-model, the organization could not understand how costs could be generated before the actual physical production stage. Hence KAS only understood BIM as a visual tool, not a model including information how to set up, construct and manage the building.

**BIM and the Radiation Equipment Supplier**

To perform treatment with proton therapy KAS signed a purchasing agreement with IBA, the world-leading supplier of cyclotron for proton therapy. As the cyclotron generates radioactive radiation IBA have certain requirements on the construction of the building in order to install the equipment. In the agreement with KAS IBA defined its requirements on the building through the Integrated Building Documents (IBD). The documents include more than 100 pages and 40 different drawings with detailed information about how the treatment rooms should be constructed to deliver proton radiation treatment. The IBD documents are adapted to the context and the unique conditions for every project, for instance in Skandion the IBD needed to correspond to the demands of Swedish Radiation Safety Authority. In order to proceed with the physical construction of the treatment area IBA needed to approve the production document provided by the design and planning organization, hence IBA needed to interact with both the planning organization and NCC. The cyclotron and the IBD document affected the work with BIM and it was also clear that the IBD-information was difficult to incorporate in the BIM-model, or as the BIM-coordinator describes it:

They [IBA] were not compatible with us. So it [information] came on DVG-files, it was flat in a way. Thereafter the architect and the structural engineer needed to interpret it, unfortunately. It was really a pity

To interpret the information into readable BIM files, the rest of the stakeholders needed to be engaged. To facilitate the translation Sweco, AH, NCC and Link paid visits to IBA reference projects in Europe and the US. To further facilitate interaction a special meeting forum was introduced; NAV-meetings in which AH, Sweco, IBA and NCC met face-to-face.

**BIM as Facilitating Planning and Production**

To use BIM on a high level required linking and connecting the planning and production organizations. Hence NCC joined the planning organization with Link and a number of technical consultants coordinated by Sweco. Through the initial BIM instruction it was easy to convince the whole planning organization how to use BIM for planning. It was
decided to use ‘increased modelling’, hence the program information was very simple with low level of details, while the detailed level increased for system drawings and finally for production drawings. For each planning meeting the planning consultants supplied information that was synchronized by the BIM-coordinator into one model, all in all 13 people supplied BIM information to the model.

Even though the planning is characterized as “smooth” by Sweco the high level of BIM in Skandion have required more time due to increased interaction among planning stakeholders compared to traditional planning. A lot of time was put on investigating and discussing ventilation and energy supply along with installation clashes and collisions while developing the BIM model. The increase cost in planning by using BIM is commented on by Sweco as: “It [using BIM] can have cost more in the planning in order to do the modelling in BIM but we have gained in the fact that there are few faults on site”. While the project leader of AH comments on the use of a combination of partnering and BIM as determinants in increased meetings throughout the project by saying: “Partnering in itself creates more meetings and together with BIM it creates even more meetings. But I guess it is the main point of it all that we together perform at our best. The right house, to the right prices to the right quality”.

Due to a tight time schedule, planning and production took place in parallel. Consequently the planning and the production of the clinic needed to be coordinated alongside each other. The planning was steered by the production planning that was divided section by section through the assistance of BIM, hence NCC decided on what production drawings the company needed at what time, which determined planning time and resources schedule put up by Sweco. Even though the planning and design phase was time consuming it minimized on-site adaptations in production. NCC used BIM foremost as a tool for planning production activities, i.e. informing foremen and workers what to do along with introducing new subcontractors on site. In order to facilitate the use of BIM in production the NCC production team got basic BIM training and was equipped with IPads. All relevant documents, protocols and other BIM information could be accessed through a system of drop boxes through the software iBinder. Moreover, in reducing the use of drawings NCC invested in a plotter with the possibility to print drawings on site. NCC also used BIM for purchasing activities by calculating quantities; which was indirectly related to planning the logistics of purchased materials.

**CONCLUDING DISCUSSION**

It is evident that BIM is affecting the interaction among the main project stakeholders in various ways. In being able to use BIM as a ‘mutually shared resource’, new arenas for interaction among the stakeholders needed to be developed in the project.

AH as a client and long-term owner of the new facility have the most possibility to actually use the information generated in the project. It was AH as a unit who pushed for the Skandion project to become a BIM-pilot. In combining resources, i.e. experiences and knowledges of various stakeholders it was possible to generate a new resource, a BIM-manual which could be used on subsequent projects. Hence in being able to develop the BIM-manual AH relied on the other stakeholders to insert valuable information into the BIM-manual and also the BIM-model.

KAS as the tenant did not understand BIM at all as the unit only viewed BIM as a cost not a resource that could generate increased value such as a better working environment for the employees, better patient flows or better management and operations of the new facility. Instead the lack of understanding of BIM and KAS being an immature tenant
caused effects on other stakeholders, for instance NCC needed to make on-site adjustments along with the Sweco needed to revise the production documents after the actual construction. The interaction between the resources of KAS and that of the other stakeholders thus obstructed a more full use of the BIM model. The lack of knowledge related to construction and BIM affected the rest of the project actor network in order to extract value from using the model.

NCC saw the benefits of BIM and used BIM for planning the production, procurement and logistics. Indirectly this also facilitated the work of the design and planning organization. However in actual production BIM was mainly used for production preparation and planning of activities. As NCC signed a partnering agreement with AH the unit pushed for the use of BIM in production, this also resulted in training of production employees and on-site IPads to facilitate work on site. Also NCC saw the value of not printing the design drawings but instead use the digital BIM-models and only occasionally print out designs on sites when needed.

IBA the radiation equipment supplier influenced the use of BIM in the project, as the critical IBD documents did not support BIM information the IBD had to be translated into new information in the BIM-model. AH, Sweco, NCC and Link had difficulties in understanding the IBD and sort out what information needed to be incorporated in the BIM-model. To solve this, increased interaction among the stakeholders and IBA was necessary including on-site visits to other IBA facilities. Through these visits the stakeholders could ask the right questions to IBA concerning the IBD documents which facilitated the translation of IBD-information into information inserted in the BIM-model.

Sweco the design and planning coordinator with extensive experience from BIM saw the potential of using the BIM-model while designing and planning the complex project. Also it is evident that the use of BIM actually resulted in increased interaction among various stakeholders in the project and hence facilitated the establishment of a joint 'vision' of the project. Also the architect viewed the use of BIM as something valuable in the project, much due to that the architect had previous experiences of using BIM on a high level which also resulted in a new actor role of the unit - the BIM-coordinating role. The architect also mentions the necessity to actually use BIM in order to be able to complete the complex project, also the use of BIM forces the design and planning actors to jointly develop an instruction that facilitated the work.

Due to BIM the project display less on-site adaptations as the production drawings contained little faults. It is however evident that the value of BIM is not always direct and spread evenly across the project stakeholders, specified construction actors such as AH, NCC, Sweco and Link saw different values of using BIM, while stakeholders such as IBA and KAS did not understand the value of the information inserted in the BIM-model.

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DIGITALIZATION AND INNOVATION IN THE REAL ESTATE SECTOR

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Recently, digitalization has emerged as a main theme in the industry discourse in the real estate sector. In this discourse, some influencers foresee that digitalization poses disruption, even an existential threat, to the traditional actors, which are expected to make “digital transformations” to remain relevant. Others emphasize the potential of digitalization to drive efficiency, sustainability and servitization of the industry. However, the real estate sector is a mature business environment with a low rate of innovation and limited R&D resources, and it is not evident how this traditional sector reacts to the multitude of new predictions and propositions. Based on theories of innovation management, this study investigates real estate owners’ sense-making and strategizing in this area: how do they seek information and prioritize which initiatives to take? Which actions are taken? How are structures for innovation management affected, within firms as well as on the industry level? The results are based on semi-structured interviews conducted with Respondents responsible for digital development in large private and public real estate owners in Sweden, as well as with representatives of industry associations. Findings include that real estate firms and industry associations emphasize digitalization-related opportunities to improve efficiency and tenant satisfaction, as well as to create new services and business models. Also, real estate firms perceive that change is needed to remain competitive, and as a response, they have created digitalization strategies, formed new organizational units and recruited new people to lead digitalization efforts. Further, they have established new collaborative relationships to industry networks and competitors.

Keywords: dynamic capabilities, digitalization, real estate management, innovation

INTRODUCTION

Society of today is increasingly challenged by new requirements arising from urbanization and sustainability. Digitalization is often pictured as a catalyst for sustainable development, where digital information flows are seen as prerequisites for efficient use of resources. In the built environment, digitalization used to be synonymous with the use of building information models (BIM), but more recently technologies, such as sensors-based building monitoring has emerged as an important field (Atkin and Bildsten 2017). Digitalization is further increasingly associated with sharing economy, tenant relationships and social sustainability and companies with a background in other fields approach the real estate sector with new offers based on digital technologies (Baum 2017). Also, in the last couple of years, digitalization has emerged as a main topic in industry magazines, seminars and reports (e.g. Westergren et al., 2017; Fastighetsägarna Stockholm 2018; Kairos Future 2018). Thus, digitalization in the real estate sector is a multifaceted phenomenon with potential impact on a wide range of actors and processes.

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Here, property owners are strategic decision makers and gatekeepers (Kulatunga et al., 2011).

Real estate owners are generally considered to be slow to take up new technology and new services (Engström and Hedgren 2012), much due to an absence of competition and innovation drivers in a sector where traditional business models have delivered substantial and stable returns for decades (Palm 2015). Due to the development in digitalization, however, they increasingly find themselves exposed to a multitude of challenging predictions and propositions. Thus, more or less all property owners have to decide how to respond to this novel and complex environment.

In this research, we report the result of an interview study primarily targeting large real estate owners, but also industry associations that act as knowledge brokers and change agents in the real estate sector. We investigate the strategies for seeking information, the actions taken and planned, how these were selected, and the experiences. We further discuss how digitalization initiatives relate to existing structures and roles for managing business development and innovation within these companies, and discuss implications for future development.

Frame of Reference

In recent years, both academic and industry discourse on digitalization has shaped the understanding of this complex phenomenon. In Gartner’s (2017) definition, digitalization is seen as process, where the use of digital technologies may lead to new opportunities and changes in business models. Further, it is suggested that implementation of digital technologies is fundamentally transforming organizations (Yoo et al., 2012) and that these transformation processes should be guided by digital strategies (Bharadwaj et al., 2013; Matt et al., 2015). Several authors have argued that dynamic capabilities view (Lenka et al., 2017; Yeow et al., 2018), focusing on the ability of an organization to purposefully respond to a changing environment, as well as theories on innovation processes (Nambisan et al., 2017) would be particularly useful to understand digitalization in organizations. In the next section, we review the current understanding of innovation and innovation management in the real estate sector and subsequently relate it to research in dynamic capabilities.

Research on Innovation in Real Estate Sector

Most research on innovation in the built environment focuses on the construction sector. In this perspective, construction clients are seen as key enablers of innovation since their procurement requirements shape drivers for innovation in projects and supplier organizations (Kulatunga et al., 2011; Gambatese and Hallowell 2011). However, clients are often criticized for being conservative (Engström and Hedgren 2012; Ivory 2005). Many firms and organizations in the construction industry are project-based, which generally implies that they are decentralized and that structures for learning between projects are weak (Dubois and Gadde 2002; Winch 1998). This research is partly relevant also for real estate owners since many of them are engaged in building projects as well as in refurbishment and maintenance.

Another stream of literature, closely related to real estate owners’ perspective, concern innovation in facility management (FM). It is often argued that innovation is important for FM organizations (Noor and Pitt 2009), but also in this area innovation seems to be more of one-shot events than continuous activity (Mudrak et al., 2005; Cardellino and Finch 2006). According to a review by Atkin and Bildsten (2017), current research debate primarily relates to incremental development on operational issues, while strategic
management of innovations has received less attention. They also note that most of
digitalization related research deals with intelligent buildings and communications
technology, mainly focusing on BIM, whereas other potentially disruptive technologies,
such as Artificial Intelligence or Internet of Things are discussed mainly in the informal
media (Atkin and Bildsten 2017).

**Dynamic Capabilities and Innovation Process of a Firm**

Dynamic capabilities are often seen to be embedded in organizational routines and
processes (Eisenhardt and Martin 2000; Winter 2003). While operating routines guide
the day-to-day activities of the organization, dynamic capabilities can be understood as
second order routines designed to continuously assess and update the operating routines
(Nelson and Winter 1982). In particular, an organization's absorptive capacity, or the
capability to acquire and process new information for developing new product and
services (Cohen and Levinthal 2000; Zahra and George 2002), is considered important.
Sense making processes, where individuals interpret and give meanings to events (Weick
1995) are central in this perspective.

Much innovation research is focused on organizations active in high-velocity markets, but
several authors, such as Eisenhardt and Martin (2000) and Easterby-Smith et al., (2009)
claim that the theory of dynamic capabilities is useful also for studying more traditional
industries as well as the public sector. The real estate sector clearly falls into this
category, and the dynamic capabilities perspectives implies that it is the routines and
resources to manage innovation that should be in focus. In accordance with the dynamic
capabilities view, Tidd et al., (2005) further conceptualize the innovation process in a
firm in terms of three phases: search, selection and implementation. They emphasize that
the process is by no means always rational or linear and can vary from firm to firm as the
context for innovation varies, but also that having a degree of structure and a framework
for behavioural routines can help in making sense about the innovation process.

Important routines in each phase are (Tidd et al., 2005):

- **Search**: The firm develops understanding of the search environment and appropriate
  search strategies.
- **Select**: The firm prioritizes between the signals from the search phase based on its
  existing capabilities and the overall business strategy.
- **Implement**: The firm acquires knowledge resources, executes innovation projects,
  launches innovative products or services and sustains the innovation.

In this paper, the framework of Tidd et al., (2005) is used to guide the data collection and
research approach.

**METHOD**

This paper focuses on digitalization in the real estate sector, an area that is currently in
rapid development and high on the agenda in industry discourse. Thus, a phenomenon-
based research approach is used (Von Krogh et al., 2012), where the overall purpose is to
establish a deeper understanding of a specific - often novel - phenomenon. In this
approach the selection of research methods and theory is driven by the phenomenon,
which means that multiple methods and data sources are often combined (Schwarz and
Stensaker 2016). The present study is based on interviews, industry press and reports,
and observations and informal conversations at industry seminars.

Interviews were conducted with managers responsible for digital development in eight
Swedish large private and public real estate owners. Of these, two were private owners of
commercial property such as retail and offices, four were owners of residential buildings

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(three private and one public), and two were public owners of community service buildings. The real estate owners were selected to represent different categories of property owners in order to gain a holistic overview of the phenomenon. Further, three representatives of real estate industry associations were interviewed. These were selected due to their knowledge and central role in the industry digitalization discourse in Sweden, and are here labelled as knowledge brokers. The interviews took place in fall 2017 and spring 2018, lasted between 45 minutes and 1 hour 45 minutes, and were recorded and transcribed.

The interview guidelines were based on themes identified in the theoretical framework to define a firm's absorptive capacity (Cohen and Levinthal 2000; Zahra and George 2002) and innovation process (Tidd et al., 2005): strategies and routines for sense-making and seeking information, selection of actions taken and planned, and implementation processes. The interview transcriptions were analysed and classified according to these categories, and thereafter interpreted by both authors individually and jointly. Previous research on innovation and innovation management in the real estate and construction sectors was reviewed, as well as research, industry reports and articles in industry press on digitalization in the real estate sector. In order to understand the context in which the owners operate and the signals they are exposed to, the first author participated in four industry seminars.

FINDINGS

The findings are presented as follows: first, the industry discourse on digitalization is described. Then, interviewees' views on how digitalization is affecting the real estate owners' strategies and organizations are presented. This part is organized according to the three phases of in a firm's innovation process identified by Tidd (2005). Finally, the opinions of the industry knowledge brokers are presented.

Context: Industry Discourse

In the last year or two, abundant industry seminars and media coverage have had digitalization in the real estate sector as a main theme, and several industry reports focusing on this sector have been released (Baum 2017; Westergren et al., 2017; Fastighetsägarna Stockholm 2018; Kairos Future 2018). Topics have covered examples from other industries, reasons and motivations for digitalization, specific technological aspects such as the role of big data in the real estate sector, and threats and opportunities related to new actors entering the sector. Also, companies with a background in other fields approach the real estate sector with new service offerings, and the term PropTech (property technology) has emerged to describe a collection of various smart real estate technologies and platform-based sharing solutions (Baum 2017). The new actors are often technology start-up firms and venture capitalists, and some contributors to this discourse claim that such PropTech firms pose an existential risk to real estate firms. For example, at one seminar the metaphor of tsunami was used by one speaker to describe how PropTech firms will eventually disrupt the real estate sector value chain, similar to how Uber and AirBnB have transformed the transportation and hospitality sectors. Comments made during such seminars include views that most traditional real estate managers would be out of business in a few years. Other participants, however, foresee that the implications for the real estate sector will be slower but nonetheless potentially substantial. One presenter used a metaphor of a melting ice cube to demonstrate how real estate owners, unless they find ways to innovate, will slowly lose value to technology firms.
Innovation Search Strategies

In general, the interviewees were highly aware of the industry discourse on digitalization and said that it had influenced their firms and the industry at large and also raised the sense of urgency in their own work. Since the digitalization agenda is broad and uncertainty is high, the interviewees reported that much effort was spent only on mapping the phenomenon. Regarding search strategies (see Table 1), media cover of digitalization was seen as important, and six of the interviewees explicitly mentioned the role of industry seminars. In general, interviewees had mainly approached their traditional networks within the real estate sector, such as the industry associations and contacts in other real estate firms, when seeking for guidance and input on digitalization, but some had been in contact with new sources of information, such as PropTech companies, consultants and suppliers.

Table 1: Innovation search strategies

<table>
<thead>
<tr>
<th>Question</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where and how do firms search new information on digitalization?</td>
<td>Seminars: both traditional industry seminars and PropTech seminars</td>
</tr>
<tr>
<td></td>
<td>Benchmarking in real estate and other industries</td>
</tr>
<tr>
<td></td>
<td>Industry associations and other sectoral actors</td>
</tr>
<tr>
<td></td>
<td>Collaboration with consultants, suppliers and PropTech firms</td>
</tr>
<tr>
<td></td>
<td>Internal workshops, own employees and parent organizations</td>
</tr>
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<td></td>
<td>Hiring new talent</td>
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</tbody>
</table>

Based on this new information acquired, the real estate companies had identified various business opportunities, but interviewees also saw risks in digitalization. For example, new solutions have high uncertainty and there is a risk to invest in technologies that may soon become obsolete. Similar concerns were raised in relation to partners, for example PropTech companies have high risk for bankruptcy in the first years of business. Uncertainty in customer demand for new services was also mentioned, as well as uncertainty related to legal frameworks. Many also shared concerns about data security when investing in new information systems or sharing data with third parties. Most of the interviewees however perceived a need to act somehow, much because they expected that the threat from existing competitors or new entrants would likely grow over time. One interviewee said that the new competition may also be indirect, as for example access to medical services on a smart phone may decrease the need for health care facilities.

Innovation Selection

Despite that many interviewees felt that the process of digitalization was only in the beginning, and that there is much talk and less action, all real estate firms had initiated actions related to digitalization (see Table 2). As interviewees represent different sectors, there was considerable variation in the types of initiatives taken. This illustrates that many aspects of digitalization are highly contingent on type of property and business context.

Some firms prioritized fairly classic and technical aspects, such as information technology-based property management systems and investments in smart building technologies, while others had developed new service offerings to existing and new customers. Also, two interviewees said that the roles had switched in procurement of telecom services, as before they had to pay for the provision of cables, while today they can charge the telecom provider for the access to customers. This indicates that firms are in the process of developing new business models based on their existing customer relationships.
However, the implementation of these digitalization initiatives had not been without struggles. Most interviewees said that they lacked resources or capabilities to work on digitalization activities and that it was hard to find new talents or capable partners to work with. They also found it difficult to manage change within their organizations, mostly due to a conservative business environment.

Table 2: Innovation selection

<table>
<thead>
<tr>
<th>Question</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which digitalization initiatives have been selected?</td>
<td>Smart building technologies (i.e. sensors and energy optimization systems)</td>
</tr>
<tr>
<td></td>
<td>ICT-based property management systems</td>
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<tr>
<td></td>
<td>Smart locks and keys (i.e. smart phone key application)</td>
</tr>
<tr>
<td></td>
<td>Customer service software (i.e. websites, chatbot, mobile apps)</td>
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<tr>
<td></td>
<td>Virtual reality classes for real estate sales process</td>
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<tr>
<td></td>
<td>e-learning systems</td>
</tr>
<tr>
<td></td>
<td>Artificial intelligence-based tenant matchmaking service</td>
</tr>
<tr>
<td></td>
<td>New digitalization-enabled service concepts</td>
</tr>
<tr>
<td></td>
<td>Customer tracking system in retail stores, e-commerce solutions</td>
</tr>
</tbody>
</table>

Implementation: Impact on Innovation Strategies, Processes and Structures

Further, implementation of new initiatives had required changes in the real estate organizations (see table 3 for summary), and all interviewees had recognized some organizational changes in structures, processes or roles in their firms. Almost everyone saw new demands and more workload on business development functions. Digitalization in several cases had led to increased resources for development in the firms. However, resources are still limited, and consequently the companies can only undertake a small number of projects in parallel.

Table 3: Implementation: Impact of digitalization on real estate firms

<table>
<thead>
<tr>
<th>Question</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>How has digitalization impacted firms' structures and processes?</td>
<td>Higher workload for IT departments and development functions</td>
</tr>
<tr>
<td></td>
<td>New business development roles, teams and functions</td>
</tr>
<tr>
<td></td>
<td>Developed digitalization strategies</td>
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<tr>
<td></td>
<td>Increased innovation search activities</td>
</tr>
<tr>
<td></td>
<td>Increased training activities</td>
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<td></td>
<td>Cross-functional development</td>
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<td></td>
<td>Customer orientation (i.e. customer journey)</td>
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<td></td>
<td>New roles for property managers</td>
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<tr>
<td></td>
<td>Established a &quot;digital transformation lab&quot;</td>
</tr>
<tr>
<td>How has digitalization impacted firms' collaborations?</td>
<td>New collaboration projects with industry actors</td>
</tr>
<tr>
<td></td>
<td>Increased collaboration with employees (i.e. workshops)</td>
</tr>
<tr>
<td></td>
<td>New collaboration projects with existing suppliers and consultants</td>
</tr>
<tr>
<td></td>
<td>New collaborations with PropTech startups</td>
</tr>
<tr>
<td></td>
<td>New collaboration projects with owners and related stakeholders</td>
</tr>
<tr>
<td></td>
<td>Increased collaboration with competitors</td>
</tr>
<tr>
<td></td>
<td>Participation in regional development projects</td>
</tr>
<tr>
<td></td>
<td>Interest towards academic research collaboration</td>
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</table>

All interviewees saw that their own role had changed due to higher focus on digitalization activities, and three of them stated that the IT department had new responsibilities. Some had chosen a mainstreaming strategy, where digitalization was seen as "normal business development with a twist". Others had established specific units focusing on digitalization, and some hired new personnel from within and outside of the sector to lead digitalization activities.

Work on digitalization in many cases had created new collaborations and relationships. Digitalization strategies were often developed in cross-functional teams. Many interviewees reported that technology-related projects had previously been done in isolated projects, but that digitalization work had brought new structure to such activities. One firm had set up a "digital transformation lab" that collaborates with other business
areas and serves as a joint development platform. In one case, the role of a property manager had developed into one of a community manager, as the firm had invested in communication platform, where tenants could interact with each other and the facility owner. Several firms had sought for new collaborations with consultants and industry associations, and one interviewee said that they had never before included customers in development activities.

**Views of Knowledge Brokers**

The knowledge brokers from the industry associations perceived the work done on digitalization in real estate sector to be of great importance. At the same time, they had concerns that real estate firms were doing work on digitalization as tick box exercises without fully committing to development initiatives. In their view, some firms initiate digitalization activities without really understanding why and how certain projects would add value in their specific context. They suggested that once firms gain maturity in working on digitalization, they may become better at focusing on the right initiatives. However, they also emphasized that access to sufficient resources and capabilities may limit opportunities. It may be impossible for real estate companies to independently develop new business models, as only the monetary investment may be over their budgets. Thus, disruption may come from PropTech start-up firms or more established technology companies that have resources and capability to invest in digital technologies, such as big data platforms.

**DISCUSSION**

The interviews showed that digitalization is high on the agenda for all interviewed firms. The interviewees recognized various opportunities and threats, and all firms had taken actions in the field of digitalization. The findings clearly show that developing digitalization strategies in real estate firms is a sense-making process, and as an outcome new organizational roles, strategies and structures had been formed. These added resources for innovation search, selection and implementation activities can lead to better absorptive capacity on both firm level and in the real estate and construction industry at large (Cohen and Levinthal 2000), and that is a key determinant for future development in this area.

On the other hand, the interviews show that currently most real estate firms have limited resources for business development, and most interviewees have struggled with project delivery and change management in their digitalization projects. Limited resources may imply that digitalization initiatives crowd out resources from other types of development work. Also, the interviewed knowledge brokers raise a general concern for the quality of the digitalization activities, since firms may take initiatives in this area mainly for marketing and legitimacy reasons and lack commitment to fully engage in development work. Thus, questions arise whether real estate firms can execute innovative digitalization projects in this conservative business environment and if they are able to sustain already launched products and services. Another risk is that existing cognitive and organizational barriers may lead to innovation search strategies that focus only on current business contexts and thus lead to status-quo decisions (Engström and Hedgren 2012; Tidd et al., 2005), but this said, digitalization has raised the awareness about the risks of focusing exclusively on the current business models.

Further, the interviewees reported that as a part of their innovation process the real estate firms had engaged with various information sources and established new relationships to competitors, suppliers and customers. The role of industry knowledge brokers seems
crucial to complement lack of firm resources and facilitate knowledge sharing in this field. As questions in digitalization seem to cross departmental, organizational and industry sectoral boundaries, digitalization affects the collaborations in the industry at large. On the other hand, digitalization enables new forms of indirect competition that may spur from established technology firms and PropTech start-up companies.

CONCLUSIONS

Digitalization has recently emerged as a central theme in real estate sector discourse, and often presented as holding both opportunities and threats to real estate owners. However, is still unclear how actors in this traditional industry will act in this new environment. This research has investigated real estate owners' search strategies and sensemaking in the field of digitalization, as well as their prioritization of actions and implementation processes. Based on dynamic capabilities view, the impact on existing routines, resources and relationships for enabling innovation is discussed.

The findings indicate that development within digitalization has spurred innovation activities within the real estate sector. Initiatives in digitalization have contributed added resources in development functions and also better utilization of firm's existing capabilities through cross-functional and inter-organizational projects and strategy development. This development may potentially have wider implications in raising the level of absorptive capacity for further learning and innovation in the real estate sector. Further, digitalization may act as a catalyst for new relationships and networks, which may potentially have spin-offs in many areas.

This research demonstrates that digitalization in the real estate sector has much broader meaning than previously discussed in literature, which has mostly focused on certain digital technologies, such as BIM (Atkin and Bildsten 2017). As digitalization challenges both real estate firms and other actors in the sector, we suggest that future research should take a dynamic ecosystem perspective. For example, the role of knowledge brokers deserves further attention. Also, any significant organizational and societal change process motivates longitudinal research.

REFERENCES


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BOUNDARY-SPANNING IN DIGITALIZATION: CREATING TRUCES ACROSS TEMPORAL AND OCCUPATIONAL BOUNDARIES

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As digitalization creates changes in temporal and occupational boundaries, it also demands greater collaborative working across these boundaries. This paradox creates a major challenge for the AEC industry. This paper draws on the role of organizational routines in creating truces as a promising theoretical perspective in addressing this paradox. It studies how they enable boundary-spanning work and lessen conflict in the industry. While empirical studies have shown that routines can act as truces, enabling different organizations and occupations to work together (Zbracki and Bergen, 2010), studies of its application in the AEC industry are limited to intra-organizational studies (Cacciatori, 2012). This paper extends this work by drawing on the routines literature to theorize the critical role that routines play in enabling a broader set of interorganizational boundaries to be spanned, temporal and occupational, in temporary organizations. It presents selected field data gathered from two research sites to suggest that organizational routines are being used to develop truces and enable the collaboration needed in digitally-enabled work. In taking a dynamic view of routines, which sees routines as generative in nature and so a source of both stability and change in organizations, these truces are viewed as temporary and their adaptation as ongoing in the situated flow of time.

Keywords: digitalization, boundary objects, organizational routines, truces, conflict

INTRODUCTION

As the pace of technological change accelerates markedly, so the need to create and adopt digital innovations across boundaries is growing. This is necessitated in part by the combinatorial and generative qualities of digital innovations (Yoo, Boland, Lyytinen, and Majchrzak, 2012). Technologies recently introduced to the Architecture, Engineering and Construction (AEC) industry follow this line of thinking. Digital innovations are increasingly ‘unbounded’ in nature, and their use requires collaboration within and between firms (Harty, 2005). While they have the potential to create wakes of innovation across construction supply chains, this promise is only realised when traditional occupational and temporal boundaries are crossed (Boland et al., 2007). Recent research argues that, in contrast to early, policy-driven rhetoric, digital innovations such as BIM demand, rather than create, greater collaboration (Dainty, Lerringer, Fernie and Harty, 2017). In an industry that continues to struggle to work together, despite significant policy initiatives (Lathan, 1994; Egan, 1998; Wolstenholme, 2009), the organizational interoperability needed to create and adopt digital innovations effectively may account, in part, for the slower than expected early rates of adoption of BIM (Bew and Underwood, 2009).

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However, the introduction of new technologies can also create greater conflict and tensions as boundaries between occupations, organizations and project stages change, as revealed in Davies and Harty’s study of the ‘dark side of BIM’ (2012). This has been noted in management literature in general occupational groups (for example Mazmanian, Orlikowski and Yates, 2013; Barret, Oborn, Orlikowski and Yates, 2012). It is also an emerging theme in studies of the AEC industry. For example, the changes wrought on professional roles are particularly notable (Jaradat, Whyte and Luck, 2013). Traditional borders between the groups have become blurred: there is a different configuration of the team (Sebastian, 2011). New occupational groups are being created as BIM is adopted, such as information managers and BIM coordinators. Similarly, digital innovations are changing project processes and their temporal nature (Whyte, Lindkvist and Ibrahim, 2013).

Thus, a paradox is created by digitalization: on one hand, technologies demand greater boundary-spanning work; on the other, they are a potential source of conflict. In an adversarial and fragmented industry such as the AEC industry, this creates a significant potential barrier to realising the potential benefits of digitalization. We turn to an aspect of the theory of organizational routines, namely the metaphor of routines as truces, as a promising theoretical contribution to explore this paradox (Nelson and Winter, 1982). Limited studies in the AEC industry adopting this theoretical perspective indicate its value: by drawing on the metaphor of routines as truces in intraorganisational settings, Cacciatori shows how routines can be used to enable work across disciplinary boundaries (Cacciatori, 2012). Focusing on temporal boundaries, studies show that practitioners use routines to create truces that enable timely collaborative working amongst the teams that comprise temporary organizations (Bechky, 2006). This paper draws on and extends this literature by suggesting how the motivational aspect of routines as truces can be operationalised to enable work across boundaries: both occupational and temporal (related to traditional project processes).

This paper proceeds as follows. Digitalization in the AEC industry is reviewed and the increased need for collaboration, particularly within temporary organizations is discussed. The effects of digitalization on changing boundaries are presented particularly with regards to occupational and temporal boundaries. Routines dynamics and the role of routines as truces are then discussed. Vignettes from substantial empirical data sets of temporary organizations are used to generate conceptual insights into how dynamically changing routines are being used to create the truces needed for digital work.

DIGITALIZATION IN THE AEC INDUSTRY

In this paper, attention is given to the context of use of technology, thus it focuses on ‘digitalization’ as opposed to ‘digitization’. Digitization is understood here as the technical process of “encoding analogue information into digital format” (Yoo et al., 2010). In contrast, digitalization is a more recent term that refers to the wider context into which digital technologies are applied. This is significant in the AEC industry as research shows that adopting technologies is a complex, multi-layered process (Linderoth, 2017).

In the AEC industry, digitalization has been prevalent since the 1950s, apparent in the application of both process and product technologies (Gann, 2000). Its most recent manifestation can be observed through attempts to adopt BIM, a process that demands both software and process changes (Bew and Underwood, 2009). BIM is viewed as an “unbounded innovation” requiring collaboration between many firms for its implementation to be successful (Harty, 2005). The implementation of BIM requires attention to be paid to the interactions within a range of actors and between actors and
technological artefacts (Harty, 2005). An emerging body of research in the AEC industry supports this view of digitalization, finding that the adoption of digital technologies is heavily influenced by its context of use (Linderoth, 2017; Jacobsson and Linderoth, 2010; Harty, 2005). Interoperability between organizations and processes is vital in its use (Eastman et al., 2008). The industry’s resistance to collaborative working has been the focus of a series of policy reports published in the UK (Latham, 1994; Egan, 1998; Wolstenholme, 1998) and subsequent substantial public funding was given to implement the resulting ‘industry improvement agenda’. However, practitioners in the industry continue to struggle to develop the collaborative working practices necessary to realise the benefits of digitalization, as has been evident in ongoing attempts to adopt BIM across the industry (Bew and Underwood, 2009). Collaboration is particularly important in temporary organizations that dominate work in the AEC industry (Winch, 2013). These are commonly established through inter-organizational relationships (Jones and Lichtenstein, 2008) where delimited time influences the organising problem of coordination between the multiple participants (Söderlund, 2012).

If digitalization necessitates greater boundary-spanning work, it also challenges several traditional boundaries. Amongst others, these boundaries are temporal and occupational: they pertain to roles and responsibilities of the team and the processes used within the life cycle stages of the temporary organization. Turning first to temporal boundaries, the dominant mode of organizing in the AEC industry is through temporary organizations (Lundin et al., 2015). Temporary organizations are time limited, meaning they are created anew and given ex ante defined time limits to achieve a certain task(s) (Lundin and Söderholm, 1995). However, the efficacy of the time bound nature of this life cycle model, while not rejected, has recently been challenged by suggesting that it potentially constrains our thinking about the way projects actually behave (Winter et al., 2006).

The traditional processes followed by temporary organizations are changing, as reflected in institutional standards such as the RIBA’s new Plan of Work (2015), published to update the standard project processes followed in the industry to incorporate a digital innovation (BIM). As project processes change, so temporary organizations are creating and adapting their routines within the life cycle model (Zerjav et al., 2018). A theory of temporary organizations shows this clearly: a basic concept within the theory is that of ‘transition’, which can be understood both as the movement, or change, through the project life cycle itself and as the perception of causal relations by the participants (Lundin and Söderholm, 1995). This concept of transition offers the opportunity to explore further the relationship between the temporary and the permanent organization (Jacobsson et al., 2013), specifically their organizational routines which are said to influence the capabilities of the project organization (Davies and Hobday, 2005; Davies and Brady, 2016; Sydow et al., 2004), as well as challenge the ubiquity of the temporal aspects of the life cycle model (Winter et al., 2006).

Turning to occupational boundaries, research shows that these are changed as new technologies are introduced. New technologies disrupt shared frames and power struggles amongst occupational groups become explicit. Organizational and institutional scholars have observed this in a range of empirical studies. For example, Barley’s seminal study of 1989 shows how the introduction of new scanning technology effects the occupational boundaries between radiographer and technicians. Conflict and tension between the two occupations are apparent as they learn to use the new technology; hierarchies’ shift and power struggles are prevalent. Scholars working in the AEC industry have found similar boundary changes in occupational groups. Current efforts to adopt BIM is causing and will continue to cause significant changes in the relationship of
project participants (Eastman et al., 2008). Traditional borders between the groups have become blurred and teams are configured differently (Sebastian, 2011). These role changes are creating conflict between occupational groups who develop different understandings of deliverables and how they are achieved (Hartmann and Fischer, 2007). People use new technologies to reassert professional status and differences, and revisit previous distinctions and divisions (Dossick and Neff, 2010).

**Organizational Routines**

Organizational routines are a central feature of organizations. “To understand routines is to understand organizations” (Becker, 2008:3). Organizations are said to develop their capabilities through the evolution of routines (Nelson and Winter, 1982) and such an understanding has been applied to temporary and project-based organizations within AEC industries (Davies and Brady, 2016). Routines have become to be understood as containing three aspects, the ostensive, performative and the artefact, through which they have been defined as “repetitive, recognisable patterns of interdependent actions, carried out by multiple actors” (Feldman and Pentland, 2003:95). Recent work has identified two different approaches to the study of routines, ‘capability’ and ‘practice’. The former seeing routines as a ‘black box’, with the latter opening the black box to explore inside the routine (Parmigiani and Howard-Grenville, 2011). This paper adopts the practice approach, more recently termed routine ‘dynamics’ (Feldman, 2016).

In emphasising the central role of routines in organizational life, Nelson and Winter argue that routines have both cognitive and motivational functions (1982). One motivational function they discuss is the ability of routines to create truces. Recent studies adopting the dynamic perspective of routines have theorized around this metaphor, showing for example how conflict is both latent and overt, cycling through these stages as truces are built and break down (Zbracki and Bergen, 2010). Salvato and Rerup (2018) look at how regulating actions within single organizational routines are used to achieve conflicting goals, not through removing goal conflict and creating a stable truce, but by understanding routines as process, and so achieving a dynamic truce where conflicting goals are achieved. Such an orientation calls for a more distributed agency perspective, wherein different organizational members at different levels of the organization contribute to the situated action of routine enactment.

The role of artefacts is central to the practice perspective of routines and are attracting significant researcher attention (D’Adderio, 2008). Artefacts both influence and represent the ostensive and performative aspect of an organizational routine (Pentland and Feldman, 2008), either as proxies for the ostensive aspect of the routine or as material entities such as computers and physical space for the performative aspect of the routine (Parmigiani and Howard-Grenville, 2011). Types of artefacts, called boundary objects, have attracted scholarly attention for their ability to work between boundaries (Star and Griesemer, 1989). Cacciatori’s study of change in a major AEC firm builds a longitudinal process study where the evolution of a technological artefact - an Excel spreadsheet - developed to afford the creation of a new routine - a bidding process in an engineering consultancy (2012). Cacciatori uses the metaphor of routines as truce (Nelson & Winter, 1982) to explore the politics and conflicts inherent in problem solving and the creation of a new routine. She finds that the company was only marginally successful in restructuring its bidding process because of struggles for occupational dominance (Cacciatori, 2012).
METHODOLOGY AND METHOD

We draw on selected episodes that demonstrate how routines create truces that enable collaboration across temporal and occupational boundaries in the AEC industry. These episodes are drawn from substantial data sets collected separately by the authors but that share sufficient commonalities to allow data analysis. Precedents for pooling data in this way are found in Harty and Whyte (2010) and Bechky and Okhuysen (2011). In the former paper, they combine data collected separately on one construction megaproject and use their combined data set to identify the hybrid practices evident across the project. In the latter, Bechky and Okhuysen’s study of organizational surprises draws together data from two settings in which ‘uncertainty was pervasive’, in their case SWAT teams and film crews. Our data sets shared a similar commonality. As we worked separately on our field-based research projects and provided input into each other’s work, both of us developed a theoretical interest in organizational routines and their significance in enabling boundary work, both occupational and temporal. We discussed extensively how occupational boundaries were changing, often due to digitalization, leading to conflict amongst occupational and professional groups. We observed how digital tools were changing, and changed by, the nature of temporal boundaries.

The researchers employed similar approaches to collecting data, both used intensive data collection methods, and draw on data sets collected at similar times. The researchers also used the same theoretical perspective - the practice perspective of organizational routines - to analyse the data. However different levels of analysis (firm and temporary organization) and research sites were used. The first author was embedded (as a researcher, not employee) in an organization, known as Design Partnership, for 15 months while it was adopting a digital innovation. During this time, she collected data using participant observation methods which drew on semi structured interviews (54 were conducted in total), archived documents, internal meetings and seminars and extensive field notes. Similarly, the second author also undertook an intensive single case study (Yin, 2014; Eisenhardt and Graebner, 2007), using organizational-auto-ethnographic inquiry methods (Parry and Boyle, 2009; Doloriert and Sambrook, 2012) as he project-managed the stage gate transition of a major infrastructure project, London Underground’s Bank Station Capacity Upgrade project, from design to construction. Data collection was undertaken over a 53-week period commencing in July 2015 and completed in June 2016. During this time, the author collected some 175 hrs of audio recording of meetings, 79 interviews and an autoethnographic diary which exceeded 170,000 words.

As both researchers theorised their data using the practice perspective of organizational routines, it became apparent that both data sets were showing the dynamic process of adapting organizational routines. In turn these served as ways in which actors could address the conflict and create truces so boundary work - both temporal and occupational - could be addressed. We follow Harty and Whyte in our initial data analysis in presenting ‘vignettes’ from the data to illustrate emerging findings. These vignettes illustrate a dynamic process of routine adaptation created truces and addressed latent and overt conflict.

EMERGING FINDINGS

Selected examples of changing boundaries in both research sites are presented, as summarised in Table 1. Firstly, one illustrative episode of how digitalization was created changing occupational boundaries and the temporary truce that was created is presented. This example relates to the role of the engineer and technician. Traditionally the
relationship between engineer and technician is a very hierarchical one: the engineer has a high status acquired through the virtue of considerable professional training. The technician adopted more of a support role. The engineer would create the design and the technician would then translate this design (often paper based) into a digital model. However, this was changing across the organization as modelling became a more highly valued skill, the technician gained considerable status and sometimes took on more of the engineer’s role. A member of the Project Media team commented that there had previously been a ‘Berlin Wall’ between the technician and engineer, but that as the use of BIM became more widespread, technicians were increasingly working on design problems that were previously the domain of engineers:

Now technicians are greatly improving their knowledge of buildings - they’re asking engineering questions and getting more involved in project management roles.

This tension was evident in the firm’s work on ‘Project Media’. This project was the first time in which all the engineers were required to work directly into a 3D digital model. Previously this work had been performed by technicians. The engineers had relatively little experience in 3D modelling. Consequently, the engineers became reliant on the technician’s skills and expertise to help resolve issues or problems that they were regularly encountering. In this project, substantial initial conflict between the engineer and technician was temporarily resolved to deliver the demanding time schedule required by the client through a routine that allowed engineers and technicians to work together. The routine specified how and when consultation between the two would occur. The performance of this routine was adapted by the engineer and technician involved and the project stage requirements. Thus, a temporary truce was created that enabled collaboration between the two occupations.

In the Bank Station Capacity Upgrade project, the time boundaries (life-cycle) for the project had been established within the corporate governance authorised by the client organization and so the time bound transition from design to construction had subsequently been encoded in the contract (artefact) between the client and the contractor. The contract stipulated a single design ‘compliance’ submission, with overhead and profit paid on the client’s regulatory approval of the single design submission. Necessary design changes emerged that had the potential to create a conflict through a delay to the full design compliance approval and hence impact the ex-ante defined date for transition into construction and the resulting regulatory and commercial alignment that had been set down in the contract.

The project had implemented a BIM strategy with a central digital model of the design and associated quality and clash detection processes to build up a 3D model of the underground station and its associated asset configuration, supported by a Product Breakdown Structure (PBS) that aligned with the projects Work and Cost Breakdown Structures (WBS, CBS). The PBS and centralised digitization of the design process enabled the team to adapt the ongoing routine of a single design compliance submission into five separate submissions, supported by the realignment of the work and cost profile of the project in a timely manner. This dynamic and coordinated adaptation of the routine, in the situated flow of time, through the adaptation and realignment of artefacts created a truce by keeping the commercial and regulatory goals of both parties aligned. A new artefact was produced - design compliance strategy - that acted as a proxy for the ostensive aspect of the routine during its adaptation through the transition and across the time boundary, with the ongoing development of the design through the BIM model being the performative aspect of the routine.
**DISCUSSION**

The main contribution from the data presented here suggests that practitioners in temporary organizations in the AEC industries are using the adaptation of organizational routines to overcome conflict and create truces that enable boundary-spanning work. The selected vignettes presented suggests that organizational routines have a significant role in creating a truce that enables the collaboration demanded by novel digital technologies to take place and offers an opportunity to realise the potential benefits that digital technologies can offer to enhance collaborative practices (Dainty et al., 2017). The boundaries discussed in this paper relate to occupations and time. Occupational boundaries are changing substantially with digitalization and becoming increasingly prevalent sources of conflict. Roles are developing and professions are changing. In the pressurised environment of temporary organizations, truces are used to create a framework within which practitioners work together to achieve the delimited goals of their role within the temporary organization. Thus, the predetermined date to transition from design to construction can be achieved. The digital environment created by BIM allowed for clarity of data in its separation and repackaging without significantly disrupting accountabilities for separate packages of the processes associated with digitisation of design and design management.

Our data supports existing research that finds that in the AEC industry, digitalization is changing occupational and temporal boundaries and is thus a potential source of conflict. It also supports the view that digital innovations demand increased boundary work and the development of collaborative working practices (Harty, 2005; Dainty et al., 2017). The dynamic view of routines suggests that these organizational routines are generative in nature and so influence both stability and change: routines can create truces at boundaries, but the potential for conflict is always present. Like Zbracki and Bergen (2010) we find that conflict is overt or latent and that routines can act to make overt conflict latent. The ever-changing and complex nature of digitalization means that routines must be adapted in order to (re)create new truces. This is particularly important in the temporary organisations that dominate the AEC industry where truces enable predetermined goals to be achieved.

In addressing this growing issue for the industry, theorising from the organizational routines perspective, drawing on the motivational aspects of routines as truce, seem a promising avenue. From an occupational perspective, it offers the opportunity to further explore the ‘network role’ of project actors in the digitalization of temporary organizations in AEC industries and ask questions of how, and for what function, actors are contracted for in these types of organizations (Pryke, 2017). In addition, from a temporal perspective, asking questions about ‘how’ organizational routines are adapted as
they transition across ex ante defined time limits offers the opportunity to explore alternative images of the project life cycle model (Winter et al., 2006).

REFERENCES


RECONCEIVING MULTIDISCIPLINARY COLLABORATION FOR MANAGING DESIGN
DESIGN COLLABORATION AS ORGANISATIONAL
SENSE-MAKING AND SENSE-GIVING

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Construction design has largely been pictured as a fragmented effort that is prone to ineffectiveness due to its multi-disciplinary and multi-organizational nature. As a result, design management is traditionally considered to be focused on adjusting and integrating disparate disciplinary contributions with the intention of overcoming consequences of this fragmentation. However, existing empirical work reveals that design in construction does not develop through such adjustment and integration of separately created discipline-specific parts, but rather as a whole through interdisciplinary interactions which present a continuous path of unfolding decisions and activities. This paper will argue that, for the purposes of design management, multidisciplinary construction design can be viewed as an organisational endeavour; thus, suggesting a shift away from management centred upon design outputs to management centred upon design interactions. Based on this argument, interdisciplinary interactions from the practices of a construction design project are analysed using an ‘organisational sense-making’ perspective which is originated in organisational studies. When seen from an organisational sense-making perspective, the problematic issues of disciplinary and organizational fragmentation and integration become reformulated as issues of sense-giving and sense-making among various design stakeholders that are part of the same organisational whole. Under this perspective interdisciplinary interactions are not seen as the means for design integration that imply compromises for discipline-specific design solutions. Rather they are the means for sense-giving and sense-making to continuously redefine the organisational direction, thereby continuously reconfiguring discipline-specific tasks in a consistent and coherent manner. As a result, an organisational sense-making perspective enables conceiving the fragmentation in construction design as a productive force. Ultimately, the paper provides fresh insights into design collaboration and management. It concludes that fragmentation is not something to be ‘resolved’ through simplistic measures of integration, such as design data integration, but it is rather something that needs to be ‘cultivated’ through raising an explicit awareness of the means and processes of sense-giving and sense-making.

Keywords: collaboration, design management, organisational analysis, sensemaking

INTRODUCTION

Design is developed through iterative trials of ideas and potential solutions in the face of unfolding and unpredictable design challenges. Hence, the direction of design process depends on design stakeholders’ perceptions, as well as inferences, regarding the outcomes of these ongoing trials (Dorst 2011). For this reason, the concept of ‘sense-making’ (Klein et al., 2001) has been used in design research to conceive design as the result of the perceptions and inferences of design stakeholders (Krippendorff 1989; Kolko 2010; Johansson-Sköldberg et al., 2013; Manzini 2015). Nevertheless, importantly, design is an inherently social endeavour (Luck 2012), and the perceptions and inferences

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of design stakeholders regarding ‘what is going on’ are not only influenced from their individual backgrounds and sensory/cognitive experiences but also from the immediate and wider organisational environment within which they operate.

For this reason, the present paper will argue that drawing on ‘organisational sense-making’ literature (Maitlis 2005; Weick et al., 2005) is promising particularly for better comprehending design collaboration, and thus for improving overall management of multidisciplinary design in construction, and elsewhere. When seen from an organisational perspective, sense-making is an ongoing intersubjective accomplishment, for which the sense given by the counterparts of interactions become critically determinant (Gioia and Chittipeddi 1991). Ultimately, as will be shown in this paper, the notions of organisational sense-giving and sense-making highlight the productive nature of multiplicity of disciplines and organizations in construction design, instead of picturing organizational and disciplinary fragmentation as a problem that needs to be resolved through simplistic measures of integration, such as design data integration.

To this end, this paper considers a construction design project at its detailed design stage. The project is analysed from an organisational sense-making perspective through a consideration of its organisational context as well as two events from its practice that exemplify how sense-giving and sense-making are accomplished through interdisciplinary interactions. The discussion of the findings reveal that an organisational sense-making perspective sees disciplinary and organizational fragmentation as something that needs to be ‘cultivated’, as opposed to the traditional understanding that it needs to be ‘resolved’. This provides an alternative managerial framework for multidisciplinary design, which suggests focusing on interdisciplinary interactions rather than design outcomes, hence shifting the attention away from simplistic measures of integration to strategic organisational management. It is concluded that further organisational studies of design must be undertaken to develop practically-relevant and productive understandings of multidisciplinary design and design collaboration in construction, and elsewhere.

**Organisational Sense-Making and Design**

As stated by Lundgren-Henriksson and Kock (2016: 20) “sense-making focuses on the individual and collective activities of meaning production, which direct action and interaction”. Significant in this statement is the emphasis on the role of sense-making as the determinant of subsequent ‘action and interaction’ because it provides a particular definition of organising. According to Weick et al., (2005), from a sense-making perspective, organising is the response to “an ongoing, unknowable, unpredictable streaming of experience in search of answers to the question ‘what is the story?’” (410). This response involves “turning circumstances into a situation that is comprehended explicitly… and that serves as a springboard into action” (Weick et al., 2005: 409).

Hence, according to the authors, in the flux of events, plausible stories animate and gain their validity from subsequent activity; thus, enacting a sense of continuity and coherence over time, which makes the essence of an organisation.

Based on this definition, it can be argued that ‘organisational sense-making’ perspective is well-aligned with the practice of design. This is because central to both is the coherence and consistency achieved in an unknowable environment through an unfolding series of action driven by a judgement of the plausibility of alternative courses of action. Hatchuel at al. (2018) emphasise the centrality of ‘unknowability’ of design exploration process claiming that it is the ‘unknowability’ that enables generativity inherent to design. Besides, it is well-established in design research that designers navigate through
 unknowability by evaluating the plausibility of potential courses of action with the help of, for example, material design artefacts like drawings (e.g. Ewenstein and Whyte 2009) and/or verbal “what if” conversations (e.g. Bucciarelli 1994). Additionally, in line with organisational sense-making perspective, there is a wide agreement in design research that design process is path-dependent, or in other words, it is continuously unfolding and becoming through a path-dependent series of actions and knowledge accumulation (e.g. Dorst and Cross 2001; Hatchuel and Weil 2009; Dossick and Neff 2011). Consequently, it can be argued that organisational sense-making and the practice of design are conceptually coherent; and therefore, analysis of design practices from an organisational sense-making perspective can yield valuable organisational and managerial insights.

In the case of multidisciplinary design, such an analysis would benefit from a joint consideration of the complementary notions of sense-making and sense-giving, as the two notions can be used as an analytical structure to explain interdisciplinary interactions. According to Gioia and Chittipeddi (1991), sense-giving refers to the attempts for “influencing the sensemaking and meaning construction of others toward a preferred redefinition of organizational reality” (442). Sense-making and sense-giving are not distinct domains like two sides of the same coin but rather one implies the other and cannot exist without it (Rouleau 2005). Therefore, several scholars have pictured sense-giving and sense-making as the two drivers of a constructive process (Currie and Brown 2003) through which people create and maintain an intersubjective world (Balogun and Johnson 2004). Maitlis and Christianson (2014) emphasise that sense-giving is not simply a top-down process as the recipients have their own interpretations, and also that they may be engaging in sense-making processes outside a given organisation which in turn might influence their sense-making in that organisation. Hence, unintended consequences of sense-giving are reported in the literature, for example, in the area of strategic organisational change (Balogun and Johnson 2005). Nevertheless, no matter whether it is intended or not, the collectively created organizational world (i.e. through sense-giving and sense-making) determines the space of meaningful actions and interactions for those who operate in it, thus enabling (encouraging) and disabling (discouraging) certain courses of actions (Weick 1995). It is this aspect of organisational sense-making perspective that makes it useful for organisational and management research, as it provides an explanation of how existing organisational routines and outcomes are created and maintained as well as what would it take to change them.

**METHODOLOGY**

The perspective of organisational sense-making (Maitlis 2005; Weick et al., 2005) can provide a useful conceptual ground to comprehend the process, potential and outcomes of design collaboration, thus providing an alternative managerial framework for multidisciplinary design. According to this perspective, multidisciplinary design is a process of (reality) construction by professionally fragmented entities that engage in sense-giving and sense-making activities through interdisciplinary design interactions. This implies that the effectiveness of design collaboration relies on the effectiveness of the means and processes of sense-giving and sense-making. In return, such an understanding of design collaboration enables a new perspective for managerial evaluation and possible managerial interventions, which will be demonstrated through the analysis of the findings from a construction design project.

Empirical data are collected from a construction design project as part of a larger research. The project was in the UK, and it was at its detailed design stage. The author observed 23 meetings (each 1 - 1.5 hours long) over a period of ten months including
design coordination meetings, one-off design coordination workshops as well as clash detection and information model coordination meetings. Audio and video recordings were not allowed. The observational data were recorded in the field notes, and the reflections on these were supported by five semi-structured interviews and several informal communications with the participants of the observed meetings. The analysis aimed to establish the effectiveness of sense-giving and sense-making means and processes. Hence, particular attention is paid to the agreements and disagreements among multiple design stakeholders during their interactions as well as the unfolding actions resulted from these agreements and disagreements. Following from Cipolla and Reynoso (2017), two different levels of organising that affect sense-giving and sense-making are jointly considered for such an analysis. These are (i) wider organizational context, and (ii) practice-level situations of interdisciplinary interactions. A joint consideration of these two levels enhances the rigour of the analysis by including the effects of both contextual and situational aspects of the observed phenomena. The results of the analysis are then discussed to develop insights into multidisciplinary design collaboration and management.

FINDINGS

This section is divided into two parts reflecting the findings related to two levels of organising in the studied project. First part presents an overview of the wider organizational context in order to set the interpretive background of the analysis. Second part presents two events from the practice of interdisciplinary interactions and their respective brief analyses.

Organisational Context of the Project

This was a ‘design - and - build’ educational building project, and therefore, the main contractor had the main financial and design risks of the project. Design was first developed to the level of detail needed for appointing the main sub-contractors with design responsibility (i.e. the construction proposals were prepared, and the design was developed to RIBA Stage D - design development) under the coordination of the main contractor. This initial period of design development mainly involved mechanical and electrical engineering (M&E) consultant, the structural engineering consultant, and the architect. The researcher started to observe the project after M&E sub-contractor was appointed to take over the design and installation of M&E works for the project. However, even after M&E sub-contractor was appointed, M&E consultant stayed on board as a consultant for the client.

The design saw a significant change after RIBA Stage D, during which most of the fundamental decisions regarding building systems and main areas of the design had already been made. The client asked to increase the indoor space in the building, and this had serious implications on the design. M&E sub-contractor that was appointed after initial design struggled to navigate through the existing design to further develop the M&E design, particularly after this significant design change which required alterations to the initially established design strategies. Therefore, issues related to the further development of M&E design occupied a substantial amount of the time during the observed interdisciplinary design meetings. These issues were mainly about clarification requests from M&E sub-contractor regarding the thinking behind the initial design as well as complications that arose due to the late design change, which were unexpected to the entire design team.
Event 1:
During one of the design coordination meetings (DCM), the representative of the M&E sub-contractor stated that the revised ventilation calculations, which were based on the revised design and occupancy rates, revealed that on one of the floors few doors needed to have transfer grilles to satisfy the ventilation requirements. The representative of the architect rejected this as soon as it was proposed. Following the rejection, the representative of the M&E sub-contractor provided the results of the ventilation calculations together with the story of the changing occupancy rates due to the revised design. After this explanation, the representative of the architect still insisted that having grilles on the doors in that area was not an option. The representative of the M&E sub-contractor accepted his objection, and stated that they would think about something else. After a short silence, the representative of the architect stated that the wall between those doors would be painted to the same colour as the doors, and therefore they would not want to have grey transfer grills on the doors. The representative of the architect concluded that he would have a look at the issue, and think about it until the following DCM. In the following meeting, the representative of the architect stated that the actual number of the doors that needed to be equipped with grilles was much more than he anticipated. He stated again that the grilles were not visually good and asked other members of the team whether it was possible to omit them. One of the alternative ideas appeared as undercutting the doors. During the discussion of this option the representative of the architect stated that they needed to communicate the size of undercutting to the manufacturer, and also to make sure that the doors had not been produced and packaged yet. The representative of the M&E consultant added that the original intent was not having that many transfer door grilles on the doors at that area as part of the ventilation strategy. In parallel with the discussion of undercutting the doors, the representative of the architect asked the colour range of grilles, and even the option of painting the grilles on the site was discussed as a potential solution. However, the latter proposition then was found non-viable thinking about the long-term maintenance requirements. Finally, the parties decided to have another look at the occupancy rates and the assumptions that underpin them.

In this event the M&E sub-contractor engages in sense-giving that goes beyond the statement of problem to the statement of a potential solution: adding transfer grills to several doors. This whole initial sense-giving is constructed on the backdrop of the increase in the occupancy rates due to the design change, which has already been known as causing several disruptions to design development. Arguably it is for this reason that initially the proposed solution of using transfer grills went unchallenged and the negotiation revolved around minor amendments to the solution proposed by the M&E sub-contractor. In other words, the reality that has been constructed in the project suggested that complications are unavoidable due to the design change and design stakeholders made sense of these as 'normal' problems that needed to be accommodated in a way or other. This determined the organisational dynamics as the sense that was initially made largely determined further sense-giving by various stakeholders; and thus, leading the designers to consider even reorganising the supply of the doors or grills by undercutting them or painting them on the site respectively. It is only after substantial amount of time and negotiations that a wider perspective was adopted and the underpinning occupancy rates were decided to be scrutinised.
Event 2:

During a DCM towards the end of the observation period, one of the representatives of the M&E sub-contractor raised the point that there were no services designed to feed the video pod in the atrium area. He argued that it was neglected in the initial design that was handed to them, and that it was not mentioned in the service strategy of the building which was part of the construction proposals. He started to ask about the design intent of this pod and its mechanical and electrical service requirements. The discussion revealed that the pod was originally designed by the architect to create an interactive experience for the students. It was planned to be a small, self-contained structure with a large screen and a bench in it. Upon this initial information, the representative of the M&E sub-contractor inferred that it needed to be ventilated and equipped with a power outlet. Nevertheless, the M&E consultant stated that the name ‘video pod’ sounded like it required a special acoustics performance that needed to be satisfied but she could not remember, and therefore, she asked for this issue to be included as an agenda item for the following DCM. In the following DCM, the representative of the M&E consultant stated that she could not find any information regarding the acoustics needs of the pod, and she therefore needed to contact the acoustics specialist to ask whether any particular acoustics requirements were assigned for this pod. However, it was known from previous experience that the acoustics specialist had completed her job in the project long ago and was unwilling to devote further effort to this project. On the other hand, acoustics requirements of the pod became an issue mainly because of its ventilation requirement. The only way to ventilate the space was to install an independent fan in the pod and this would cause noise. Furthermore, the opening required to fit the fan would cause the noise in the atrium to enter the pod. After a discussion around acoustics implication of potential ventilation solutions, it was decided to contact the client to understand what exactly the pod would be used for to understand whether there were special acoustics requirements for the pod. In the following DCM, the representative of the M&E consultant stated that she contacted the representatives of the client and learned that the space was planned to have an interactive space between the educational institution and students but no specific activities for the pod were known at that moment. She further stated that she proposed to change the name of the space from ‘video pod’ to ‘diary pod’, and this was accepted by the client. She stated that changing the name of the space to ‘diary pod’ surely eliminated the possible high acoustics requirements of the space and therefore it was fine to proceed with an individual fan for the ventilation of the space.

In this event, the name of a building element (i.e. video pod) played a significant role in sense making of design stakeholders, and thus determined the direction of interdisciplinary interactions. This was partly because the design of the element was neglected, and there was not much cue to draw upon at the time it was noticed. Based on the name ‘video pod’, various design stakeholders gave sense regarding the potential functions and service needs of the element triggering further sense-making activities, and leading to a certain framing of the issue in hand. Interestingly, the resolution is achieved through a reconsideration of the initial cue at hand, the name of the element. According to the design stakeholders, the new name of the element that is approved by the client relaxed the functional and service requirements of the element by enabling a novel story and reality about the element. Overall, organisation of the work to tackle the issue reflected the particular framing of the issue, which was constructed gradually through sense-giving and sense-making based on the contextual and immediate cues at hand.
DISCUSSION
Design collaboration is under-theorised and the term is being used to mean different things by different studies in construction management research. Additionally, design management in construction predominantly assumes that organisational and professional fragmentation in the industry is problematic, and hence, the current focus of multidisciplinary design management is on integrating various parts of design produced by different design stakeholders. Nevertheless, the practice of design suggests that design develops through inextricably intertwined day-to-day interdisciplinary interactions, which present a continuous path of unfolding decisions and activities. Therefore, new perspectives are required to focus on ‘cultivating’ the fragmentation, rather than ‘resolving’ it, and this requires building design collaboration and management theories upon the unfolding interactions of design stakeholders.

Organisational sense-making perspective provides an adequate lens for such an endeavour, and suggests that multidisciplinary design collaboration can be seen as organisational sense-giving and sense-making through which a joint reality is constructed among design stakeholders. Hence, in the following, first design collaboration will be unpacked from an organisational sense-making perspective. Then, the implications of adopting such a perspective for design management and technology will be discussed.

**Design collaboration as organisational sense-making and sense-giving**
Organisational sense-making perspective provides a useful vocabulary and lens to comprehend design as the result of inextricably intertwined interdisciplinary interactions, thus enabling practically relevant theories of multidisciplinary design and design collaboration. As the analyses suggest, when this perspective is adopted, disagreements in practice are not understood as competing technical and/or aesthetic priorities or concerns of various design stakeholders. Rather, they either refer to missing/forgotten parts in the shared past (i.e. shared story) of design stakeholders which needs to be constructed through sense-giving and sense-making; or different interpretations of the previously constructed story of design (i.e. shared past) that needs to be reconstructed, again through sense-giving and sense-making. However, this can be a very challenging task because the developing (story of) design is fixed in different material forms (i.e. drawings, calculations) and design decisions (e.g. calling an element ‘video pod’) which limit the subsequent sense-giving and sense-making activities. Hence, problematic situations arise when design stakeholders deal with missing or different stories about certain aspects of the design especially when these are combined with conflicting or missing sense-making cues (i.e. in the form of material design objects and/or previous design decisions made by various design stakeholders).

Overall, adopting an organisational sense-making perspective enables a novel interpretation of interdisciplinary design interactions that is in line with the practice of designing. Thus, it enables a novel avenue for building practically-relevant theory on design collaboration. Different in this perspective is the emphasis on the productive force of organisational and professional fragmentation inherent in the construction design. As discussed above, when seen from an organisational sense-making perspective, disagreements and struggles are not about adversary beliefs and stances strictly held by design stakeholders but they are rather about the difficulties regarding sense-making and the organisational inefficiencies that result from them. Importantly, under this perspective, design is not accomplished through creative problem solving of designers. Rather, it is accomplished through jointly constructing a reality, or in other words a shared story of design, as well as the ability of navigating in this story through a skilful
use of various sense-giving and sense-making means and processes. It is in this sense that this perspective sees organisational and professional fragmentation in construction design as a productive force. Hence, it suggests moving away from the fragmentation-integration dichotomy, which problematises fragmentation and leads to simplistic measures of integration in order to enable design collaboration.

**Organisational sense-making perspective for enabling design management**

Adopting an organisational sense-making perspective has also implications for the technologies and approaches for facilitating and managing multidisciplinary construction design. In terms of design management, most importantly, this perspective suggests a practice-based, interventionist management approach that shifts the focus away from integrating design outputs to facilitating interdisciplinary design interactions. Although previous descriptive studies of design similarly suggested a focus on design interactions for effective management of design, these have fallen short in providing a conceptual and/or theoretical basis to undertake systematic analyses to build theory on design management. Organisational sense-making perspective can fill this gap by enabling a new level of granularity to understand the complex and iterative interdisciplinary interactions, thus enabling comparable analyses of design practices as well as theory building.

A managerial focus on facilitating interdisciplinary design interactions suggest that the inherent fragmentation in the construction industry is not something that needs to be 'resolved' through measures of integration that tend to be simplistic due to the temporary nature of construction teams. Rather, it is something that needs to be 'cultivated' through establishing an awareness of (i) design collaboration as an unfolding process of sense-giving and sense-making; and (ii) means and process of sense-giving and sense-making. Therefore, when an organisational sense-making perspective is adopted, a major issue in design management becomes establishing the organisational capability of identifying and using the adequate sense-giving and sense-making means and processes in addition to creative problem-solving tools and processes. Previous empirical and theoretical work on organisational studies can provide a fruitful starting point to think about how such a capability can be established at various level of organising including project-, firm-, and industry-levels.

Finally, an organisational sense-making perspective on design has also implications for support technology development for multidisciplinary design. According to this, the primary concern of these technologies must be facilitating sense-giving and sense-making processes during interdisciplinary interactions, rather than supporting creative problem-solving and/or integrating different parts of design developed by various design stakeholders. Currently, the focus of design collaboration and management software is based on the traditional view of design collaboration, and thus, aiming to eliminate the fragmentation through technological measures, such as digital data integration. However, previous empirical work revealed that (i) in many cases this alone does not deliver the expected benefits; and (ii) in cases where the social aspects of technology implementation are overlooked, such measures can even be harmful for multidisciplinary design collaboration (Dossick and Neff 2009; Çıkik et al., 2017). As this paper exposes, simplistic integration measures, such as the integration of digital design data and/or design outputs through digital technologies, are based on inadequate understandings of fragmentation and collaboration in construction design. Therefore, technology developers for construction design must work with construction management researchers in order to develop technologies that are based on a more practically-relevant and productive understanding of fragmentation. Such technologies should primarily help
cultivating the fragmentation to improve design collaboration rather than resolving it through simplistic measures of integration.

CONCLUSIONS

Professional and organizational fragmentation in construction design have widely been pictured as problematic. As a result, majority of research and practice on design collaboration and design management focus on adjusting and integrating disparate disciplinary contributions with the intention of overcoming consequences of this fragmentation. However, the practice of design suggests that design is developed through ongoing interdisciplinary interactions that continuously configure discipline-specific work. Therefore, the present paper proposed adopting organisational sense-making perspective to capture this continuous co-construction process. Such a perspective suggests that design collaboration can be seen as organisational sense-giving and sense-making, and thus, implying that fragmentation is not inherently a negative thing, but can be seen as a productive force that needs to be 'cultivated' rather than a problem that needs to be 'resolved'. This shift in the understanding of 'fragmentation' introduces a new mindset and priorities for design management and technology, through which current challenges of multidisciplinary design in construction, and elsewhere, can be addressed. More research should adopt this perspective to develop theory on design collaboration by theorising the means and processes of sense-giving and sense-making in multidisciplinary design. Also, the practice of design collaboration and design management should focus on cultivating fragmentation as an organisational capability rather than focusing on resolving it through simplistic technological and/or structural measures.

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INTEGRATION AND COLLABORATION FOR SUSTAINABILITY
PROCUREMENT TACTICS FOR SELECTING SUITABLE CONTRACTORS FOR COLLABORATION AND LONG-TERM RELATIONSHIPS

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The construction industry has increasingly embraced collaboration and long-term relationships (CLR) practices in recent years. Nevertheless, most people have been trained and accustomed to the traditional approaches. There is limited understanding when it comes to how clients should go about procuring suitable contractors for CLR despite significant roles contractors play to the success of projects. Since it is not all contractors that are suitable for CLR, this study empirically investigates the procurement tactics that clients are employing to select suitable contractors for CLR in the construction industry focusing on framework contracts. Data was collected through semi-structured interviews with eight organizations employing framework contracts in South Africa. The findings show that the organizations are employing many tactics generally aimed at vetting contractor's background behaviour and past performance; in addition to getting closer in meeting and talking face to face with the potential contractors to observe and assess their suitability for CLR. Some of the tactics employed to achieve this include: conducting interviews with potential contractors, conducting training and workshops, asking for CV's of key participants, top management involvement consideration, and vetting of potential contractors via a contactable reference of past jobs. Other tactics include holding competitive negotiation/dialogue process and meetings with potential contractors. The result of the study provides insight on the procurement tactics to adopt in selecting suitable contractors for CLR in practice, especially among new adopters of CLR strategies.

Keywords: collaboration, framework contracts, long-term relationships, procurement

INTRODUCTION

In recent years there has been increasing interest in collaboration and long-term relationships (CLR) in the construction industry. The influence of the Latham 1994 “constructing the team” and Egan 1998 “rethinking construction” UK construction industry reports together with other construction industry reports from Hong Kong, New Zealand, and Singapore are attributed to have influenced the rising trend of CLR practices in the construction industry (Kamudyariwa et al., 2018; Donohoe and Coggins 2016). Strategies that internalize CLR in construction are partnering, alliance contracting and framework contracts (Ayegba et al., 2018). While partnering and alliance contracting can also be used for once-off project-based strategies, a framework contract is mainly intended for long-term relationships (Joint Contract Tribunal 2011). Therefore, framework contracts represent an excellent strategy to examine with regards CLR.

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The international standard organization (ISO 10845-1 2010) defines a framework agreement as an agreement between an employer and one or more contractors, the purpose of which is to establish the terms governing contracts to be awarded during a given period, in particular regarding price and, where appropriate, the quantity envisaged. Watermeyer (2013) in his article 'unpacking framework agreements for the delivery and maintenance of infrastructure' submits that construction clients can develop collaborative procurement relationships with their construction partners and supply chains for long-term gain through framework contracts. Therefore, framework contracts create an environment in which clients and contractors can work collaboratively together for a long-term in delivering several projects, in contrast to the adversarial and short-term contracts in traditional approaches. From previous studies, CLR is indicated as a vehicle to maximize value, levels of quality, service delivery and operational efficiencies (Khalfan et al., 2014; Meng 2013; Frödell 2011). A central area of concern is the selection of suitable contractors for CLR. Particularly as it is not all contractors that are suitable for CLR owing to the level of commitment, teamwork, flexibility, mutual trust, integration of project team members, and information sharing essential to achieve greater success in CLR practices. This shows that there is a need for different procurement tactics for selecting contractors for CLR, as the use of traditional approaches is not likely to yield the expected outcomes. This is because the technical and functional evaluation of contractors which focuses on hard criteria such as time, quality and price only as emphasized in traditional approaches will be inappropriate to cover all the issues upon which to select a suitable contractor for CLR (Kadefors et al., 2007). Procurement tactics are in effect a tool for identifying a suitable contractor during the tender process and managing risks during the execution of a contract (National Treasury Department 2016). Such tactics are aimed on the selection of a contractor who is most likely to deliver the best value through the performance of the contract, life cycle costs of what is offered, the availability of spares, operation and maintenance requirements (ibid). Little research has been done to examine the procurement tactics employed by clients to select suitable contractors for CLR effectively. Therefore giving the importance of contractor selection to the success of every project (San Cristóbal 2012; Doli 2009; Singh and Tiong 2005), this study aims to investigate the procurement tactics clients are employing to select suitable contractors for CLR in the construction industry.

RELATED LITERATURE

Contractor Selection for CLR

Coping with the increasing level of complexity has been a challenge to the construction industry, as evidenced by reports of construction projects failing to meet clients expected outcomes which proliferate across the globe. This is due to several factors such as macroeconomic factors, project-specific factors, as well as factors relating to the performance of other project team members (Nkado 2010). However, since the success of construction projects is argued to largely depends on the appropriate selection of contractors for projects (Palaneeswaran and Kumaraswamy, 2000; Singh and Tiong, 2005), appropriate selection of contractors is seen as a very important factor for achieving expected project outcomes. This is partly because of contractors responsibility to manage and utilize project resources (labour and materials) (Kog and Yaman 2014), and also as a result of the significant role they play in promoting good project management and creating enabling environment for achieving expected project outcomes (Skeggs, 2003).

The dominant criteria such as time, quality and cost; as well as the tactics employed in evaluating these criteria, particularly for a normal project-based, short-term contracts are
well covered in the literature (see for example: Nasab and Ghamsarian 2015; Ebrahimi et al., 2015; San Cristóbal 2011; Favié et al., 2007). However, with the increasing adoption of CLR practices in construction, more knowledge is needed on how the selection of contractors to accommodate for CLR can be achieved. Some studies suggested that contractor selection for CLR should consider not only hard criteria and technical competences but also more subjective attributes (Kadefors et al., 2007; OGC, 2003). Concurring, Laryea and Watermeyer (2016) submit that the selection of experienced and skilled contractor with capacity and collaborative attitude is the first condition for success in such contracts.

While criteria such as altruism, cooperation, openness, flexibility, trustworthiness, and inter-organization relationship are indicated as being necessary for CLR (Ayegba et al., 2018; Kadefors et al., 2007; Skeggs, 2003). The procurement tactics and mechanism for identifying and evaluating such criteria need to be clearly understood through empirical studies. Mainly since most construction stakeholders have been trained and accustomed to traditional approaches.

**RESEARCH METHOD**

The qualitative research methodology is adopted in this study, as physical access for in-depth probing questions, allowed in a qualitative study is required to elicit data from participant’s narrative experience on the procurement tactics employed in selecting contractors that accommodates for CLR in framework contracts. Participants will be allowed to provide data in their own words and understanding and meanings will be informed from their point of view in line with the interpretivist philosophy (Saunders et al., 2012). More so as there will be varied and multiple subjective meanings from the experiences of each participant. The abductive approach is considered appropriate and adopted in this study, as the findings from the study are not intended to test a theory or develop a new theory as will be required in a deductive and inductive approach respectively.

Data for the study was collected via semi-structured interviews with key informants of purposively selected organizations employing framework contracts in South Africa, and documentary analysis of procurement documents of the organizations. Key informant interviews involve interviewing people, who are selected for their first-hand knowledge about a topic of interest and are likely to provide needed information, ideas, and insights on the topic of interest (Kumar 1989). In addition to already known client organizations employing framework contract, the identification of other client organizations using framework contracts was also through several other sources that include enquiring from construction professionals and reviewing tender information on relevant databases on the internet such as National Treasury, Department of Public Works, and the cidb databases.

A total of eight organizations involving sixteen key informants with different background and positions comprising of directors, project managers, chairperson and executive managers participated in this study. The interviews were audio recorded to ensure that all information was captured during the interviews. In addition brief notes were taken during the interviews to capture both verbal and nonverbal signals from the key informants. The audio record was transcribed verbatim. The organizations also provided the procurement documents (such as the expressions of interest/the letter of invitation to tender, tenders, framework agreements and tender outcome notification) that were requested for in advance. The documentary analysis of the procurement documents provided evidence to ascertain and corroborate the findings from the interviews. The data collected from the key informant interviews and documentary analysis were analysed with the aid of the
Nvivo 11 pro qualitative data analysis software for windows and following thematic qualitative data analysis techniques outlined by Miles, Huberman and Saldana (2014).

**FINDINGS AND DISCUSSIONS**

In this study, the procurement tactics employed by organizations in selecting suitable contractors for CLR was empirically investigated. The expectation is that to reduce the risk of selecting an inappropriate contractor for CLR, several cognitive steps and processes are employed in screening potential contractors for CLR suitability. To get a sense of the emerging pattern and ideas on the procurement tactics employed in selecting suitable contractors for collaboration and long-term relationships across the data from the eight case organizations investigated, a word frequency query was carried out on the data using Nvivo 11 pro qualitative data analysis software. By using stem words grouping for the fifty most frequent display words with five minimum lengths, the result is presented in the word cloud shown in Figure 1.

![Figure 1: Word Cloud Depicting Prominence Words on Procurement Tactics for Selecting Suitable Contractors for Collaboration and Long-Term Relationships.](image)

The word cloud indicates the most frequent words used in the data, which are displayed larger and bolder in the word cloud as shown in Figure 1. From Figure 1, the most frequent words includes: ‘experience’, ‘interview’, ‘previous’, ‘workshops’, ‘commitments’, ‘references’, ‘dialogue’, and ‘meetings’. These words reveal the trends and pattern of responses across the data on the procurement tactics employed in selecting contractors for CLR. The contexts of the highlighted words were also captured for in-depth meaning and understanding of the individual words and are discussed below in themes.

**Conducting Interviews with Potential Contractors**

Virtually all the key informants from the case organizations indicated that conducting interviews with the potential contractors is one of the tactics they employ in selecting contractors for CLR. This shows why the word ‘interview’ was displayed as the most frequent word in Figure 1. In a study on conceptualization of CLR, open communication, trustworthy-ness, cooperation and social exchange behaviour are reported among the important requirements for CLR (Ayegba et al., 2018). Due to the intangible nature of these requirements, it will be difficult to gain assurance that a contractor is suitable for CLR and will not act opportunistically or behaves such that will cut short the contract relationship. Therefore, interviews provide greater opportunities for parties to sit face to face to probe and sieve down the number of potential contractors further. It also provides opportunity for clarifications and to test reactions from the contractors. A common practice alluded to during interview by most of the case organization is to involve all.
relevant parties and departments within the client organizations to take part in the interviewing. In addition, interviews provide an opportunity for the contractors to express themselves furthermore on why they are suitable for CLR. As A3 puts it:

That allows us to test that can they produce a program, activities and work with us, to me it is more like a job interview find the best candidate, price, preference, quality and matching your objectives of CLR - A3

A common concerns in interviewing potential contractors has to do with who is to be interviewed, number of contractors to interview and what type of questions are to be asked that will provide evidence that a contractor will be suitable for CLR. The response from A1 well illustrates how these concerns are addressed in an interview:

You interview the people that are going to be on site and not the directors and the marketing team. We tell them who we are and our value system, we ask if they can align with what we are doing? Can they perform what we are asking of them? That is where we tested the compatibility. You ask them for their approach paper and skill development plan, what is the quality of their staff? Are they innovative or are they just doing what they are told to do without coming up with ideas? Ask them for their value-engineering proposition. What could they do better? Can they adapt and are they providing the right people, do they have the right commitment? Because it takes a lot of effort, energy and cost to participate in that bidding process and it is ridiculous and unfair to take this huge pool forward. If you want people to participate meaningfully, give them a 1 in 4 or 1 in 3 shot because if you give them 1 in 10 shot, you will get 1 in 10 quality returns - A1.

Hence the procurement tactics of conducting interviews with is a good medium of communication that provides opportunities gathering and assessing information from the potential contractors.

Conducting Training and Workshops for Potential Contractors

Conducting training and workshops is another procurement tactics alluded to by 6 out of the eight organizational cases in the study in selecting suitable contractors for CLR. This justifies the display of the word ‘workshop’ as one of the most frequent words across the data in Figure 1. The response from A3 well illustrates the context of the practice:

Another thing we have found successful in running and building framework contracts is running workshops. We have also run Workshops on the NEC and how target contracts work because if you want contractors that have used NEC and target contract, you may not get any tender. I regard these workshops as bringing about a culture change, what we do is to have the contractor and the professionals and client team go through it. The head of the unit will always come around to watch the reactions and responses and not to hear us, and then he can figure out how to deal with the contractor and where their strength and weaknesses are - A3.

Since the concept and practice of CLR are not familiar to most contractors and professionals, mainly as people have been more used to the traditional approaches. Workshops and training provide the opportunity to build the contractors up for CLR. It also provides the opportunity for clients to observe as part of an evaluation process the active involvement and commitment characteristics of contractors, which are also critical for successful CLR.

Asking for CV’s of Key Participants

The keyword ‘experience’ was also displayed as one of the most frequent words across the data in Figure 1. Apart from finding out directly during interviews if contractor team members have the right experience for the job and for CLR, another procurement tactic that was indicated to be used in evaluating the suitability of contractors for CLR was requesting for CVs of key participants from the contractor's. This tactic was indicated to
be employed by all the case organizations and was also corroborated by the evidence from the procurement documents. The following responses below illustrate further:

..we ask for CV's and indirectly we check through past experiences, looking at say for instance what type of projects you did in a 10 year period, who were your clients and what the success rate -A3

Asking for CVs of those individual teams enable us to be able to basically tell if they have the right experience -A7.

….we ask for CVs for key resources, Over and above the price, we need to know whom I'm working with, Not interested in the people that are going to rock up in fancy suits, do not send me the marketing people. Send me the construction professional. The foreman and the people below we will assume everything is okay, but the project managers, the cost controllers those are the people you are going to interact with, you need to work with, and you need to understand, that is part of the beauty contest -A1.

Therefore, requesting for CVs of key participants from the contractor side provides the organizations with information on the previous experience and quality of professional people in the contractor team. This will obviously have an impact on the quality of expected outcome and promotion of CLR.

Consideration of Top Management Involvement

Probing further, a test search query was carried out on the word 'commitment' which was also displayed as one of the most frequent words in Figure 1 with the aid of the Nvivo software. The context by the references from the probe shows that apart from A5 which uses the word in the context of enquiring about future commitments of contractors to get information about their availability for CLR, five of the organizations used the word ‘commitment’ to indicate consideration of top management commitments in the selection process as one of the tactics for assessing suitability of contractors for CLR. A3 puts it this way:

…..commitment of top management, when it comes to a grade 7 or 8 contractors, the guy sitting in front of you is the guy intimately involved in the tender and the execution, the director has been actively involved all through the process, he is the decision maker. So the relationship with them is better, there are no limitations on where you are going to go -A3.

The involvement of contractor’s top management in all the selection processes including interviews, workshops and competitive negotiations and meetings is considered as a good attribute for CLR. Such that it may create skewed results against the bigger contractors of higher grades that may not be having their top management representatives in the selection process. This is partly because such representatives will have limited decisions to make due to limited authority and their top management are disjointed from the execution team.

Vetting of Potential Contractors

Observations and interviews may not discover the warranting properties that a contractor may be suitable for CLR. One cannot see that a contractor will be honest and trustworthy and it's not uncommon to have contractors being deceptive during interviews. So asking contractors to provide contactable references of past clients for vetting purpose is also one of the tactics employed in selecting contractors for CLR by all the case organizations. Other vetting concerns as indicated by A8 has to do with checking if contractors have not been found guilty of corruption and other fraudulent practices, and cross-checking blacklisted list of tender defaulters with Government agencies. Most of the case organizations indicated that they usually request for at least three references of past jobs.
In some cases, the request is for past-related jobs references. A7 well illustrates the significance of asking for contactable references of past clients:

> When we cross-reference based on the previous job that they did. Remember, all of them will tell you that they are fit for the job. Take one example, in one instance, somebody lied and said he developed A, B, C, D for BP but when we call BP, BP says “no, there is no such a thing, the person did not develop that”. So automatically, we know that he is a liar. But during the interview they will tell you everything, we are transparent, we good communicators, everyone wants a job. That’s why is important to dwell deep and contact the reference they provided from previous jobs- A7

Vetting of contractors by proper due diligence crosschecking of contactable references of past jobs provides knowledge on the contractor’s background behaviour and suitability for CLR which is critical to the solution the contractors can offer. Previous behaviour is a good indicator of future behaviour following trait laws of "once a K, always a k" which are invoked when you deal directly with someone and you are reliably informed about the person (Gambetta and Hamill 2005). This is epitomized by sayings such as “you are as good as your last job”.

**Holding a Competitive Negotiation/Discussion Process with Potential Contractors**

The keyword ‘dialogue’ was also displayed as one of the most frequent words across the data in Figure 1. Probing further, six of the case organizations in this study reported having a competitive dialogue process with contractors as one of the procurement tactics employed in selecting contractors to accommodate for CLR. The competitive dialogue process is employed at the final stage when the potential contractors must have been sieved down to two or three as indicated by A6. This involves an open conversation process, which is used to test contractor’s reactions and innovativeness. A1 suggested the practice is also employed to give feedbacks that will improve the competitiveness of contractors as illustrated below:

> The contractor was asking some awkward questions to the architect. The architect had never been in a situation where the servant checked the master about his design and in the middle of all of this, the contractor stopped and said look, sir, I am not challenging your architectural ability, please understand, I need to understand your flexibility in order to price the job. Therefore, it is a two-way street, with contractor sizing up his risks in meeting the client, testing reaction. We test reactions. For example, when we did the mathematical jobs, the discussion went around the movement of joints to accommodate better prices in formwork- A3

An important advantage of having the competitive negotiation/dialogue process is the feedback contractors provides during the process. A1 well illustrates this:

> At the west campus where we provided for concrete slab floor that was supposed to be followed by a screed and then a vinyl floor onto the screed. During the competitive dialogue process, the contractor stepped in and said hang on I can finish my concrete slab at the level at which you need the vinyl floor. By doing this, we were able to make a saving on the entire screed we would have needed. So it is this type of input from the contractor that saves you money, unlike the traditional approach where he will just make money off the screen without telling you -A1.

Therefore having a competitive negotiation/dialogue process with potential contractors gives the organizations greater opportunity to probe and sieve the potential contractors further and also to extract more information from the contractors in a face to face encounter.
Selecting Suitable Contractors

Holding Meetings with Potential Contractors

Holding meetings which may be compulsory or non-compulsory is another tactic employed by most of the case organizations in selecting contractors to accommodate for CLR. This shows why the word ‘meeting’ is displayed among the most frequent words across the data. In some cases, such meetings are termed clarification meetings when it is to clear any ambiguities on information and to provide more information and understanding regarding the organizations and projects objectives. Meetings with contractors also provide the opportunity to get more information from the contractors and on their perceivable behaviours. It is also used to evaluate contractor’s commitment and interest in the job, which are good ingredients for CLR.

Use of NEC3 Contract Documents

The form of contracts is amongst others is also a tool used for the effective procurement process. The standard forms of contracts used in practice in South Africa are the International Federation of Consulting Engineers (FIDIC), General Conditions of Contract for Construction Works (GCC), Joint Building Contracts Committee (JBCC) and the New Engineering Contracts (NEC3). Most of the case organizations reported the use of the New Engineering Contracts (NEC3) contract documents in procuring contractors for CLR. Although one of the organization A2 specializing only in building works and another A5 that only carries out roadworks reported using the JBCC and GCC contract documents irrespectively. The preference for JBCC and GCC was because JBCC and GCC deal specifically with their area of specialization, which is building works, and Engineering works respectively. In the words of A8 below:

We use NEC suite of contracts because it is one that people within our organization understand better than the FIDIC, GCC, and JBCC. It is what our people have been trained on and we, therefore, stick to NEC because at least the legal practitioners understand it better and we can easily depend on it. Our project managers as well have been trained with NEC.

A8

Watermeyer (2015) describes the NEC embodying collaborative and cooperative practices as well it facilitates project team integration and early contractor involvement. It is developed in line with recent approaches to project management including CLR practices. These characteristics of NEC may be the motivation for its preference by most of the case organization.

Other procurement tactics indicated from the findings involve the use of open tendering by publishing an expression of interest as tender invitation practice; and employing bill of quantities or activity schedule depending on the size of the contract as pricing strategy.

CONCLUSIONS

In this study, the procurement tactics that influence the actual decision process in selecting contractors for CLR was empirically investigated. Focusing on framework contracts which is one of the strategies that is intended for CLR in the construction industry, eight purposively selected organisations employing framework contracts in South Africa participated in the study.

The study gives the detailed account of the procurement tactics the organizations use in selecting suitable contractors for CLR. Overall the tactics include: conducting interviews with potential contractors, conducting training and workshops, asking for CV’s of key participants, top management involvement consideration, and vetting of potential contractors via a contactable reference of past jobs. Other tactics include holding competitive negotiation/dialogue process and meetings with potential contractors. Also,
the use of NEC3 Contract Documents, use of a bill of quantities and activity schedules as Pricing Strategies and employing open tendering by publishing an expression of interest in inviting contractors to tender are other tactics adopted in selecting suitable contractors for CLR.

This implies that the organizations employ many tactics aimed at getting them closer to meeting and talking face to face with potential contractors. This enables the organizations to observe, listen and read signs such as expressions, politeness and other behavioural properties displayed by contractors in assessing their suitability for CLR so as to minimize the risk of inappropriate selection for CLR. These procurement tactics are not intended to be exhaustive but represent a range of areas and issues clients should consider in selecting suitable contractors to accommodate for CLR. Often the final verdict on the selection of contractors for CLR is the result of taking a cluster of these procurement tactics into consideration.

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Selecting Suitable Contractors


INVOLVING SUBCONTRACTORS IN CONTINUALLY IMPROVING PERFORMANCE IN INDUSTRIALISED HOUSEBUILDING

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Utilising the invaluable knowledge of subcontractors and incorporating it to improve performance of construction supply chains is an important topic. Despite this, such integration in continuous performance programs largely fails. To overcome this weak subcontractor involvement a case study has been conducted. Its purpose was to investigate key challenges for weak subcontractor involvement within continuous improvement and to propose measures which could contribute to overcome the weaknesses identified. The findings show that traditional structures and practises within the industry as well as a mismatch of interests and expectations of participants leads to difficulties. Measures to overcome those challenges and enable a better involvement of subcontractors are proposed. Finally, real-life data served for the assessment of the developed measures. This investigation may help practitioners and scientists to better understand challenges arising for CI implementation and may help to find solutions for improving the performance of the entire IHB supply chain.

Keywords: prefabrication, productivity, SCM, total quality management

INTRODUCTION

Continuous improvement (CI) is well-known and frequently applied in manufacturing industries. It contributes to a reduction of reworking due to non-conformities and to a realisation of improvement potential. This method has the potential to increase the efficiency of working processes within the industrialised housebuilding (IHB) supply chain (Lessing et al., 2015).

Depending on a companies’ prefabrication strategy, more or less value-added activities are performed on-site or through supply chain participants. An estimation of their contribution to value generation is probably only useful for each company individually. For example, in companies utilising modular building systems where most installation and interior construction is done within a plant, subcontractor services are of little importance. To the contrary, the significance of subcontractor services within component manufacture and subassembly is probably more profound. In general, subcontractors supply specialised services for the fulfilment of building production and are an important source of expert knowledge (Love and Smith 2016).

Despite the importance of CI for performance enhancements, its implementation is not extended far beyond operations within the prefabrication plants. The involvement of

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Involving Subcontractors in Continually Improving Performance

construction site and supply chain operations in incremental innovation by incorporating subcontractors and suppliers is largely lacking (Meiling et al., 2014).

Introducing CI in IHB supply chains and incorporating the expert knowledge of subcontractors is not without conflict (Love, Ackermann, et al., 2015). There are few examples of successful subcontractor involvement in CI programs (Söderholm 2010). Reasons may be found in the usual structures and practices of the construction industry as well as in conflicts of interest between both the IHB companies and their subcontractors, and between subcontractors themselves. However, the involvement of subcontractors in continually improving the supply chain performance remains beneficial, as they perform valuable services and can provide a lot of expert knowledge to on-site activities. To improve business performance of their supply chains IHB companies strive to integrate subcontractors within product and process improvement initiatives. Solutions for interdisciplinary collaboration to better use subcontractors’ knowledge within incremental innovation programmes are essential (Lessing et al., 2015).

This paper investigates the reasons for weak subcontractors’ participation in CI and suggests some improvements, which have developed during a two-year case study which involved an IHB company and its subcontractors. The research sought to answer two research questions: (1) What are the key challenges for successful implementation of CI within an IHB supply chain? (2) Which measures contribute to a better adaption of CI methodology to overcome identified challenges for subcontractor involvement within IHB industry?

This paper is organized as follows: The literature review analyses the current situation in IHB supply chain management (SCM) and provides an overview of relevant CI work in general as well as within the IHB literature. The material and method section presents the applied research process before findings of the case study are shown. These findings include a stakeholder analysis, including interests, contribution and expectations of stakeholders on an incremental improvement program, an analysis of resulting key challenges, the developed measures and, finally, real-life data from the case study. Findings are discussed before finally conclusions are drawn.

LITERATURE REVIEW

CI by most definitions is a commitment to eliminate waste within systems and processes to increase the efficiency of an organisation in the long run (Abu El-Elia et al., 2013). It is embedded within a culture focusing on sustained performance enhancements through involving employees’ specific knowledge of production processes within improvement activities (Bessant and Francis 1999).

CI is not a single methodology. A number of tools, techniques, approaches and methodologies, dedicated to enable constant performance improvements, are included within its context. Best known methodologies are lean manufacturing, the balance score card, six sigma or hybrid methodologies of those (Bhuiyan and Baghel 2005). The difficulty with CI is that simply transferring it from one organisation to another is not normally successful, as it cannot be a simple implementation of a tool for waste reduction. It relies on many soft factors such as learned routines and practices. For the successful implementation, such routines need to be adjusted to characteristics of a company and its supply chain (Bessant et al., 2001).

Despite the lack of an identical CI program, each CI program shows core abilities and key behaviours which have develop over time. An important observation by Bessant and
Caffyn (1997) was that CI maturity can be assessed on the base of existing core abilities and key behaviours. They assigned these to five levels of CI maturity. A higher CI-level shows more of these core abilities and key behaviours as well as an intensified problem-solving ability.

Enablers such as procedures, companies’ policies, resources, or structures support the development of these key behaviours and core abilities. It is necessary to consider whether the characteristics of the company and its supply chain i.e. project orientation or a fragmented order fulfilment process, could complicate the provision of elaborated enablers and hinder the development of core abilities (Caffyn 1999).

**Structures and Management Practices**

IHB, which is a part of the construction industry, is uniquely situated between management practices and structures of the construction and manufacturing industries. It has created new ways of building production and implemented many management concepts which are not found within traditional construction industries. These include a mainly process based prefabrication of elements or modules and a higher degree of product standardisation on the level of building components and of recurring processes, just to name a few. Concurrently, it relies on many legacy structures and practices of the construction industry (Höök and Stehn 2008). Figure 1 shows the positioning of IHB concerning the degree of project and process orientation in the order fulfilment process. Due to the integration of management practises and structures from manufacturing industries to those of construction industries, IHB companies deal with customer orders in a project and process oriented way.

![Diagram of positioning of IHB based on the degree of project and process orientation of the order fulfilment process (Höök and Stehn 2008)](image)

Some of the usual construction industries' structures and practices hamper the implementation of proven management concepts and methodologies. Reasons may be both the inadequate adaption of such concepts as well as the structures and practices within IHB industries. The most important ones are found in: the project based focus of order fulfilment (Ballard and Howell 2003), the uniqueness of building projects, the fragmented IHB order fulfilment process (Knauzeder et al., 2007), the different locations where activities are performed (e.g. off-site and on-site) (Eriksson 2010), in inspection based rework of failure (Lundkvist et al., 2014) and to some extent the short term contracts between supply chain participants (Josephson and Saukkoriipi 2007). These structures and practices, with their inbuilt weaknesses, produce an ineffective defect management regime (Lundkvist et al., 2014), weak knowledge sharing and at the least, the weak participation of subcontractors within CI (Höök and Stehn 2008).

In an investigation of the development of the IHB industry, a case study of three Swedish IHB companies by Lessing, Stehn and Ekholm (2015), revealed similar areas of conflicts for the future management. But they also showed an increase in long-term collaborations between IHB companies and their subcontractors which enhanced the importance of
supply chain management in the field. The above mentioned requirements influence the implementation and development of CI.

**CI Application within IHB**

Some previous publications covering the application of CI within IHB industry Lessing (2006) described various management concepts including lean production, lean design or six sigma and their relevance for IHB. Söderholm (2010) investigated performance improvement through CI application within the design phase of industrialised buildings. Lessing, Stehn and Ekholm (2015) reported that CI concepts are used for improving repetitive activities in the prefabrication process. Meiling, Sandberg and Johnsson (2014) demonstrated the applicability of a Plan-Do-Check-Act improvement process for the reduction of failure both in off-site and on-site scenarios. Already missing is an investigation into the challenges of successful integration of CI within an IHB supply chain. Such an investigation may help practitioners and scientists to better understand challenges arising and may help to find solutions for improving the performance of the entire IHB supply chain.

**MATERIAL AND METHOD**

To investigate reasons for weak subcontractors’ participation and suggest valuable improvements for CI methodology a two-year case study was conducted. The data was provided by an IHB company and its subcontractors. The applied research process is presented in figure 2. In a first phase, key elements within the CI methodology and their purpose are investigated through a literature review. Expert interviews and literature research revealed the current nature of IHB construction supply chain management. To analyse the key challenges for implementing CI within an IHB supply chain, stakeholder analysis, interviews with IHB supply chain participants, and participating observation were conducted. In a subsequent phase, adaptions of the CI methodology were iteratively developed and tested with participants of this specific construction supply chain. Twelve scientifically accompanied flagship building projects, built during a 22-month period were used for the development and test of adaptions.

![Figure 2: Research process applied during the case study](image)

The industrial partner of this case study sells and builds around 200 single- and two-family homes a year and it focuses on complete order fulfilment from sales to handover. According to Gibb (2001) the construction method can be defined as a mixture of non-volume and volumetric preassembly. To enable a full completion of the customers’ order many construction processes such as installation, plumbing, screed works, tilling, plastering, wall painting etc. are contracted to subcontractors within the supply network.

**Identification of Key Challenges**

From the established state of IHB supply chain management and CI application, key challenges for successful implementation of CI within an IHB supply chain were identified. This was performed first through a stakeholder analysis and an analysis of
structures and practises and secondly its outcomes were verified through interviews with supply chain participants and participatory observation.

The stakeholder analysis helped to identify important stakeholders and to characterise their area of interest, their contribution and their expectations (Jepsen and Eskerod 2009) when contributing to product or process improvement. The stakeholder groups which were assessed were; (1) subcontractors, (2) suppliers, (3) top management and (4) two different groups of employees, and are all important for improving IHB supply chain performance.

Interviews with supply chain participants and participatory observation served as check to avoid false assumptions, and enabled a deeper and stronger analysis of the key challenges (Yin 1994). This information was necessary for the iterative development of supplementary CI measures. Its consideration is essential for the useful integration of supply chain participants to continually improve products and processes and reduced the risk of biased influences or the unilateral preference of SC participants.

Development of Measures to Adopt CI Methodology

After analysing the challenges, consideration was given to measures which might best overcome them. These were implemented. Measures which were found to be useful were further developed over time. Some further measures were incorporated and ineffective ones were eliminated. The development of measure complies with theory building through case studies (Eisenhardt 1989, Yin 1994) and was done on the base of participating observations and interviews.

Analysis of Performance Indicators (PI)

To assess the performance within the case study a selection of the lean indicators proposed by Martínez Sánchez and Pérez Pérez (2001) was applied. Data for performance indicators was used for both the initial and improved state. It was obtained in the year preceding the study and in the year of completion.

RESULTS

In this section an analysis of key challenges is presented based on a stakeholder analysis and an analysis of the influences of the usual structures and practices within IHB industries. Upon this foundation improvements for applying CI methodology within an IHB supply chain are iteratively developed. The proposed improvements for CI methodology together with their rationale are described. Finally, performance indicators derived from the case are given.

Key Challenges for Implementing CI in an IHB Supply Chain

Stakeholder analysis revealed a variety of guiding principles under which they operate. This analysis is illustrated in figure 3. Participants had a variety of reasons for participating in the CI programme and these are shown within the column "the area of interest". Their ability to contribute and their expectations for contributing are also shown.
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<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Area of interest</th>
<th>Contribution</th>
<th>Expectations (reward for contribution)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-contractor</td>
<td>Good coordination between main and subcontractors' processes to ensure profitable work</td>
<td>Subcontractors specific knowledge in the product and process development</td>
<td>Ensure a good long-term utilisation of subcontractors’ resources</td>
</tr>
<tr>
<td></td>
<td>Influence the development of standards concerning activities (including interface areas) fulfilled by the subcontractor</td>
<td>In some cases capacity to invest within the improvement process is restricted</td>
<td>Develop standards that enhance their own value as subcontractors</td>
</tr>
<tr>
<td>Supplier</td>
<td>Influence the development of standards concerning suppliers own products</td>
<td>Suppliers’ specific knowledge in process and product development</td>
<td>Enhanced profitability from their products</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Support the contractor and subcontractor during implementation and usage of suppliers’ products</td>
<td>Develop standards that enhance the value of their products</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Support the contractor during the development of standards where suppliers’ products are incorporated</td>
<td>Ensure long-term sales partnership with main contractor</td>
</tr>
<tr>
<td>Top management</td>
<td>Efficient product development process</td>
<td>Specify strategic goals for improvement</td>
<td>Enhanced efficiency of working processes to achieve performance targets</td>
</tr>
<tr>
<td></td>
<td>Involvement of SC participants knowledge within product and process development</td>
<td>Active support for the improvement process (resources, time, …)</td>
<td>Decision-making authority and competence must finally be the responsibility of the IHB company</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contribute to a profitable business development of the IHB company</td>
<td></td>
</tr>
<tr>
<td>Employees</td>
<td>Improvement of their working processes</td>
<td>Contribute employees specific knowledge in the product and process development</td>
<td>Reduce uncomfortable working activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contribute to the profitable business development of the company</td>
<td>Acknowledgement for effort concerning improvement suggestions</td>
</tr>
<tr>
<td></td>
<td>Improve and support sales activities</td>
<td>Suggest interesting product and process innovations for sales</td>
<td>Attractive products and solutions to convince potential customers</td>
</tr>
</tbody>
</table>

Figure 3: Analysis of important stakeholders for CI within the IHB supply chain

The analysis reveals both conflicts and enhancements within the three areas of one stakeholder group and those of another. Overlaps between arguments for the area of interest and contribution are beneficial and will be supportive. For example, the top management is interested in involving the knowledge of supply chain participants in order to improve products and processes. This overlaps with arguments for contributing their knowledge.
In contrast, an overlap between arguments within the area of interest of one stakeholder and the expectations of another may lead to conflicts and mistrust. As an example, subcontractors may be interested in influencing the development of processes they fulfil which conflict with the expectations argument from the top management, their expectation of decision-making authority and competence within the IHB company. Conflicts within these guiding principles may lead to challenges for a successful CI implementation since, when expectations are not met, the willingness of the subcontractor to participate is diminished.

Compared to manufacturing industries, where the implementation of CI has been very successful, IHB industries differ in both practice and structure. These include:

- Various activities for the fulfilment of orders are performed in different locations (e.g. design offices, production sites or different construction sites).
- A very complex product is design and produced, which is mostly unique at the level of the building project. Despite this uniqueness there are similar activities undertaken during design and production.
- Within the order fulfilment process building projects are mostly handled as a single project. For this reason the order fulfilment process is more project than process oriented.
- Defect management is traditionally based on inspection.
- The fulfilment of various working operations is done by a variety of a companies’ departments and supply chain participants in a consecutive way. Due to the spatial distribution and temporal sequencing of the activities, there is a lack of cooperation both interdepartmentally and between supply chain participants.
- In some cases, the short-term nature of contracts between supply chain participants provides little impetus for participating in improvement projects.

A consequence of these structures and practices is low interest in sharing experiences for solving problems which mostly remains in the hands of supply chain participants and will not be used for long-term solving of problems.

**Measures to Adapt CI Methodology for IHB Supply Chains**

To overcome these challenges for subcontractor participation within CI, measures are iteratively developed. Those include:

- an involvement of subcontractors’ employees in feedback channels and within suggestion schemes
- periodical flagship projects in order to test improvement potentials and to sensitise supply chain participants for process- and product improvements
- involvement within the preliminary and debriefing meetings of improvement projects
- long-term partnerships to strengthen the team spirit within the supply chain
- periodically inform supply chain precipitant of implemented improvements

**Assessment of the Program with PI**

The adapted CI method is assessed with CI related performance indicators as presented in table 1. The analysis revealed improved subcontractor involvement within CI, an increase in the number of subcontractors’ improvement suggestions per year, an increase in the percentage of implemented suggestions per year as well as an increase in the involvement of subcontractors within improvement meetings and information systems.
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Table 1: CI related performance indicators

<table>
<thead>
<tr>
<th>Performance Indicator</th>
<th>Initial</th>
<th>Improved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of total suggestions per year</td>
<td>27</td>
<td>42</td>
</tr>
<tr>
<td>Number of suggestions from subcontractors per year</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>Percentage of subcontractors’ suggestions on total suggestions</td>
<td>11</td>
<td>40</td>
</tr>
<tr>
<td>Percentage of implemented suggestions</td>
<td>85</td>
<td>94</td>
</tr>
<tr>
<td>The frequency with which information is given to subcontractors</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Meetings dedicated to knowledge sharing between employees from main- and subcontractor</td>
<td>0</td>
<td>18</td>
</tr>
</tbody>
</table>

DISCUSSION

CI has enabled impressive performance gains within manufacturing industries in recent years. Its implementation within IHB supply chains is, as yet, not to successful. The reasons are probably due to the characteristics of IHB supply chains.

To enable successful implementation in the future, challenges due to the structures and practices of IHB supply chains as well as from stakeholders’ expectations and interests have to be carefully considered in the development of appropriate measures.

Little sharing of experiences between supply chain participants was identified. Höök and Stehn (2008) and Eriksson (2010) revealed this challenge for the participation in CI of on-site workers. This investigation revealed, as causes, the usual inspection-based defect management regime, the project orientation of the order fulfilment process, the uniqueness of building projects, the distributed nature of the order fulfilment process and the lack of cooperation between company departments as well as supply chain participants. To overcome this challenge periodical flagship projects are proposed. These serve to better involve subcontractors within CI programs and to sensitise them to contributing to improvement measures. Additional important measures proposed were to both to actively involve them in meetings related to improvement projects and ensure participation within suggestion schemes.

Conflicts between the interests and expectations of different supply chain participants will probably appear. These should be balanced through the proper management of the CI program. It is important to consider that each stakeholder should get a fair reward for his / her contribution, otherwise the interest in participating within CI decrease.

One of the most important reasons to apply CI on the level of supply chain management is to incorporate the specific knowledge of subcontractors for performance enhancements. Subcontractors can probably contribute a lot of specific knowledge to the production process, which is difficult to acquire from the main contractors' viewpoint. To obtain a holistic view of the building process and reduce the complexity of it is also an important advantage to be gained from the involvement of subcontractors and their knowledge within CI. The previously mentioned flagship projects and the involvement of subcontractors in CI meetings contribute to a better analysis of complex problems and the joint development of solutions. A further important factor is long-term partnerships. These reduce mistrust between supply chain participants and help build a team spirit. As a consequence of participation in CI subcontractors can expect increased revenues due to the improved efficiency of their services and an increase of orders from the main contractor.
The analysis of CI related performance indicators obtained from the case study revealed improvements. Based on this data it can be assumed that applied adaptions of CI methodology help to overcome challenges for CI implementation within IHB industry.

CONCLUSION

To improve the productivity of the order fulfillment process through the involvement of subcontractors’ knowledge is an important competitive factor for IHB companies. To gain such advantages, incremental innovation along the entire supply chain is essential and IHB companies can benefit substantially from examples which illustrate the successful implementation of CI within an existing construction supply chain.

To overcome the existing difficulties within CI challenges for its implementation must be known. For this purpose, the key challenges have been analysed with a review of literature, participating observation and interviews with IHB supply chain participants. This included a stakeholder analysis to explore interests of SC participants on the IHB companies’ improvement process, reasons for non-participation as well as both the beneficial and undesirable effects of improvement of processes and products. In a subsequent phase, adaptions of the CI methodology were iteratively developed with supply chain participants. Performance improvement through the application of the improved CI methodology with real-life data is presented.

Evaluations of the applied adaptions, as they are presented here, may also help to implement appropriate measures. The applicability of CI methodology to reduce reworking of non-conformities and to realise improvement potential within the entire supply chain is demonstrated for a single case. Additionally, indications for potential efficiency enhancements were found.

During this investigation, a specific IHB supply chain was analysed. Even though the investigated supply chain was chosen as a representative example for Central Europe, there is a need for further research to enable a broader applicability of findings. To contribute to the generalisation of findings, future work should provide output from a multiple case study which should include IHB companies and their construction supply chains from other customer segments (e.g. multi-family homes), different construction methods (e.g. modular building or component manufacture and subassembly) as well as other regions. Such investigations should contribute to verify best practice measures and indicated efficiency enhancements.

REFERENCES


DIGITIZATION FOR INTEGRATION: FRAGMENTED REALITIES IN THE UTILITY SECTOR

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The construction industry and its reform agendas commonly assume that digitization of a construction asset's life cycle also integrates its stakeholders. Behind this lies the premise that stakeholders reduce ambiguity and create consistency by using software that operates on the basis of shared and uniform knowledge. To explore this premise, this study identified the knowledge bases - data standards and modelling protocols for engineering software - that distinctive underground infrastructure owner’s use. To this end, we analysed a utility engineering consultancy that registers and processes asset data of twelve major utility owners. We observed their utility information managers and studied their asset management guidelines. We used two utility taxonomies from literature to compare identified digital modelling standards. Subsequently, we used literature about modelling standards in digital practices to argue how selected examples of divergent digital models hamper uniformity. We conclude that digital reality models may also differ and thus confuse, fragment, and ultimately delimit collaborative digital practices. This insight stresses the relevance of defining shared domain understanding to facilitate the uptake of software for collaborative engineering practices. It stimulates construction improvement agents to consider this important notion of shared digital realities in their debates about achieving integration by 'going digital'.

Keywords: digitization, fragmentation, integration, standardization, utility sector

INTRODUCTION

Building Information Modelling (BIM) advancements drive state-of-the-art engineering and problem-solving in the construction industry. Its implementation is a much-discussed topic in literature and policy documentation (e.g. Bradley et al., 2016; Lu et al., 2015; Pauwels et al., 2016). One of the main steps in converting to this 'BIM paradigm' is through digitization, which involves the development of 'digital twins' of construction assets. A general belief in the construction industry - for example, visible in industry reform agendas - is that digitization of the information relevant to the construction asset's life cycle further integrates stakeholders. The argument follows the implicit logic that ambiguity will decrease and consistency between exchanged information will increase when stakeholders all accept and implement one uniform knowledge base for their (BIM) software. Taking this for granted, however, may cause 'digitization hubris'.

The problem with this ideal perception that digitization stimulates integration of the fragmented supply chains in the construction industry is that it ignores that digital practices themselves are also fragmented. Software interoperability and information integration issues (Lu et al., 2015) complicate this integration of fragmented practices. Turk (2001) describes a typical way in which construction-IT developers capture

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practitioners' realities. He argues that standardized data formats and structures help to achieve integration under the condition that these are accepted and represent practitioners' shared perceptions of realities. In addition, Gustavsson et al., (2012) and Samuelson and Björk (2011) indicate that a lack of consistency in and acceptance of the adoption of standards creates a barrier to the realization of integration.

The lack of consistency in and acceptance of the adoption of standards has led to the phenomenon of, drawing on Timmermans and Epstein (2010), "a world of standards, but not a standard world". This phenomenon is also typical for the architecture, engineering and construction (AEC) industry, where nations, organizations and even individuals have been developing digital (BIM) standards in a rather fragmented and self-centred manner (Azhar 2011).

Although existing literature argues that consistency in and acceptance of standards is a prerequisite in achieving integration through digitization, this suggests that a professional paradigm is able to develop a unified and accepted standard. This study verifies whether such a unified and accepted standard is developed in practice. In specific, it explores the digitization practices in the utility sector to understand the extent to which digitization leads to uniform digital practices. We identified and assessed digital standardization practices in a utility engineering consultancy and show that the industry currently uses various standards to model the same utility asset information. Consequently, we argue that implementation of digital practices may lead to digital information but that this does not necessarily result in a common and accepted set of uniform practices. We show that the existence of different digital realities hampers the integration of stakeholders.

The remainder of this paper is organized as follows: we first describe related literature about digitization and standardization. Second, we present how we used a case study to compare standards in practice. Third, we present findings by elaborating on selected examples of differing standard descriptions of an asset object. We compare the findings to literature before we draw our conclusions.

Related Literature

The use of technology in construction projects can improve the inter-organizational communication, cooperation and coordination (Adriaanse et al., 2010; Peansupap and Walker 2005). In the process of using such technologies, the construction industry digitizes construction assets by defining concepts, attributes, and their relations (El-Diraby and Osman 2011). Digitizing asset data is realized through applications like BIM (Bradley et al., 2016). Methodologies should be developed to facilitate exchange and communication between such applications in order to streamline work flows. Currently, this happens through the development of semantic web ontologies (Pauwels et al., 2016) and asset data modelling standards such as the Industry Foundation Classes (IFC) for BIM software (Turk 2001) and CityGML for geospatial software (Open Geospatial Consortium).

Standardization is critical to facilitate communication between different stakeholders in a fragmented industry - like the architecture, engineering and construction (AEC) industry (Howard and Björk 2008). Standards for representing construction data, such as IFC and CityGML are gradually accepted and used as the predominant way to exchange data between engineering software. However, common data formats for major types of infrastructure projects, such as transport, utilities or environmental projects (Bradley et al., 2016) are less developed.
The aim of standardization, in general, is to capture realities and construct uniformities across cultures, time and geography on the basis of agreed-upon rules (Timmermans and Epstein 2010). These agreed-upon rules are thereby captured in standards, which, on their turn, emerge from many fields (Bowker and Star 1999; Timmermans and Epstein 2010). The types of standard relevant to this study, are digital modelling standards. Such standards are also referred to as 'ontologies' (El-Diraby and Osman 2011). In computer science, ontologies are used in the process of knowledge elicitation - i.e. the process and output of reality modelling. In this process, knowledge is modelled in artefacts such as domain ontologies. Ontologies describe the world as seen by a group of people at a certain time according to a school of thought that is based on a set of fundamental propositions or world views (El-Diraby and Osman 2011). Once adopted and shared amongst practitioners, they represent domain knowledge in a unified, simplified, and consistent way.

Capturing realities through digital modelling standards - i.e. ontologies - for the fields in which digitization emerges requires thought about phenomenology - a branch of philosophy that deals with how to take things for what they are and what it means 'to be' - and hermeneutics - a branch of philosophy focussing on interpretation. Intention and interpretation are relevant when capturing realities, because their meanings can be shaped both by the authors and users of standards. Once explicated in a textual form realities can, therefore, have several plausible interpretations (Turk 2001). Likewise, Lampland and Star (2009) argue that it is not surprising that standards have many possible antonyms, given the range of possible meanings packed in a term.

When digital modelling standards are not adopted in digital practices, this may hamper construction IT adoption. In their adapted model of IT adoption - based on the unified theory of acceptance and use of technology, the theory of planned behavior, and the technology acceptance model - Adriaanse et al., (2010), have identified that differences in working practices, resources and objectives hamper successful adoption of IT. The existence of differing work practices also impacts digital modelling practices. Co-existence of multiple practices, may, for example also result in situations where practitioners use distinctive digital modelling standards to model an asset. As a result, adopted IT may use distinctive knowledge bases, and therefore show little uniformity in knowledge representation. Therefore, we hypothesize that using IT, and developing standardizations, does not automatically enable adoption and integration of IT users. The different digital realities can explain why adoption and use of IT in AEC industry are not always as effective and efficient as they could potentially be (Hjelt and Björk 2006; Sulankivi 2004).

To date, literature seems to have focussed on proposing a standard for a certain domain (e.g. El-Diraby and Osman 2011) or argue that standards should be developed to achieve integration (e.g. Gustavsson et al., 2012; Samuelson and Björk 2011; Turk 2001). It does not, however, focus on the multiple standards - and as a consequence realities - that co-exist as a result of varying work practices. Limited attention is given to the impact of different realities on the successful adoption and integration of digital modelling practices. In light of this research gap, this study observes the use of standards and IT in the AEC industry and seeks to provide the first evidence for our hypothesis.

**RESEARCH METHOD**

Different standards of reality, as a result of varying work practices, have received limited attention in literature. Therefore, we considered an exploratory research approach most appropriate. We conducted a qualitative case study to collect data and gain insights in the
topic investigated (Yin 2014). In this case study, we identified and compared the
different standards used in the construction domain. More specifically, we decided to
focus on a domain in which BIM technologies and standards are not adopted on large
scale. The utility sector is a good example of such a domain and was therefore selected.
We studied how standards and data protocols have been used in a Dutch utility
ingenering consultancy company. This company registers and processes utility data of
twelve major utility owners, being our unit of analysis. The twelve utility owners cover
the disciplines of water, gas, electric, telecom and district heating, where several utility
owners represented multiple disciplines. As such, each utility discipline was covered by
three utility owners.

The data collection approaches used in our case study include observations of work
practices and study of asset management guidelines. To this end, we observed seven
information managers whose daily task was to model underground networks. During the
observations, the information managers showed and explained how utility owners store
their realities in digital environments. While keeping notes on this, we had dialogues in
which they explained their asset management work routines.

We also collected asset management guidelines from six utility owners that were used by
the information managers as a guideline to verify data that surveyors and engineers
modelled. We found international, national, and organizational standards. Asset
management guidelines from the other utility owners were either not available or made
accessible due to privacy reasons.

The elicited realities from practice were analysed in a two-stage process: (1) qualitative
coding to abstract and compare the standards and guidelines, and (2) identifying
differences or similarities between the elicited realities.

To abstract and compare the standards and guidelines, we used qualitative coding
(Saldaña 2015). El-Diraby and Osman's (2011) typology of infrastructure objects was
used to compare the various concepts and attributes in the standards that we found. This
typology distinguishes between component level, subsystem level, and system level
objects and captures, for example, spatial, dimensional, and material attributes. To this
end, we identified how various asset owners of underground infrastructures describe and
store their ‘realities’ in data standards and protocols.

After assigning objects to these various levels and attributes, our next step was to identify
differences or similarities between modelled realities. For this, we used a typology from
Gasevic et al., (2009) that essentially describes three elements of an ontology: (1)
taxonomy and hierarchy, (2) vocabulary, terms and names, and (3) semantics: the
linguistic meaning of the representation.

After identifying similarities and differences, we selected examples to explain how
standards, albeit digitized, are still fragmented. This serves as first evidence for our
hypothesis that using digital systems, and developing standardizations, does not
automatically enable adoption and integration of IT users.

FINDINGS

Our findings show that modelled realities used by information modelers were represented in:
(1) international, (2) national and (3) organizational standards. The case study, both
through observations of the work practices and study of asset management guidelines,
reveals that, for example, each utility owner prescribed her own asset data registration
standard, based on their own work practices. According to the modelers, the
organizational standards were used more frequently than the international and national standards. Since most examples follow from these organizational standards, these will be elaborated on below.

The modelled realities represented in the organizational standards describe a comprehensive set of utility asset data. To this end, we found around twenty to forty infrastructure objects within a single reality, dependent on the type of utility discipline. Captured realities within the telecom discipline, for example, covered around twenty objects, whereas realities from the gas discipline covered up to forty objects. Most of the infrastructure objects found belong to the component level of El-Diraby and Osman's (2011) typology of infrastructure objects. We also found extensive lists of attribute information for the infrastructure objects at hand. Within elicited realities from the electricity domain, for example, up to fifteen attributes for the component level object 'kabel' (cable) were found. Within this example, spatial and dimensional attributes were, amongst others, included. A comparable number of attributes was found for other infrastructure objects.

When comparing the abstracted realities, we found that in general similar objects and attributes were captured in the standards. Standards include comparable component, subsystem and system level objects. This finding also applies to the type of attributes captured. However, a more detailed comparison between these standards - i.e. realities - shows differences. Following the typology of Gasevic et al., (2009), three illustrative differences are presented in more detail, while briefly noting others:

First, one example of a taxonomical difference is visible when comparing three standards of the telecom discipline. These standards use subsystem level and system level objects to model their telecom network in the following two ways. First, two standards use subsystem level objects to model their coaxial and fiber network as individual subsystems. Their main telecom network, including both the coaxial and telecom network, is modelled on top of the taxonomy at the system level. Second, one standard models both the coaxial and fiber network on the subsystem level as one main telecom network. The particular network type here is specified as an attribute of the subsystem object, i.e. the main network.

Another taxonomical difference, for example, is visible within the modelling of the object 'station' (station) when comparing three standards of the gas discipline. Where two standards model a station as one single component level object and define its type (internal, external) at the attribute level, one other standard defines the type of station already at the component level object. In total, we found around six taxonomical differences.

Second, an example of the way in which realities are modelled with a different vocabulary is the similar use of the words 'meting' (measurement) and 'nauwkeurigheid' (accuracy) when comparing two standards of the electricity discipline. Both standards use these words to describe the type of measurement of coordinates (either analogous or digital) in order to estimate how accurate the coordinates of component level objects are.

Another notable difference in use of vocabulary, for example, is the similar use of the words 'ligging' (area) and 'locatie' (location) to describe the x and y coordinates of a component level object. Differences in use of vocabulary were found to be most frequent, compared to the other types of differences in ontological representation. In total, we found around fifteen differences of the way in which realities are modelled with a different vocabulary.
Third, a semantic difference in the elicited realities is the ambiguous meaning of the word 'uitvoering' (implementation). The word is used to describe various characteristics of objects on mainly the component level. Six standards across the telecom, gas and electricity discipline, show the use of the word to describe divergent characteristics such as diameter, manufacturer, material type, and installation type. This difference was even found in individual realities of the gas discipline. In addition, in three standards of the electricity discipline, the word is used to describe multiple characteristics at once, including manufacturer, material and diameter.

Other examples of semantic differences include the ambiguous meaning of both the words 'sort' (soort) and 'type' (type). Similar to 'uitvoering' (implementation), these words are used to describe various characteristics of objects, being mainly the installation type and material type. In total, we found around eight examples of semantic differences.

Findings show that assets were modelled in standards for international, national and organizational communities. There seems to be a favored use of organizational standards defined by utility owners, rather than international and national standards. Moreover, the results show differences in ontological representations, since the elicited realities differ in their structure, use of terms and linguistic meaning of their representation.

**DISCUSSION**

Many organizations nowadays digitize their assets (e.g. Bradley *et al.*, 2016; Lu *et al.*, 2015; Pauwels *et al.*, 2016) through applications like BIM. Consequently, lots of different digital knowledge bases for software systems are created. Whereas it is believed that digitization of the information relevant to the construction asset's life cycle further integrates stakeholders, the existence of different realities - as represented in standards - has implications on the successful adoption of digital practices.

Realities in utility companies show differences in regional coverage and the ontological aspects taxonomy, vocabulary, and semantics. The realities, therefore, reveal different standards. This stresses the importance of the perspective of philosophy on integration. The utility owners studied create their own knowledge base, from their own perception on how to model the reality. Every utility owner, therefore, followed her own organizational standard. Moreover, these various standards reveal different realities and work practices. Literature argues that work practice differences and lacking acceptance of standards provide barriers to successful IT adoption (Adriaanse *et al.*, 2010), but we add to this that, even with usage of locally accepted standards, it is not likely that an integrated digital practice emerges. This eventually limits the adoption of a sector-wide uniform digital modelling practice.

Differences in standardized realities cause confusion in a digital reality. One reason for this observation may be the fragmented nature of the AEC industry. According to Dubois and Gadde (2002), the AEC industry as a whole can be featured as a loosely coupled system, which stimulates the generation of variation. Because of this loose coupling, and therefore, fragmentation, it is not a great surprise that also fragmented realities are seen in digitization practices. A second reason may be the existing assumption in technology acceptance models on the effect of standardization. The study showed that without a shared and accepted standard, fragmented realities are likely to emerge. Whereas standardization is believed to be a driver of adoption and integration of digital practices, fragmented standards mainly cause confusion and thereby delimit collaborative digital practices.
This study contributes to literature as follows. First, this study adds better understanding to the dynamics underlying the studies that identify 'factors' for the adoption of technology and concludes that effectivity and efficiency of inter-organizational technologies are sometimes below average (Hjelt and Björk 2006; Sulankivi 2004). By going beyond assuming that digitization, via standardization, leads to integration, we provide evidence for the hypothesis that technology adoption in an emerging field goes in line with the definition of many standards. Based on this, we argue that such digital standards need to be unified and shared before being able to achieve collaboration benefits of information systems. This notion of 'varied standardization' should receive greater attention in technology acceptance models.

The limitation of this study is that it focussed only on the modelling practices in the utility domain. Although this is not representative for the full construction industry, it provides valuable lessons for other domains in construction where digital systems are not yet adopted by the larger community - e.g. in lower-tiers of supply chains and infrastructure domains. Therefore, we believe that the differences in realities found in this study are likely to learn the utility industry and the wider construction community about the importance of considering shared domain understanding in research as well as in industry digitization initiatives. Future studies can confirm these findings by extending our work with observation in other parts of the construction sector. Moreover, this study has only assessed digitization of construction asset data from an ontological perspective. Future studies should elaborate on the effect of other types of standards on the integration of stakeholders through digitization.

CONCLUSION

This study postulates the hypothesis that digitization of the construction asset life cycle does not automatically lead to integration of stakeholders and more collaborative work practices. Our findings show that modelled realities are represented in international, national, and organizational standards. Although similar objects and attributes were captured in the various digital modelling standards, we show that these are 'standardized' in distinctive ways. A selection of examples from digitization practices in the utility sector illustrates differences in how domain knowledge is represented. The examples show how elicited realities differ in use of taxonomy, vocabulary, and semantics. This provides evidence for the existence of diverging realities. Such differences in modelled digital realities are likely to create ambiguity and may, therefore, fragment and ultimately delimit integration of digital practices.

The existence of the distinctive standard realities imply that the utility sector currently lacks a uniform digital modelling practice. This, in turn, limits the possibilities for IT developers to align information systems that exchange network data in a uniform way between network operators and contractors. These observed diverging realities seem less present in the facility and building industry. This part of the construction industry already established and adopted the object-modelling standard IFC.

This study confirms that various standards can co-exist in the utility sector. One reason for this may be that this domain is currently making the transition toward a digital practice for planning and managing their assets. This demonstrates that, while a sector moves toward implementing digital practices, this does not immediately lead to unification of practices and communication flows.

The example shows that initiatives that are aimed at stimulating 'digital collaboration', should be cautious in assuming that digitization immediately supports integration. We,
therefore, urge practice in developing standards that capture shared ontological understandings. Such shared perception is a precondition for achieving integration though digitization in the fragmented construction sector.

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GREEN SUPPLY CHAIN MANAGEMENT IN CONSTRUCTION: A SYSTEMATIC REVIEW

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The construction sector is particularly destructive of the natural world, in terms of resource and energy consumption and generation of waste. The industry itself and construction research are increasingly focusing on ways in which the construction process can become more environmentally sustainable. The concept of green supply chain management in construction (GSCMC) addresses the issue, following advances in green supply chain management in other sectors. However, a systematic review of scholarly work on GSCMC is unavailable and this paper aims to address the gap by providing a timely and thorough review of existing research. Applying the established method of Systematic Literature Review, an initial search yielded 207 papers, with a final set of 44 relevant peer-reviewed papers analysed in detail after systematic and transparent refinement. The field shows an increase in interest from 2012 and a more dramatic upturn in 2016 and 2017. Little attention has been paid to conceptual definitions or theoretical frameworks. The papers acknowledged different stakeholders but few considered how GSCMC may vary by role. An agenda for future research is proposed, including the need for end-to-end as well as detailed, subdomain studies, for different stakeholder perspectives and for addressing the challenges specific to fragmentation and potentially adversarial relationships in the industry.

Keywords: green supply chain management, systematic literature review

INTRODUCTION

As a sector, construction extracts a heavy toll from the natural environment. The industry consumes enormous quantities of raw materials, produces prodigious amounts of waste and is responsible for a major proportion of global carbon emissions. Environmental sustainability in construction is a pressing concern for the industry and society globally (Kibert, et al., 2000). In response, sustainable or green supply chain management (GSCM) has much to offer. Complementing the burgeoning literature on GSCM in different sectors, practitioner and research interest in GSCM in construction is developing. However, the challenges for the construction sector are in some ways different from other industries and a systematic review of the application of GSCM in our sector is unavailable. The study presented here aims to address this gap by providing a timely review of existing research on GSCM in construction (GCSMC²). It contributes to the literature in its synthesis of work to date and proposed agenda for future research.

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2 In the discussion below, GSCMC refers specifically to green supply chain management in construction, whereas GSCM is used to refer to green supply chain management more generally.

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The paper is based on a systematic review of the literature. The context for the review is first outlined by summarising the evidence for the environmental impact of construction and governmental and industry concerns. The method of systematic literature review (SLR) is then explained. A descriptive analysis of the literature is presented followed by a synthesis, both selective due to space constraints. Finally, an agenda for future research is proposed. The aim is to provide researchers with a consolidation of work done and pointers to current weaknesses and gaps, that is, to describe the status of the field and to indicate areas not yet addressed.

The fifth assessment from the Intergovernmental Panel on Climate Change reports the built environment as a major determinant of energy demand (Lucon et al., 2014). The sector is recognised as heavily dependent on extraction of raw materials (European Commission, 2008). Construction and demolition waste constitutes one of the highest volume waste streams in the EU, generating between a quarter and a third of all EU waste (EU, 2015). Its high consumption of resources and energy, in delivery of the built environment and in operation of buildings and infrastructure thereafter and its generation of heavy, voluminous and mixed waste contribute to the construction sector’s particularly negative environmental impact. This impact is exacerbated by the long-term nature of the final product: today’s buildings and infrastructure ‘lock in’ energy consumption over the next decades (Lucon et al., 2014) and represent a potential legacy of future waste. National and regional governments worldwide have recognised the challenges and are reacting with tighter legislation (c.f. EU waste reduction) and initiatives to lead by example. The industry too has begun to address the challenges, with over 70 national Green Building Councils working to offer leadership and co-ordination. Environmental performance assessments such as BREEAM and LEED are increasingly applied to new developments and innovation on materials continues. However, the character of construction as a fragmented industry remains an issue and the need for systemic approaches and collaboration within and across sectors in the construction supply chain has been proposed as crucial for more rapid progress. The domain of green supply chain management (GSCM) offers such a systemic and collaborative approach. GCSMC then is critical to facilitating more sustainable construction and reducing the sector’s negative impact on the natural world of today and tomorrow.

Before describing the method for the research, it is important to clarify the primary term and distinguish it from concepts with which it is sometimes confounded. At this point, the definition is necessarily high-level - in the discussion below, we consider the definitions in the literature, offer a more rigorous formulation and discuss the challenges of definition. GSCMC is initially defined as activities aimed at reducing the environmental impact of the supply chain for the built environment. It is differentiated from sustainable supply chain management, a broader concept that incorporates economic and social sustainability as well as environmental (Ahi and Searcy, 2013). The aims of GSCMC also differ from those of lean supply chain management (SCM) lean principles address the identification and managing out of waste with the objectives of increasing efficiency, lowering cost and providing improved value to the customer (Banawi and Bilec, 2014). The objectives of GCSMC centre on environmental performance.

**METHOD**

A systematic review of a research literature is a critical appraisal of previous studies conducted using a methodical and transparent process. Originating in the field of health as a method offering a rigorous approach to the synthesis of empirical data, SLR is applied increasingly widely in a broad range of domains where a thorough and
comprehensive review can contribute to knowledge (Briner and Denyer, 2012). The systematic review differs from a non-systematic or expert review in its explicit recording of all decisions pertinent to the review. Beginning by mapping the territory in an explicit manner, the systematic review then attempts critically to examine the included studies and synthesise the findings into a coherent account of the field. The current paper is aimed at consolidating existing knowledge for the research community. The method can also be used to distil empirical evidence for practitioners and the practical insights from the GSCMC literature are discussed elsewhere in a longer version of this paper (in preparation).

Following the stages set out in Gough et al., (2012) table 1 summarises the protocol for the current review. The objective of the review was to evaluate the status of the field and to identify directions for future research.

### Table 1: Systematic review protocol based on Gough et al., (2012)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Define the research questions</td>
<td>What is the status of research on GSCMC? What are the key insights?</td>
</tr>
<tr>
<td>2</td>
<td>Define the exclusion/eligibility criteria</td>
<td>Paper in English in peer-reviewed journal. Published before 31st August 2017. Paper topic is green supply chain management. Paper focus is the construction sector.</td>
</tr>
<tr>
<td>3</td>
<td>Define search terms and sources</td>
<td>Search terms: supply chain AND (green OR sustainable) AND construction IN subject. Sources: a proprietary metadata integrator (Primo Central Index supplied by Ex Libris) which receives data from over 500 sources, including Scopus and Web of Science.</td>
</tr>
<tr>
<td>4</td>
<td>Search, screen and compile set of included studies</td>
<td>207 papers found; 163 excluded, of which 14 duplicates; 44 papers in final set.</td>
</tr>
<tr>
<td>5</td>
<td>Analysis: code and critically evaluate included studies</td>
<td>Thematic analysis: deductive based on coding structure; then inductive critical evaluation.</td>
</tr>
<tr>
<td>6</td>
<td>Formulate synthesis</td>
<td>Thematic synthesis: deductive based on analysis by codes; inductive critical evaluation.</td>
</tr>
</tbody>
</table>

In order to ensure high quality, only papers from peer-reviewed journals were selected. In determining whether a paper addressed GSCMC, decisions on inclusion were challenging given the fuzzy boundaries of the topic. The guiding rule applied was that, for inclusion, the research or discussion had to cross stakeholder boundaries or consider the perspectives of different supply chain actors. The default decision was inclusion if the paper was found from the search terms specified, as the original authors deemed their work as relevant to GSCMC through their choice of keywords or phraseology. Papers that addressed any aspect of construction were included, whether focused on a specific sub-sector such as road maintenance or construction more generally.

To ensure rigour, both authors independently conducted the search and assessed the papers for inclusion in two stages: (a) reviewing title, keywords and abstract; (b) skim reading of the paper. At each stage, any discrepancies were discussed and if not resolved, the paper was included in the next stage.

The a priori coding structure comprised: focus (specific subdomain or industry generic) aim, method and findings. Emergent themes were added as analysis progressed and comprised: stage (planning, design, procurement, etc.) definition of GSCMC, use of theory and stakeholders. Analysis proceeded by coding theme: A brief summary was produced for each theme. The summaries were then integrated into an initial synthesis, which drew out the main themes, gaps and areas for future research. This overview was
then checked back to the papers in a second, detailed review. The thematic summaries were extended, the overview findings were refined and the future agenda was expanded into greater depth to provide the final synthesis. A limited set of themes from analysis and from the synthesis are presented below due to restrictions on space.

**ANALYSIS**

**Research Interest over Time**

No qualifying papers were found from before the year 2000. A small proportion (16%) were published up to and including 2011 and the field shows an increase in interest from 2012 and a more dramatic upturn in 2016 and 2017 (see Figure 1). With growth in interest in GSCM in general being mapped to the early 1990s (Zhu and Sarkis, 2006) it would appear that construction and allied research fields have been slow to adopt the concept, but that research interest in application of the concept is now firmly underway.

*Fig 1 Number of papers by year of publication*

*Note: papers published up to 31.08.2017 were reviewed so the 2017 total is partial.*

**Source Journals**

The 44 papers appeared in a surprisingly large variety of journals, 31 in total, with only three publications including multiple papers on the topic: Journal of Cleaner Production published 10 of the papers; Sustainability (Switzerland) published three and Journal of Construction Engineering and Management and WIT Transactions on Ecology and Environment, each published two. With papers published in disciplinary outlets ranging from Waste Management to Resource Policy to Building Research and Information, there is evidence of wide interest in GSCMC and related topics, with recognition of its importance across many disciplines. The range of publication outlets also speaks to the multi-faceted nature of the construct.

**Methods**

A variety of methods has been used to examine different facets of GCSMC (see Table 2). Fifteen papers applied specialised quantitative methods, including material flow analysis, modelling, lifecycle analysis (LCA) and organisational environmental footprint, to examine particular questions within the GSCMC process. The remainder of the studies used a range of methods: interviews only (5) survey only (6) mixed methods of interviews and surveys (5) and case studies (6). In most cases, the number of cases was appropriate for detailed analysis, with up to 31 individual professionals being interviewed and usable
responses on surveys ranging between 39 and 455. The literature therefore is generally founded on a solid empirical base. The exceptions were studies with low numbers of interviewees (2) and one paper in which data sources were not quantified making it difficult to assess robustness.

Table 2: Methods used in reviewed papers

<table>
<thead>
<tr>
<th>Method</th>
<th>Number of papers</th>
<th>Further information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviews</td>
<td>5</td>
<td>n = 4 to 31</td>
</tr>
<tr>
<td>Surveys</td>
<td>6</td>
<td>n = 39 to 455</td>
</tr>
<tr>
<td>Mixed</td>
<td>5</td>
<td>Interviews n = 6 to 29; surveys n = 27 to 84</td>
</tr>
<tr>
<td>Case study</td>
<td>6</td>
<td>Cases included reuse process; project supply chain</td>
</tr>
<tr>
<td>Action research</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Lifecycle analysis</td>
<td>7</td>
<td>Lifecycle analysis and associated methods</td>
</tr>
<tr>
<td>Other modelling</td>
<td>8</td>
<td>Including decision models for subcontractor selection</td>
</tr>
<tr>
<td>Commentary or literature review</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Stakeholders

The range of stakeholders referred to in the papers surveyed illustrated the complexity of the construction supply chain. Beyond the suppliers and logistics operators who would be expected to feature in SCM more generally, reference was made to developers and clients (10 papers) construction professionals including architect/designers, engineers, project managers and specialist subcontractors (15) and principal contractors (4). Opinions varied on the level of commitment and motivation of different stakeholder roles. While most authors who commented on stakeholder responsibility considered the client/developer as an important driver, not all considered the general contractor to be motivated to green the supply chain (Wong et al., 2016). Some scholars viewed designers as having limited incentive to collaborate in green supply chains (Wong et al., 2016, Balasubramanian and Shukla, 2017b) but others argued that the design team has a major influence on the final product through design and materials selection (Albino and Berardi, 2012, Arroyo et al., 2016, Sertyesilisik, 2016).

The absence of discussion of stakeholders in almost one third of the papers, however, represents a weakness in the literature reviewed, through omission of one of the primary foci of GSCM (Ahi and Searcy, 2013). Further, as Balasubramanian and Shukla (2017b, 2017a) argued, stakeholder perspectives differ and therefore the different standpoints, approaches and objectives of each stakeholder should be examined.

Definitions of GSCMC

Not all authors sought to define GSCMC. Many of the papers with a complementary focus to GSCMC defined ancillary concepts such as lean or sustainable construction, sustainable materials management, waste management and reverse logistics. Where authors provided definitions of GSCMC, most were operationally focused, specifying the constituent processes. Green procurement featured extensively, along with green manufacturing, green distribution, green purchasing, green production, green consumption, green transportation, green design, packaging and waste minimisation. These processes themselves were rarely defined. The objectives of GSCMC were considered in some papers and these were proposed to be: to enhance competitiveness, to add value for stakeholders, to improve environmental, economic and operational performance, to improve service, increase market share and sustainability of supply.
increase operational efficiency, cut costs and minimise risks or for ethical reasons and to reduce environmental impact. Surprisingly few authors attempted to consider a more conceptual perspective although in a small number of papers, there was recognition of the holistic, end-to-end perspective. These papers emphasised integration of processes between suppliers and clients and integration of green practices into business processes and into inter-organisational SCM. The findings here echo those of Ahi and Searcy’s (2013) systematic review of GSCM definitions, in which they found limited consideration of principles of business sustainability such as a stakeholder focus and long-term perspective.

Theory

Given that GSCMC is a form of SCM (Ahi and Searcy, 2013) an a priori assumption that the research papers would draw extensively on SCM work to inform their studies theoretically was not borne out. Use of the SCM literature was generally limited although a few papers harnessed previous insights from SCM, including an end-to-end perspective and the importance of trust to facilitate inter-firm integration, issues of supply chain integration and the importance of co-makership in innovation. The absence of theoretical frameworks for GSCMC was a noticeable weakness in the literature surveyed, with a few exceptions. Balasubramanian and colleagues offered the only new theoretical framework proposed for GSCMC in the papers reviewed (Balasubramanian, 2014, Balasubramanian and Shukla, 2017a). Deriving first a quadrant-based categorisation of enablers of GSCMC, based on an extensive review of the GSCMC literature (Balasubramanian 2014), Balasubramanian and Shukla (2017a) proposed and tested a nine-construct structural model. In which they demonstrated the relationship between internal and external drivers and barriers to core and facilitating green practices and the relationship between core and facilitating green practices and environmental, economic and organisational performance. Further, they tested these relationships for four main roles in construction (developer/client; architect/designer; major contractor; material suppliers). This represents an important step forward in the literature in offering a tested framework which future research can seek to apply or extend.

SYNTHESIS

Overview

The review of 44 papers showed rapidly increasing interest in topics associated with GSCMC, following somewhat later than a more general surge in research interest in GSCM in other industries (Zhu and Sarkis 2006). The spread of journals in which relevant studies have been published demonstrates wide interest and is a promising basis for a thriving research domain. A mixture of methods has been used, including in-depth interviews, surveys, mixed methods, case studies and modelling, which provides a generally robust empirical base, with a few exceptions where insufficient data were provided.

Definition

A point of note was the failure of many papers to define explicitly what they understood by GSCMC. Da Rocha and Sattler (2009) drew on earlier definitions of SCM as (a) the activities involved in the flow of goods or services from primary source to end client and (b) the integration of the main processes between suppliers and end client to add value for stakeholders. The latter usefully draws attention to a strategic business objective of SCM - that of adding value - although the definition is quite narrow in its limitation to integrated processes: this omits critical aspects of SCM such as developing inter-
organisational relationships. The former definition, in contrast, uses a broad conceptualisation but the underlying model is linear which poses problems for a sustainable economy in which circularity - the retrieval and reuse of resources - must feature.

Across the set of papers, it is noteworthy that there is limited discussion of how GSCMC may be understood as similar to but differentiated from SCM. A final striking absence in terms of definition is the concept of ‘true sustainability’ - the notion that the end goal (even if not wholly achievable) must be the absence of adverse environmental impact, the potential for positive environmental contribution and for indefinite continuance of the supply chain (assuming non-supply chain factors remain favourable) (Pagell and Wu, 2009).

Drawing on the papers reviewed, a definition of GSCMC is now offered. GSCMC comprises the management of all activities in an organisation related to minimising the environmental impact of all of its supply chains, which contribute to its final products, with the aim of achieving zero net harm and the potential to operate indefinitely, given an available market. The activities comprise, at a minimum, green purchasing. GSCMC can also include green design, green manufacturing, green transportation, waste management, green operation and end-of-life management. The objectives of GSCMC comprise improved environmental performance, improved business performance through greater efficiency, increased competitiveness and increased value to stakeholders.

Across all supply chain actors, GSCMC requires management of the above activities to achieve the required objectives, that is, planning, control, measurement, monitoring and evaluation. The activities, objectives and management of GSCMC will vary by role of firm, as discussed below. Successful GSCMC requires relationship management as part of greater integration of business processes and systems along supply chains. This is offered as an overarching definition and is therefore relatively abstract, aiming to address the notion of GSCMC at a conceptual level. There remains a need for complementary and partial definitions at a more concrete level, relating directly to perspective of stakeholders.

Stakeholder perspective

Within construction, critically, the role of the firm influences its primary GSCMC activities, with the contractor holding key responsibility for green transportation and architectural and engineering consultants for green design, for example. This entails fundamentally different processes and different management challenges. By implication, different definitions of GSCMC by stakeholder may be appropriate. Balasubramanian and Shukla (2017a) have led the way in their analysis by organisation type but further research specific to the role in the construction project team is needed.

FUTURE RESEARCH AGENDA

Having synthesised key themes from the papers, gaps which merit further research were identified.

Detailed Research on Subdomains

The complexity of supply chains in construction speaks to the need for both detailed, subdomain specific as well as sector generic research. For example, it is not known if the same principles or the same priorities in operational processes and procedures apply across all types of projects - are there differences, for example, in managing the supply chains for residential development where high numbers of units of similar design will be
constructed and in managing the supply chains for a mixed-use commercial development? Similarly, it is not yet known if the same approach should be taken for different components and materials. Studies to add to knowledge are required which consider the issues by size of focal organisation, by material (further work on timber and aggregate, new studies on window systems, roof systems, HVAC, for example) and by type of project (in additional to the work on residential, studies on commercial, health, education, hospitality and infrastructure projects).

**End-to-end Perspective**

Further, an holistic, end-to-end perspective is also needed - a long-term view which in practical terms should look for the greatest impacts along the supply chain in order to achieve the greatest and/or most rapid improvement. Although it has been suggested that the failings of any one link in the supply chain weakens the supply chain’s overall performance (Balasubramanian and Shukla, 2017a) not all supply chain roles are equal. Supply firms may vary dramatically with respect to their environmental impact and resources (time, expertise, finance) are best applied to the most damaging aspects in the chain. This points to the value of a ‘hotspot’ analysis along a whole supply chain (Dadhich et al., 2015) to facilitate the most effective commitment of resources and potentially quicker beneficial impact.

**Stakeholder Perspective**

In parallel with an end-to-end perspective, potentially owned by the client, there is a need to investigate what GSMC means for different roles within the supply chain further. Building on the work of Balasubramanian and Shukla (2017a) research is needed on the similarities and differences of managing a green supply in developers, primary and general contractors, tier 2 contractors, specialist subcontractors, trades, different types of consultancy and process (e.g. cement) and product-oriented (e.g. façade systems) suppliers.

**Particular Challenges of Construction**

The ARCOM2018 theme of balancing fragmentation and integration highlights a primary area for future research within GSCMC. Of the reviewed papers, the few which gave thorough consideration to the nature of the construction sector pointed to challenges to the industry. The project-based nature of construction which contrasts with long-term alliances in manufacturing, for example, means that relationships between commissioning firms and suppliers are often one-off and short-term and are often characterised as adversarial (Ofori, 2000). This works against the SCM ideal of deepening relationships with suppliers to pursue integration of processes (Seuring and Gold, 2013).

In particular, the development of trust between firms, identified as crucial to stronger inter-organisational relationships (Loorbach et al., 2010) takes time to develop. Within construction, it has been noted that partnering and alliances do not necessarily bring trust and absence of competition (Bossink, 2007). Although alluded to, the issues of fragmentation and the challenges of integration along construction supply chains have not yet been subject to detailed study. Beyond these gaps, perspectives that are more critical have yet to be considered (e.g. Gold and Schleper, 2017). These topics warrant research scrutiny if the potential of GSCMC to address the socially critical concerns of environmental impact is to be realised.
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THE PROBLEM OF DEMAND IN AFFORDABLE HOUSING

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Studies on affordable housing tend to focus on supply-side concerns with less attention paid to demand. In this review, we consider the problem of ‘demand’ to identify fresh perspectives and questions that will extend our understanding of the challenges associated with affordable housing. The complexities of studying ‘demand’ are drawn from a range of disciplines. From an economic perspective, ‘demand’ is a result of techno-rational choices by individual actors in the marketplace. Yet, such a linear approach runs counter to a sociological understanding, where demand is produced by complexes of social practices. Taking a linguistic turn, ‘demand’ raises questions as to how society is brought to order, and how the rhetorical discourses of affordable housing need to account for the needs of vulnerable groups of people whose voices are currently excluded in the formal ordering of requirements through social and institutional arrangements. We reflect on these three variants of conceptualising ‘demand’ to question power relations and encourage the problematising of a more inclusive society through affordable housing.

Keywords: affordable, housing, demand, review

INTRODUCTION

Globally, affordable housing has become a policy priority and topic of considerable research interest. Despite a wealth of research into affordable housing, insufficient supply which cannot keep up with the demand remains a perennial problem (Gabriel et al., 2005, Mulliner and Maliene, 2011, Gan et al., 2017). Worldwide demand for affordable housing has grown in recent decades and is expected to continue to grow each year (Wallbaum et al., 2012, Schwartz, 2013). Furthermore, the problem of poor housing affordability is becoming more acute in many cities facing rapid urbanisation and housing is, for many people, their major expenditure and critically affects the quality of life (Ezebilo, 2017). Recent economic and foreclosure crises have also led to a tight housing market that makes it difficult for many to meet their housing needs especially those in the weaker economic band. This raises the question of how the increased and increasing demand can be accommodated and tackled (Makinde et al., 2014).

In this review paper, we establish that studies on affordable housing have tended to focus on supply-side concerns with little attention given to demand. These studies tend to address the work that provider/developers, government, and community at large perform, can and should do to improve capacity of affordable housing financing and production (Nguyen, 2005, Goetz, 2008, Tighe, 2010, Albright et al., 2013, Davison et al., 2016). Milligan et al., (2004) reviewed potential policies and strategies that would support an expansion and diversification of affordable housing models in Australia. And others have paid attention to the planning system as an alternative solution to shortage of housing

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supply (Paris, 2007, Whitehead, 2007, Gurran, 2008, Austin et al., 2014, Gurran and Bramley, 2017) with some scholars addressing barriers to promoting supply of affordable housing, such as opposition due to NIMBYISM and negative connotations associated with the term ‘affordable housing’ (Goetz, 2008, Tighe, 2012, Albright et al., 2013, Nguyen et al., 2013, Davison et al., 2017). There are also studies on regulatory regimes to motivate private developers’ interest in the supply of affordable housing. The use of low income housing tax credit in the US and application of Section 106 in the planning section in the UK are a few examples of how regulatory levers can enable the supply of affordable housing (Cohen, 1997, Oakley, 2008, Sidawi, 2009, Walter et al., 2017). What is lacking in these studies is concerted efforts to examine demand-side issue, including the perspectives of household end-users.

Against this backdrop, this paper revisits the concept of affordable housing from the perspective of demand. To understand ‘demand’, we draw on three perspectives, including economic, sociological and linguistic (discursive) to offer insights into how appreciating demand from these multiple viewpoints can stimulate fresh research questions on the study of affordable housing.

In what follows, we first provide an overview of the meaning of affordable housing and point at significant reliance on "income versus housing expenditure model" to describe affordability. We then introduce the concept of 'demand', economically, sociologically and linguistically, before discussing the potential for mobilising these lenses to examine affordable housing from a demand perspective.

What is Affordable Housing?

Despite almost daily reference in the media and significance in the research and policy documents of the need for more affordable housing, there is a little agreement about what affordable housing actually mean. The term 'affordable housing' means different things to different policy fields, depending also on the policy interests of respective governments and authorities (Mulliner and Maliene, 2013).

Bramley and Karley (2005: 687) argue that most definitions of affordable housing in the UK housing policy are centred on the phrase such as "a decent home for all families at a price within their means". Consequently, the provision of affordable housing has, in some instances such as the UK, resulted in the provision of a diversity of housing tenures for low or moderate-income households at sub-market rents or prices. However, definitions such as that proffered by Bramley and Karley (2005) leave some of the questions unanswered like what it means by a "decent" home, how different and evolving "family" structures impact on conceptions and perceptions of 'affordable housing', and what it means to live "within one's means" when there are widening inequalities. In the UK, government policy on affordable housing maintains that "everyone should have the opportunity of a decent home, which they can afford, in a community where they want to live" (CLG, 2011, p.6). Yet, the literature on 'affordable housing' also neglects spatial perspectives by implicitly assuming geographic homogeneity (Mulliner and Maliene, 2013).

Making a comparison between household income and housing expenditure is frequently a common way to define affordability. The US Department of Housing and Urban Development considers a house as affordable if households spend no more than 30% of their disposable annual income on housing cost (Nguyen, 2005, Stone, 2006). This blanket criterion has attracted some criticism for failing to consider personal preferences and choice when it comes to the provision of affordable housing (Mulliner and Maliene,
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2011, Jana et al., 2016). Nevertheless, the use of a ratio of disposable income against housing costs is a standard way adopted by various governments to assess one's needs and eligibility for affordable housing.

**Antecedents of Studying Demand**

The term demand has quite a number of different meanings, depending on the perspective taken. Oftentimes, demand is used as a quantitative measure of the market from the buyer's perspective (Smith, 1951). The Oxford Dictionary notes that demand can be used as an authoritative requirement, a need actively expressing itself or the manifestation of a desire on the part of the consumers, client or employer for a particular commodity (Oxford English Dictionary online, 2018). In this paper, we consider a variety of ways of studying and interpreting demand drawn from economics, sociology, and linguistics to explore how these can enrich discussions and debates on affordable housing.

**Demand: Multiple Perspectives**

**Economics**

Demand and supply are terms which are perhaps two of the most fundamental concepts in understanding the marketplace. The terms supply and demand refer to the behaviour of buyers and sellers of a particular good or service. Together, buyers and sellers form the market for the particular commodity. The concept is best clarified in most elementary textbooks of economics. As an example and reference, "Essentials of Economics” by Harvard economist Gregory Mankiw (2009) is used.

Demand carries a broader meaning of undertaking utility for satisfaction. It shows the users’ need and ability to obtain a certain product or service (Ball and Seidman, 2011, Joffe, 2017). Without demand, no business would bother producing anything. In other words, demand is typically measured as the rate at which consumers want to buy a product or enjoy the service. It consists of the desire and ability to acquire a service or product. Desire explains the test for a product and a willingness to buy at a specific price while ability means one must possess sufficient income to acquire it. The price of a product or service serves a particular importance as it makes markets work. The affordability (ability of customer to pay) makes demand effective, therefore plays a crucial part in demand (Mankiw, 2009). That is to say while consumer's desire is to purchase a product; they are limited by their ability to do so even when the need is of very high importance. Put simply, demand represents what people want and their purchasing power.

From an economic standpoint, the trade-off that consumers make between available goods and services when allocating scarce resources of time and money is very important and makes it very critical to be addressed (Garber-Yonts, 2005). There is an assumption that during purchase, consumers make sensible, rationale choices of utility maximization which originate from Narasimhan work (Parsa and Njite, 2008). Taking such a rational view implies that buyers can exercise their freedom in the framework of a free market. In the context of affordable housing, where those who demand such commodity are often vulnerable segments of the population who live on the margins of society with low or no income, this freedom is questionable.

It is also well established that not everyone can afford certain type of products that they desire due to a wide distribution of disposable income in society which creates different purchasing power (Mankiw, 2009). Those with high purchasing power have more control on demand and may afford luxury high price goods. It is a different story for those in weaker economic segment who often are vulnerable and marginalized as demand is a
matter of desire and affordability. Most households may be considered ineffective in demand simply because they have less power to influence and acquire their needs and are automatically excluded from the housing market. The power dynamics similarly affects what is being produced in terms of housing and mostly reflects those with high purchasing power (Joffe, 2017), making vulnerable more helpless and left out. Past and current records have shown that the market and private housing developers that primarily comprise it, cater mainly to upper income households and do not build adequate housing that is genuinely affordable for low- and many middle-income households. From an economic perspective, ‘demand’ is often framed in quantitative terms where balancing supply and demand results from rational, technological choices made by individual actors in the marketplace. Yet, such a linear relationship runs counter with other social economic view.

**Sociology**

Sociologically, demand is framed as a product of social practices by which demand is produced and reproduced. Through such a lens, demand is less of a quantitative measure of output. Rather, society demands commodities such as housing to serve a wider practical function (for instance, of sheltering oneself from the elements of weather, of living, of raising a family, of subsisting or working, and so forth). Shove and Walker (2014: P48) describe social practices as “recognizable blocks or patterns of activity that are filled out and enacted by practitioners, that is, by those who do, and who, in the enactment and performance of these doings reproduce, transform and perpetuate the practices they carry”. Certainly, social life, emerges as part of a mesh of practices and depends on material arrangements (Shove and Walker, 2014). A number of social issues will influence one’s desire for a particular housing. Studies have shown that household’s link acceptable social amenities and mobility to their choice of housing and therefore the social view of demand for affordable housing cannot be ignored.

Different social practices condition the life of vulnerable people. These groups including members of ‘the working poor’—those employed in low wage, often casual service sector jobs are often trapped on these social and institutional arrangement and found themselves in a viscous circle of poverty that they cannot get out (Berry, 2003). Taken as a whole, vulnerable groups are more likely than the rest of the population to live in poor localities (in so-called ‘Ghettos’) that are far from the decent job market, resource poor, and deprived neighbourhood, be unemployed, have low incomes or no income, live in poor housing, have poor health, and be the victims of crime due to unaffordability (Watt and Jacobs, 2000).

Vulnerable people are stuck as they have limited choice and power and therefore they cannot leave for better places. This in turn affects their ability to improve their health, education, income and reputation and repeat the vicious circle of poverty. To tackle the issue of affordable housing one may need to understand social systems and the kind of practice that needs to be in place to get these vulnerable populations out of the trap of poverty. Any change to these practices would result the change of demand for affordable housing, and we should aim at positive changes with positive results to the venerable households.

**Linguistic**

The etymological roots of the term “demand” comes from the Latin words -de- meaning formally and -mandare- which means to order (Oxford dictionary, 2018). Thus, demand can imply to formally order. This imply that demand is not simply defined by exogenous forces of the market in the economic lenses but raises questions as to how society is
brought to order and being able to formally placing a request or making an inquiry of things that matters to them.

Understanding demand raises the need to examine ways in which vulnerable segments of people in society may be excluded from formally ordering their requirements through social accounts like housing. Vulnerable population is a subgroup in societies who are in need of special care and support as they are socially and economically deprived. These households may include for instance homeless and workless, working but homeless, transient (e.g. Refugees), other minority groups most cases are of low income and those in work and housed but struggle due to housing stress. These different constituents of vulnerable people are not homogeneous and stable, thus represent different needs in demand for affordable housing.

From a linguistic point of view there is a question of "to formally order". You can only order if you have the power to order. The difference in power dynamics by households' influence ability and urgency to demand and the vulnerable groups might have different and perhaps difficult experience in the process of demanding their needs and rights for housing due to less power. The ability to pay is conditioned by how much money an individual has and how the money is spent. Increased demand of affordable housing can be seen as threat to social order and cohesion as the vulnerable are increasingly being pushed to the back of the housing queue (Berry, 2003).

Demand in Affordable Housing Context

The problem of affordable housing is not limited to supply but also demand. People miss housing because of high cost that they cannot afford. Affordable housing is not an isolated challenge as it affects other aspects of life such as economics, psychological and social (Schwartz, 2016). Housing demand is the number of dwelling units that are actually needed by the people at a particular point in time, while housing supply is the number of residential units that are provided by the key players in the accommodation provision (Makinde et al., 2014). Whitehead (2007) discusses that in practice, in what is clearly a very suboptimal world, neither demand nor supply properly reflect real resource costs and there are therefore many potential opportunities to improve outcomes. Whitehead (2007) recommends modifying demand by either reducing net incomes or decreasing relative price of housing to address affordability. Yet, (Gurran and Bramley, 2017) suggest that building more housing units is not a sustainable solution, so price control is not the answer to affordable housing. This may imply potential in the multi dimension of demand tied together in social practice and institutional arrangement and practice that condition and operate affordable housing market to realise and contribute to minimise the problem of affordable housing.

Literature has ample evidence on how vulnerable households are faced with the problem of affordability. They are the first group that spend more than 30 percent (in most cases more than 50%) of their income on housing and suffer acute affordability stress (Mulroy and Ewalt, 1996, Hamidi et al., 2016). They fail to formally order both housing and non-housing requirements. It is not surprising that different vulnerable households are more likely to fall victim to this pressures of housing costs burdens and as a results they are forced to make a difficult trade-offs in other social aspects like health and financial stability, food and clothing, transport and retirement saving (Hsu, Jenny, 2016) as housing is an asset so expectations matter (Barker, 2003). This category also heavily depend on public transport since their income is not sufficient to own private means of transport (Welch, 2013). Since the vulnerable cannot formally make a request on socially acceptable standard house in a potentially good location, they are forced to live in the
outskirt and spend additional time and money in transport to work and in search of other social services (Fisher et al., 2009). It can be argued that, in order to bring society to order, the demand side of affordable housing needs to be looked in critical lenses.

From the sociological point of view, it can be inferred that demand for affordable housing is increasing due to changes in some social practices and trends; for instance, getting married and home. One could argue that, currently it is very easy to be single especially in the western world by either not getting married or forming civil partnership (formally or informally). Baker (2003) argue that change in demographic formation characterised by single family households, increased divorce, improved life span and general population increase translate to extra accommodation need hence increased demand for affordable housing. It is by no means suggesting that getting married or more civil union will resolve the affordable housing crisis, yet it point out issues which need serious consideration in the planning and execution of affordable housing that reflect the current and future need of their expected households which are not homogeneous even to vulnerable groups.

Certainly, taking the economic view of demand, low income and vulnerable households are excluded from the effective demand as they desire for better and affordable housing but lack purchasing power which is fundamental in the transaction. This group tend to have less power to claim on this fundamental right of having a good shelter even though their needs are way too high in comparison to the less vulnerable. It is important to examine the differential impact of variable social conditions, the actual power over access to houses. Consideration of social position per se, the interaction between low social power and the attitude of powerlessness in conjunction with crowding should be carefully studied.

Moving Forward Toward Demand: Fresh Perspectives on Affordable Housing

The purpose of this paper is to revisit past approaches and recent developments in demand. We argue that the problem of affordable housing is partly rooted in the problem of demand; how demand is conceptualised defined and interpreted. Shifting our emphasis on demand will refocus our attention on the needs of the households and how they can be empowered to exercise their voice in framing their requirements for such a basic need as housing. By accounting for the needs of those whose voices are often marginalised in institutional accounts of what ‘affordable housing’ should entail. It is hoped that this would raise standards, rather than engage providers of affordable housing in a race to the bottom.

By framing demand through the three perspectives of economic, social and linguistic concerns, a number of theoretical and methodological questions are raised. For instance, when thinking about the needs of the vulnerable people as end-users, there is the question of "who really speaks for the end-users? Do those who demand affordable housing really have a voice, and how is that voice exercised? Often these vulnerable populations tend not to speak for themselves. Instead, their needs are spoken for or tend to be spoken to or at by other people who (supposedly) represent them. Examples of these representatives include housing associations, charities and the local authorities, many of whom may not have experienced first-hand the problems of living in indecent homes and finding affordable housing.

From a behavioural, social practice standpoint, questions are raised as to how the needs of vulnerable people are formally and informally put to order. The supply and demand of affordable housing is not just a question of quantity, but also a question of quality of that
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housing (Mulliner and Maliene, 2011). To this end, there are few studies on how requirements for quality of affordable housing are co-produced with the end-users. This is despite growing recognition of the importance of co-production of knowledge between service providers and service users. In the view of what demand is from different perspective, it might not be of essence to neglect the end user (demand side) as it is often stresses that consumption is the sole end and purpose of all production; the interest of the producer out to be attended to only so far as it may be necessary for promoting that of the consumer (Smith, 1951).

Opening up the study of affordable housing to these dimensions while looking at various needs of vulnerable users will possibly inject fresh insights. Often times the vulnerable groups are assumed to be homogeneous but that may not be the case. Plurality understanding of these group and see if their perspective on demand for affordable varies is certainly crucial.

From an epistemological standpoint, a re-focus on demand for affordable housing also raises the question of how researchers, industry stakeholders, policy-makers and practitioners can access the needs of vulnerable populations. Oftentimes, these segments are hard-to-access because they are relatively invisible to the mainstream. Giving the vulnerable populations voice, and more crucially, getting the voice heard and listened by those who supply affordable housing remains a fundamental challenge.

Based on this review, understanding demand for affordable housing goes beyond a techno-rational approach often driven by quantitative and economic judgements. There is a need to lay open the understanding of demand by studying the social practices, power dynamics and institutional arrangements that condition and constrain the provision and access of affordable housing (Shove et al., 2015).

CONCLUSION

The opening argument of this article stemmed from the dissatisfaction of the far too many foci on the supply side of affordable housing discussion. That is regularly researchers tend to emphasise alternative ways of increasing supplying of housing which often times do not meet the need of the most intended groups. The research has been quantitative hence overlooking the social understanding of affordable housing. This paper has therefore contributed by opening up some possibilities of looking more critically on the demand perspectives through inter-disciplinary lenses of economic, sociology and linguistic. Housing costs have increased with significant implications for access to adequate and affordable housing, particularly for vulnerable groups.

It is thought that affordability can be improved by shifting our focus into the demand side (users) and improvement of purchasing/renting power of vulnerable households together with institutional arrangement to represent their desire. We argue that housing is a form of social and public demand which should attract more innovation and be improved through demand side approaches. Still, with limited supply, policy to improve demand may produce less fruits.

While the government and policy maker’s concerns are to increase supply and quality of affordable housing in the market and keeping its cost at minimal, developers on the other hand want to expand their investment return and earn more profit. Yet, residents, neighbours and households desire homes that showcase their lifestyle, aspiration and their ability to pay and access them (affordability) and this should be the focus of affordable housing policies and practices.
REFERENCES


A CALL FOR ACTION: CONSTRUCTING SOLUTIONS FOR THE SUSTAINABLE DEVELOPMENT GOALS

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The Sustainable Development Goals (SDGs) are the current, global call for action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. The built environment, hereunder the construction management community, plays a central role in developing solution to meet the SDGs. This paper reports on the findings from a workshop organised as part of ARCOM 2017 conference, where the participants explored "what the academic community around construction management can do to address the SDGs?" The results reveal a consensus that the SDGs are important and that researchers and educators have a pivotal role in addressing them. However, this requires connecting research and education with other domains like policy, industry, technology and civil society. In addition, the suggested strategies all includes social and technological components, including winning the hearts and minds of the wider public and creating international mind-sets, and bridging developing and developed countries. Based on the findings from the workshop, a research agenda informed by the SDGs is suggested. The agenda should cover activities like (1) understanding the complex relationships between different goals, solutions and stakeholders, (2) establishing measures for evaluating progress and impact, (3) formulating specific projects for addressing targets of the goals globally and locally and (4) facilitating knowledge transfer between developed and developing countries.

Keywords: SDGs, sustainability, innovation, construction management

INTRODUCTION

In 2015, the United Nations conceptualized the crucial problems of the world in the form of the Sustainable Development Goals (SDGs). The SDGs are the global call to action in the period from 2016-2030 to end poverty, protect the planet and ensure that all people enjoy peace and prosperity (United Nations, 2015).

The SDGs is a continuation and extension of the Millennium Development Goals (MDGs) from 2010-2015, now covering both developing and developed countries. The SDGs go much further than the MDGs, addressing the root causes of poverty and the universal need for development that works for all people. While the goals were initially well-received, critical voices emerged, questioning the underlying economic model (e.g. Hickel, 2015) and the overall complexity and inconsistency (e.g. Economist, 2015). However, recent development suggests a raising popularity of the goals, exemplified by the editor's comment from the World Economic Forum in Davos: "The SDGs may not be perfect, but the fact that these Global Goals exist is important and valuable. And if this

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year’s event in Davos was any indication - and it’s just the second year since the Global Goals were approved — they are making a meaningful difference in the way leaders understand the challenges facing the world and recognize their own responsibility in addressing them” (Kumar 2018).

Today, the goals are adopted by all 193 UN member states and explicitly addressed by more than 9,600 companies in 170 countries, representing nearly every sector and size (Global Compact, 2018). A quick review of the Global Compact database of member organisations reveals that more than 2,400 construction companies have made specific commitments for addressing the SDGs. While industry support is of utmost importance, realising the SDGs also requires a mobilization of resources within the academic community on construction management (Leal et al., 2018). Higher Education Institutions (HEIs) can play an important role in achieving the sustainable development goals through research, innovation and leadership. The academic community must equip graduates with the sustainability knowledge, skills and experience needed to solve the sustainability challenges faced by the global community through a higher education curriculum embedded with sustainability literacy (Opoku and Guthrie, 2018).

Opoku (2016) argues that the built environment could drive the agenda towards achieving the SDGs; a sustainable built environment (SBE) could highly influence the realisation of the sustainable developments. Qualitative data from expert interviews with central researchers and practitioners revealed that developing smart cities and sustainable communities, sustainable procurement, design and construction of infrastructure, and the provision of renewable energy technology such as solar on built assets are some of the roles a SBE can play in achieving the SDGs. The built environment has more impact on some of the goals than others. For example, a SBE could highly influence the realisation of goal #11 (Sustainable cities and communities), #9 (Infrastructure and Innovation) and #7 (Affordable and clean energy) (Opoku, 2016).

According to Opoku (2016) and Dixon et al., (2018) the construction industry is a key partner in the global effort to achieve sustainable development. Therefore, the built environment can act as a driver for realising the SDGs, supported by the right government policies and strategies. However, this requires the involvement of the Construction Management (CM) community.

This leads us to the following research question: "What can the academic community around construction management do to address the SDGs?"

**METHODOLOGY**

The paper adopts a qualitative research approach using Participatory Action Research (PAR) methodology. The methodology involves the research stakeholders in the process of generating the research knowledge. The PAR captures the individual participant feelings, views, and patterns and also encourages a culture of collaboration among research participants and the researchers (MacDonald, 2012). The PAR methodology provides the research participants perspective in terms of the views, concerns, feelings and experiences round the subject under investigation (Swain and French, 2004). A workshop was organised as part of the 33rd Annual ARCOM Conference in 2017. The workshop participants explored the role of the construction management research community in addressing five of the 17 SDGs, namely: #4: Quality education, #7: Affordable and clean energy, #9: Industry, innovation and infrastructure, #11: Sustainable cities and communities, #13: Climate Action.
The selected SDGs were based on Opoku's (2016) initial investigation into the role of the built environment in achieving the SDGs (goal #7, #9 and #11). The workshop extended the list with goal #4 to acknowledge the educational component of the academic community, and further included goal #13 to denote the importance of tackling climate change. However, goals #7, #9 and #11 are here in this paper assessed as the core goals, i.e. the goals most relevant for the construction community to address.

Instead of employing traditional workshop methods such as panel discussions, participants were engaged in exploring the complex areas and thus adapted the ‘Knowledge Café’ approach designed by Gurteen (2008) with inspiration from "the world café" (Brown and Isaacs, 2005). Both concepts build on the "café" as an archetype - a familiar cultural form around the world - that evoke immediate intimacy and collective engagement through conversation around a certain topic. According to Brown and Isaacs (2005:19) conversation "is the core process by which humans think and coordinate our actions together. The living process of conversations lies at the heart of collective learning and co-evolution in human affairs. Conversation is our human way of creating and sustaining - or transforming the realities in the society". Bringing a diversity of people together for a conversation in a Knowledge or World Café is a useful way of making sense of a challenge, create better decisions and secure commitment from central stakeholders. Thus, it represents a promising method for involving people in addressing the SDGs.

More than 30 people including PhD students, junior and senior researches, lectures and professors as well as a few of practitioners participated in the "Knowledge Café.

The workshop was organized in three parts covering (1) a brief introduction to the SDGs and the built environment, and to the structure of the knowledge café, (2) the actual "Knowledge Café", and (3) a final presentation and open discussion.

In the Knowledge Café, the participants were divided into five smaller groups. Each group was placed at one of five ‘tables’, where each table was devoted to one of the selected SDGs as shown in figure 1:

Figure 1: Structure and process of the Knowledge Café

At each table, participants investigated the potential role of the CM community in addressing a particular SDG by answering the central questions of What? How? and Who?

- What: What are the challenges and what is the current state-of-play in different countries?
- How: How can the CM community contribute?
Theoretically - What are the research issues and opportunities; what concepts should be useful?
Educationally - How should our teaching be modified?
Practically - What impact should - be aiming for?
- Who/Contributors: Who would like to join us; whom should be talking to?
  Researchers - Above and beyond, as well as in, the academic communities
  Governments - National, local and supra (e.g. the UN)
  The professions - National, and other disciplines and countries
  Funding bodies
  Thinking shapers
  Practitioners

After 10 minutes, each group rotated to the next table and the process continued until the groups were back to their initial tables. Each group then consolidated their ‘collective findings’ for the selected SDG and presented it to the rest of the café.

The café was finalized by an open discussion on future actions for the CM community.

FINDINGS

This section highlights the main findings from the workshop on the three core SDGs (#7, #9 and #11). Each goal is presented by an introductory text followed by the workshop result.

Goal 7: Affordable and Clean Energy

Renewable energy solutions are becoming cheaper, more reliable and more efficient every day. Our current reliance on fossil fuels is unsustainable and harmful to the planet, this should change the way energy is produced and consumed. Implementing these new energy solutions as fast as possible is essential to counter climate change, one of the biggest threats to society's survival (globalgoals.org, 2018)

What?
The participants associated the main challenges in ensuring access to affordable and clean energy with four dimensions: Social, economic, sectorial and political. The social dimension includes a general awareness in the public of the importance of energy to society and its implication for sustainable development like climate change. This also addresses the current resistance in converting to green energy. Furthermore, the energy provided should be easily accessible, in a stable supply and affordable. This overlaps with the economical dimension where affordability is a key challenge, minimizing fuel poverty in developing and developed countries. This is impacted by the speed of the technological development that is radically reducing the costs of renewable energy e.g. from solar and wind. The sectorial dimension highlights challenges on a systems level including inappropriate use of energy, balancing energy production, grid storage, and a reduction of consumption based on energy efficiency. Also, it is important to address the residual of the energy production in the environmental impacts of greenhouse gas emissions and nuclear waste. Finally, it includes a political dimension where interest organisations for fossil fuel influence governments to favour old polluting technologies.
A Call for Action

Table 1: Summary of workshop results for selected SDGs

<table>
<thead>
<tr>
<th>SDG</th>
<th>#7: Affordable and clean energy</th>
<th>#9: Industry, innovation and infrastructure</th>
<th>#11: Sustainable cities and communities</th>
</tr>
</thead>
<tbody>
<tr>
<td>What?</td>
<td>Awareness of energy production, distribution and consumptions</td>
<td>Developing and renewing infrastructures</td>
<td>Urbanization (best island, densification, migration)</td>
</tr>
<tr>
<td></td>
<td>Easy accessible, stable and affordable</td>
<td>Physical infrastructures (Buildings, schools, smart cities, transport)</td>
<td>Community (social &amp; equity)</td>
</tr>
<tr>
<td></td>
<td>Balancing energy production and use</td>
<td>Trends (digitalization, communication and broadband)</td>
<td>Pollution / air quality</td>
</tr>
<tr>
<td></td>
<td>Lobbyism</td>
<td>Resistance to change</td>
<td>Land use</td>
</tr>
<tr>
<td>How?</td>
<td>Technologies (solar, wind, smart grids)</td>
<td>Create spaces and places for (inter-disciplinary) collaboration and co-creation</td>
<td>Practical (smart cities built, local grids, evaluation, green building, electric cars)</td>
</tr>
<tr>
<td></td>
<td>Un sophisti cated technologies and simple solutions</td>
<td>Open-source collaboration and technology transfer and standardization</td>
<td>Educational (community involvement, learn community involvement, better life by education, increase awareness)</td>
</tr>
<tr>
<td></td>
<td>Transparency</td>
<td>Policies (funding and investments)</td>
<td>Research (systems thinking, data analysis, case studies)</td>
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<tr>
<td></td>
<td>Policy (tax incentives subsidies)</td>
<td>Competence development</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Research (maturing technologies, systems perspective, research based advice)</td>
<td>Transparency</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Research (systems thinking, COPS, road mapping and measurement)</td>
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</tr>
<tr>
<td>Who?</td>
<td>Industry (companies, start-ups and landowners)</td>
<td>Industry professionals as consultant engineers, planners, contractors and suppliers</td>
<td>Industry (professional bodies, architects, engineers, contractors, planners)</td>
</tr>
<tr>
<td></td>
<td>Government (ministries, regulators, funding bodies for research &amp; development)</td>
<td>Government (politicians, public sector)</td>
<td>Government (local government, regulators and policy makers, municipalities)</td>
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<tr>
<td></td>
<td>Academia (researchers, institution for higher education and schools)</td>
<td>Academia (researchers, universities and communities)</td>
<td>Academia (universities and researchers)</td>
</tr>
<tr>
<td></td>
<td>Civil society (local communities, kids, celebrities)</td>
<td>Civil society (expert and user communities, local communities, science fiction writers)</td>
<td>Civil society (NGO’s and social enterprises, citizens, celebrities)</td>
</tr>
<tr>
<td></td>
<td>Developed and developing countries</td>
<td></td>
<td>Health professionals</td>
</tr>
</tbody>
</table>

How?
The solutions to the challenges have very strong technological elements. This includes different forms of renewable energy production (solar, wind-power) combined with smarter grids to even out the energy production and consumption from green buildings. However, it is also suggested that the solutions should be based on unsophisticated technology and simple solutions favouring local production and consumption of energy. It is specifically suggested to take the geographical location into consideration when developing renewable energy, as different locations have different potentials. Finally, the technologies should be transparent for the consumers and decision makers, e.g. enabled by a stronger emphasis on circular economy. A key driver in the development and implementation of these technologies is a strong policy agency. This includes development of tax incentives, feed-in tariffs, and subsidies for renewable energy solutions while decreasing it for fossil fuel and nuclear energy sources. The CM community can play a central role in this development through initiating R&D activities for developing, maturing and implementing technologies. This includes extending the understanding of a building to include the wider energy systems. Finally, the participants identified research-based advice as a corner stone in the development.
Who?
Based on the participant's identification, the key stakeholders can be categorized as industry, government, academia and civil society. The industry included companies, start-ups with a specific emphasis of property owners, and landlords. The main governance stakeholders are ministries, energy regulators mainly, funding bodies like the World Bank, and research councils. The later overlaps with the academia and educational actors, which also include researchers, schools and institutions of higher education. The civil society includes the kids, local communities (for local energy production), and celebrities. Finally, it was argued that a categorization of stakeholders between developed and developing countries are important.

Goal 9: Industry, Innovation and Infrastructure
A functioning and resilient infrastructure is the foundation of every successful community. To meet future challenges, our industries and infrastructure must be upgraded. For this, there is the need to promote innovative sustainable technologies and ensure equal and universal access to information and financial markets. This will bring prosperity, create jobs and ensure that stable and prosperous societies across the globe are built (Globalgoals.org, 2018).

What?
The participants identified a wide range of physical infrastructures that are central in promoting inclusive and sustainable industrialization and innovation. This includes housing, schools and smart cities, as well as transport infrastructure such as high-speed railways and bridges. Furthermore, it was highlighted that infrastructure should include local requirements as infrastructure often disregards the local communities in addressing needs of the wider public. The development is influenced by a wide range of technological trends like digitalization, cheaper broadband, data, Wi-Fi, block chain technology and web services. The need for resilient infrastructures create managerial challenges like uncertainties of scenario planning, addressing resistance to change and insuring effective coordination and communication in interdisciplinary settings.

How?
The solutions to these challenges should be based on a stronger emphasis on innovation creating spaces and places for (inter-disciplinary) collaboration and co-creation. This includes promoting mature technology to low income areas, open source collaboration practices, and “proper” regulation through standardization and building codes. However, it should also cover technical features integrating BIM and GIS as technologies for improving design. Finally, it should be acknowledge that innovation takes time especially concerning physical infrastructures. Developing and maintaining infrastructures requires access to resources e.g. in terms of finance. Thus, it is important to create policies that develop incentives for investments and development as well as allowing for risk-taking. Developing resilient infrastructures is, however, not only about technologies and regulations, but also about people. It requires a development and mobilization of competences and resources through training, workshops and educational programmes but also transparency and community-led development and collaboration. From an academic managerial perspective, this requires more research into highly integrated complex systems like COPS (complex product systems) within a general framework of systems thinking. In addition, methodology and practices for road mapping and monitoring of environmental conditions should be included.
Who?
The central industry stakeholders are; Industrial professionals such as consultant’s engineers, planners, contractors and suppliers, as well as pension funds, long tail capital actors and think tanks; Governance stakeholders including politicians and governments with a special role of public sector government; Academic stakeholders including researchers, universities and communities like mainstream management science and construction management (e.g. ARCOM). Central to the academic actors is a requirement for interdisciplinary organisation and collaboration. Finally, the wider public is important, e.g. communities around experts and users, connecting expert-push and user-demands. This further includes involvement and engagement of local communities as well as science fiction writers for portraying the possible futures of societal development.

Goal 11: Sustainable Cities and Communities
The world’s population is constantly increasing and to accommodate this increase there is the need to build modern, sustainable cities. For society to survive and prosper, the global community need new, intelligent urban planning that creates safe, affordable and resilient cities with green and culturally inspiring living conditions (globalgoals.org, 2018).

What?
The participants conceptualized a wide range of challenges related to cities and human settlements. The continuing urbanisation in developed and developing countries stresses land use, enforces densification and creates heat island. At the same time, the cities are challenged by social exclusion of citizen-groups, segregation, ghettos, economic disparity, inequality and crime. Furthermore, the intensified use of infrastructure creates traffic congestion and pollution that influence the air quality and the general health and wellbeing of the citizens. Finally, the cities are challenged by the effects of climate change in terms of rising sea levels, drought, scarcity of drinking water, and flooding.

How?
The participants suggested several practical solutions: technical components elements like green buildings; smart cities; local grids; electric cars; rainwater harvesting; tunnels; urban farming; systematic waste management; and recycling. Furthermore, the social dimensions should include integrated communities through formal and informal community engagement. The technical and social elements require substantial investments and increased collaboration to handle complex decisions and prioritisation. This must be supported by research activities based on systems thinking and data analysis, and articulate case studies of what works in practice. Furthermore, the educational system should support increased awareness, community involvement and better life by education.

Who?
The central stakeholders are the governance bodies like municipalities, local governments, regulators and policy makers. Furthermore, the built environment professionals and professional bodies like ACD, RIBA, ICS, ICE (associations for architects, engineers, and contractors) are key actors for shaping problems and offering solutions for sustainable cities. In addition, health professionals represent an important resource for creating healthy and liveable cities and communities. Researchers and universities are important for sustaining and developing capabilities and knowledge supporting decision makers and the wider public. Finally, the citizens are of course at the heart of the cities. However, also the wide civil society in form of NGO’s and social
enterprises, communities of practice, and mass media are important. Even celebrities like Jenifer Lopez and Leonardo DiCaprio are considered important players.

**DISCUSSION AND NEXT STEPS**

The results reveal a consensus that the SDGs are important and that researchers and educators have a pivotal role in addressing them. The tasks, however, are highly interdisciplinary - the challenges cannot be solved from a single academic and professional discipline. It requires connecting research and education with other domains like industry, policy, technology and civil society, and thus extending the collaboration to stakeholders that are not usually engaged in academia. Thereby the findings support and extend Lucko and Kaminsky’s (2015) formulation of a research agenda bridging academia and industry. It is supporting by the attention on global systems and sustainability, technology and management, and research methods and extending by highlighting the role of the wider society suggesting quadruple helix development connecting state and government; industry and business; academia and universities; and media, public and civil society.

Comparing the results, it becomes apparent that the challenges of the developing and developed countries are fundamentally different (see also Jain *et al.*, 2017). While the developed countries already have well-functioning infrastructures, developing countries lack fundamental societal infrastructures. Thus, the challenge is to create new infrastructures for developing countries while refurbishing and renewing the infrastructures of developed countries. This highlights, as previously identified by Plessis (1999), the importance of capacity building and knowledge transfer from developed to developing countries.

Given the diversity of the challenges, the specific technologies and actors vary greatly from goal to goal. However, the strategies suggested all include social and technological components. Thus, the ability to connect our current socio-technical organization with current and future opportunities is crucial in addressing the goals. This includes leveraging technologies and trends within digitalization, GIS, big data, with existing capabilities. Here classical (research) frameworks and methodologies like systems thinking, stakeholders analysis, scenario planning, road mapping, communication, services, risk and resilience must be combined with policy making, creating funding opportunities, incentivizing investments and procurement, and establishing spaces for innovation. However, it also includes a broad social and global dimension, winning hearts and minds of the wider public and creating an international mind-set for bridging developing and developed countries.

There was a collective agreement on the workshop that the construction management community are interested in a further exploration of the SDGs. The workshop represents an initialisation of a movement that potentially can influence not only the construction management community but also the wider society. Thus, based on the findings from the workshop, the paper suggests the formulation of a research agenda informed by the SDGs. This should cover activities like:

- Understanding the complex relationships between different goals, solutions and stakeholders
- Establishing measures for evaluating progress and impact. Contextualizing the goals in various context enabling local relevance while maintaining global comparison.
A Call for Action

- Formulating specific projects for addressing targets of the goals globally and locally
- Facilitating knowledge transfer between developed and developing countries.

This agenda need a critical engagement of the construction management community to make sure that the SDGs are not just used for greenwashing. Stigson (1999) identifies that progressive construction companies understand sustainable development as a source of competitive advantage. However, there might be a discrepancy between the formal strategies / glittered annual reports and the actual practices. While the impressive number from the Global Compact of companies and organisations who target the SDGs shows an interest, it does not say anything about the actual impact of the projects of the engaged companies. Thus, it is important to develop practices for measuring progress that acknowledge the complex interplay between the goals and targets, and is based on actual impacts. This could be a core role for the academic community of construction management.

Unfortunately, the construction management community has historically been reluctant in taking up political challenges (Singh, 2012). The relation - and balance - between science and politics is delicate. There are plenty examples of manipulation of science for political gain ( politicization of science), however it should not hold us back from supporting the common good. The SDGs certainly is an outcome of political processes and include a political bias towards liberal societies. Addressing the SDGs would thus be political; however, it would be a conscious choice. It is important to literate the fact that all research potentially shapes the society whereby it becomes a part of the political agenda.

This is not a problem. The problem is that if society does not acknowledge the political dimension of our research, the relevant key stakeholders are blind to the wider impacts of our academic practices.

REFERENCES


PATTERNS AND SYMPTOMS OF MENTAL HEALTH RISKS IN BUILT ENVIRONMENT STUDENTS

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Research into mental health issues in construction is relatively scare compared to research into physical health and safety. While there has been some research, albeit very limited, into the mental health of construction workers and professionals, there has been little into students of the construction industry. This is despite accumulating evidence that students face significant mental health risks in balancing study, work and life demands. To address this important gap in knowledge a survey of 135 students from a range of university courses in Australia associated with the construction industry was conducted using the University Student Depression Inventory (USDI). Overall, the results point to significant potential concerns around mental health in built environment student cohorts with the prevalence of mental health risks being significantly higher than other non-built environment cohort groups tested using the same instrument. Reported symptoms of mental health risks include: tiredness; lack of motivation; poor concentration; absence; feelings of worthlessness; difficulty coping; questioning whether life is worth living; feelings of pointlessness; and emotional emptiness. Architect and Civil Engineering students appear to be at particular risk as do female students. Mental health risks also seem to be linked to the number of hours worked and studied and it is concluded that more needs to be done to mitigate and manage mental health risks of students of the built environment.

Keywords: Australia, construction, mental health, safety, students

INTRODUCTION

The World Health Organisation (2017, 2017a) identifies depression as the leading cause of disability worldwide and estimates that it directly affects over 300 million people globally. Depression is such a serious issue globally, that it is estimated by 2030 it will be the number one health concern in both developed and developing nations. In Australia, over the last five years, mental health has got worse with younger people (18-25), unemployed and sole parents being especially vulnerable groups (Australian Psychological Society 2015). A recent national survey into youth mental health in Australia by Mission Australia (2017) found that in 2016 22.8% of young respondents aged 15-19 years had a probable serious mental illness, a significant increase from 18.7% in 2012). The figure was 27.4% among 18/19 year olds. The top three issues of personal concern for young people with a probable serious mental illness were coping with stress, school or study problems and depression and females were around twice as likely as males to meet the criteria for having a probable serious mental illness. Those with higher levels of risk of mental health problems are more likely to seek help from the internet,
suggesting that stigma and fear of being judged continue to inhibit help-seeking behaviour.

Taken across all age groups, poor mental health costs Australia about $12.6 billion per year in lost productivity and health treatment (Beyond Blue 2012). The Australian construction industry’s workplace practices are also known to affect the mental health of its workers and professionals (Lingard and Francis 2007, Love et al., 2010, Lingard et al., 2010) and according to Doran et al., (2015), a total of 169 construction workers committed suicide in the Australian construction industry during 2012 alone (a higher rate than any other industry). Karklins and Mendoza’s (2016:28) review of mental health in the architectural profession in Australia highlighted numerous mental health risk factors. This research reflects similar findings in other countries (Sang et al., 2004, Chan et al., 2012, Bowen et al., 2014) and while still very limited compared to general occupational health and safety research, shows that the causes of mental health problems are multifactorial and caused by a number of factors in addition to the working environment such as: genetics (family history of depression); biochemical factors (brain chemistry); illness; personality; ageing; and stressful or traumatic life events (American Psychiatric Association 2013).

The focus of this paper is on students of the built environment because most students now work while they study and there has been virtually no research into the mental health of this important part of the industry’s workforce. Furthermore, there is evidence to indicate that students can be at even greater mental health risk since they have to balance study, work and life demands within the context of potential exploitation at work, reducing government support for university education, increasing educational costs and relatively under-developed defence and coping mechanisms (Lingard et al., 2007, Moore and Loosemore 2014, Turner et al., 2016). More specifically, the aim of this paper is to investigate the patterns and symptoms of mental health risks effecting undergraduate built environment students.

Student Mental Health

A recent study by the University of York (2016) highlighted the growing prevalence and severity of mental ill-health among all students on UK campuses with 80% of UK universities highlighting an increase in complex mental health crises among their student population between 2014 and 2015 due to factors including: a need to work due to rising costs associated with higher education; increased indebtedness, a more difficult labour market post-graduation; a rise in digital technology which has resulted in cyberbullying; and serious gaps in healthcare support services. While Faeq (2016) argues that it is not certain whether students suffer higher levels of mental health problems than the general population, there is evidence that some students in areas like law and medicine are exposed to concerning levels of risk. Students of the construction industry have also been identified as having especially high levels of mental health risk.

For example, Karklins and Mendoza’s (2016) found evidence of significant mental health risks in architecture student populations with female students being subject to especially high levels of risk due to institutionalised discrimination and sexism in the built environment industry being translated into the classroom. In the UK, Waite and Braidwood’s (2016) annual Architecture student survey revealed a disturbingly high incidence of stress-related illness with 52% of students expressing fears about their mental health, 26% of students surveyed having received medical help for mental health problems resulting from their course and a further 26% fearing they would need to do so in the future.
Reflecting Karklins and Mendoza’s (2016) study, more female students reported receiving mental health treatment than male students. The emotional impact of a demanding and lengthy course, increasing debt problems, concerns that courses are not preparing students for work, uncertain employment prospects and a widely-accepted culture of excessive working hours, were all concerns which worried students. Lingard et al’s (2007) study of construction and property students in Australia and Hong Kong showed significantly higher levels of burnout than other student groups due to difficulties in balancing the need to secure paid work and study, concern regarding academic grades, uncertainty about the future, low levels of control, difficulty balancing personal and professional life and lack of support from peers and friends.

More recently, Moore and Loosemore (2014) showed that levels of burnout among Australian construction management students were significantly higher than a range of other population samples especially in the latter years of their course as the demands of work, family and study intensify, creating the ‘perfect storm’ of burnout triggers. Mo et al., (2007) argues that construction students possess lower levels of emotional intelligence (an important mediator of mental health) relative to other students and Turner et al.’s (2016) survey of nine-hundred and fifty students in the built environment disciplines found a significant relationship between student resilience and levels of depression.

**METHOD**

Data was collected using Khawaja and Bryden’s (2006) University Student Depression Inventory (USDI). While numerous instruments have been developed to measure depression (for example, the Beck Depression Inventory-II, Zung Scale, Depression Anxiety Stress Scale and Life Satisfaction Scale), the USDI instrument has been validated and shown in numerous studies to be the only survey specifically designed to reflect the unique features of depression which students can exhibit that would not be captured by other general scales (Romaniuk and Khawaja 2013; Habibi et al., 2014). Khawaja and Bryden’s (2006) research shows that a special instrument is needed to measure depression in students because they lead a lifestyle (sleep disturbance and irregular eating patterns etc.) which is more symptomatic of depression than that lived by the general population. For instance, Kitamura et al., (2004) found that major somatic symptoms of clinical depression (changes in sleep and appetite), can exaggerate measures of depression in students, and Whisman et al., (2000) found that students’ depression often exhibits more cognitive symptoms than those of clinical depression.

Student respondents were randomly sampled from a selection of purposefully sampled built environment programs (construction and property management, architecture, civil engineering) at one Australian University which were pre-tested as being representative (in terms of contact hours, independent study expectations and duration) of similar programs at all Australian universities that currently offer such programs. These programs were chosen to ensure the sample contained a spread of different built environment professional disciplines and pedagogical approaches to education (design-based, mixed and engineering-based) and because of evidence above that they are exposed to a number of mental health risks factors (such as combining high levels of work and study).

Following the purposeful stratified sampling of programs to survey, students were randomly sampled by requesting the Program Director or Head of School to distribute the survey to their students across all years, with supporting evidence of ethics clearance, an explanatory letter outlining the objectives of the research, an option to withdraw at any
time and links to mental health support and help-lines. Overall, the survey response period ran for a period of three weeks, with a follow up email issued two business days prior to the closure of the questionnaire.

An online survey was used because it afforded anonymity to our respondents and because it suited the busy lives of our target students, many of whom were likely working and studying long hours and studying a range of different courses flexibly and part-time. Finally, the online method has been successfully used in previous applications of the USDI (Romaniuk and Khawaja 2013). The survey was pilot tested and refined on a small sample of built environment students before distribution.

This research strategy resulted in 162 responses from 1800 students, with 135 completed surveys and 27 incomplete surveys, a relatively low response rate which is not a-typical of surveys on mental health although it produced a statistically representative sample which is strong for studies in applied psychology (Marszalek et al., 2011).

Data Was Analysed Using a Range of Descriptive and Inferential Statistical Tests: One Sample T-Test: to Understand the Mean Responses of Students across All Three Programs to the 30 Usdi Items and to Provide a Baseline Level of Depressive Symptoms Within the Sample; Independent T-Test: to Understand the Relationship Between Independent Variables with Two Items (or Less) Against the Dependent Variable Usdi Items (for Example: Differences Between by Male and Female Respondents); Anova One-Way Test: to Understand the Relationship Between Independent Variables with Two Items (or More) Against the Dependent Variable Usdi Items (for Example, Differences Between Students Based on Hours Worked). The detailed sample structure is illustrated in Table 1

Table 1 Sample

<table>
<thead>
<tr>
<th>Description</th>
<th>Frequency</th>
<th>Percentage</th>
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<tr>
<td><strong>Gender</strong></td>
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<tr>
<td>Male</td>
<td>80</td>
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<tr>
<td>Female</td>
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<td><strong>Degree Undertaken</strong></td>
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<td>Civil Engineering</td>
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<td>52.6</td>
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<td>Full-time</td>
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<tr>
<td>Part-time</td>
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RESULTS AND DISCUSSION

The USDI scores for the sample are presented in Table 2. Table 2 shows that architecture students returned the highest score (91), following by civil engineers (86) and then construction and property management students (82). Females returned a slightly higher mean than males (86.1 and 84.7 respectively) and students who work while studying also returned a ‘moderate’ score of 87, compared to a slightly lower 83 for those who did not work. However, those working 15 to 20 hours per week returned a mean USDI score of 97.2, placing these students within the ‘high’ range. A surprising result was that those who worked more than 20 hours per week returned a USDI mean score of 83.7, almost equivalent to that of those not working (83). This suggests that they may have developed coping strategies to accommodate the mental health risks of working such long hours (reducing hours of study etc.). Surprisingly those students that spent between 5 to 10 hours per week at university returned a high mean score of 92.2 dropping when greater than 20 hours per week at university. The reason why USDI scores fall as ‘hours of study’ increases beyond 20 hours is unclear but mirrors the ‘hours in work’ finding and indicates that coping strategies (such as reducing study or work hours) are employed by students at both ends of the study/work spectrum and that it is the students who try to do everything in the mid-range that suffer greatest levels of mental health risks.

Table 1: Sample
The responses to the USDI questions around symptoms of mental health risks which were statistically significant showed that low-level symptoms such as tiredness, lack of motivation and poor concentration are most commonly experienced (‘sometimes too often’) by our respondents while more serious symptoms such as absence, feelings of worthlessness, difficulty coping, questioning whether life is worth living, feelings of pointlessness and emotional emptiness are experienced ‘seldom to sometimes’. Although extreme symptoms such as suicidal thoughts were uncommon, the fact that they emerged at a mean score of 1.72 is of concern, although we did not explore whether these thoughts were directly related to their educational experience.

An independent t-test was conducted to identify the relationship between gender and USDI scores showed that there were statistically significant differences between male and female students in only three USDI items. These results indicated that:

- Females students are more likely than males to feel that others are better than them;
- Female students are more likely than male students to find that the challenges encountered in their studies overwhelm them;
- Female students are less able to cope than male students.

Using an ANOVA test, there were five statistically significant differences in the results between the responses of each program discipline to the USDI questions. Based on the mean USDI scores for each item, the results indicated that:

- Architecture students are more likely than construction students to feel more tired than they used to.
- Architect students are less likely than civil engineering students to feel rested even after sleeping.
- Architecture students are more likely to feel overwhelmed than construction management and property students.
- Architecture students are more likely than construction management and property students to feel that tasks take them longer than they used to.
Civil engineer students are more likely to have feelings of inadequacy than construction and property students. Using an ANOVA test to explore the relationship between time spent at university and response to the USDI questions six USDI items were significant. Considering the mean scores the key findings were:

- University students that spent more than 20 hours at university reported feeling less motivated to study than those who spent 5-10 hours at university.
- University students that spent more than 20 hours at university reported feeling lower in energy than those who spent 5-10 hours at university.
- Those that spent 5-10 hours at university reported finding it harder to concentrate than those who spend less than 5 hours at university.
- Those who spent more time at university felt that their mood affected their ability to carry out tasks more so than those who spent less time at university.
- Those who spent more time at university feel as though they have trouble starting assignments more often than those who spend less time at university.
- Those who spent more time at university do not finding study as interesting as it used to be, compared to those who spent less time at university.

Using an ANOVA test two significant relationships emerged between times spent at work and responses to the USDI questions. Considering the mean scores the key findings were:

- Students working between 15 - 20 hours/week are more likely to lose interest in enjoyable than those who are working between 5 to 10 hours per week.
- Students working between 15 to 20 hours/week are more likely to feel that daily tasks take longer than they used to, than those working greater than 20 hours per week.

Overall, the USDI scores from this study were higher for both male and female students than the scores from the Khawaja and Duncanson (2008), Khawaja et al., (2011) and Habibi et al., (2014) study which used the same instrument. The emergence of architects as a high-risk group supports Waite and Braidwood (2016) and Karklins and Mendoza (2016) which highlights high incidences of mental health problems for architecture students in Australia and the UK. Given that architecture students do not work the longest hours out of our sample groups (a major risk factor for poor mental health identified in the literature by Lingard et al., 2007 and Moore and Loosemore 2014), this suggests that the reasons for the high incidence of depression among architecture students is related to other factors such as content, pedagogy, management and intensiveness of the architectural education experience, propositions which clearly need further investigation. Our results are also interesting when compared to other student cohorts where the USDI has been used such as Khawaja and Duncanson’s (2008) study across a range of other cohorts in Australian universities because they do not support numerous other studies which argue that law students experience higher levels of psychological stress than other university students in other professional disciplines (e.g. Skead and Rogers 2015).

In contrast, the results relating to the relatively higher incidence of mental health symptoms for female compared to male students correspond with the results of many other studies which have highlighted these elevated risks and symptoms outside the built environment professions and within them (Khawaja and Duncanson 2008, Waite and Braidwood 2016, Mission Australia 2017). However, interestingly our findings appear to be at odds with Moore and Loosemore’s (2014) study of burn-out in construction management and property students which found no gendered relationship with this
closely related phenomenon. One possible explanation for this divergence is that Moore and Loosemore (2014) found that female students are better at using their friend and family networks than men as a stress-coping mechanism.

Another key finding was the positive correlation between the hours of time spent at work for construction management and property students and symptoms directly related to aspects of depression. These results are generally consistent with the existing literature outside and inside the built environment, which also shows that students who work report higher levels of mental health risks (Khawaja and Duncanson 2008, Lingard et al., 2003, Holmes 2008, Moore and Loosemore 2014). Interestingly, our results indicate that it is the central band of students who attempt to combine moderately long hours of both work and study that are at greatest risk of depression because they are trying to do everything at once. Counter-intuitively therefore, while outlier students may seem at greater risk, our results suggest that the focus of any risk mitigation strategies should be on the bulk of students in the central range who may otherwise fall through the net.

Finally, like the work hours results, the impact on USDI fell backwards when students spent more than 20 hours per week at university. This finding indicates that as time spent at university increased, the easier it became be to study and complete university related work. Although there is no evidence, as in the hours of work results, to explain this phenomenon, it could be that students who spend a lot of time at university employ coping mechanisms such as reducing the number of hours they worked.

CONCLUSIONS

The aim of this paper was to investigate the nature, prevalence and causes of mental health risks in undergraduate built environment students. Overall, the results point to significant potential concerns around mental health with the prevalence of mental health risks being significantly higher than other cohort groups with Architects and Civil Engineering students being a particular concern. This may be related to the pedagogical approach employed in these courses - such as studio-based teaching which has been highlighted by other studies as being especially stressful. While there were reports of low-level symptoms of poor mental health such as tiredness, lack of motivation and poor concentration, more serious symptoms were also evident in the results such as feelings of worthlessness, difficulty coping, questioning whether life if worth living, feelings of pointlessness and emotional emptiness. In support of other studies, female students appear to suffer more than male students and the number of hours worked and studied seem have a direct relationship with the likelihood of suffering mental health problems, up to a point (20 hours) where students appear to develop coping mechanisms for the extra mental health risks they face. According to our results, there is a middle cohort of students who are both studying and working between 10 and 15 hours a week that are at the greatest risk and where focus should be directed for future research and support.

Although there are clear limitations with this study due to its small sample size and limited scope, the results are of concern and raise important questions for both universities and employers in terms of their responsibility to collaborate in protecting student mental health. They should also cause them to reflect on the mental health risks posed by their educational and work practice models. More research is needed on the causes of mental health risks for students, how minority groups such as women and ethnic minorities might be differentially affected, how these impacts might change over the progression of a course, the coping mechanisms students employ and the support structures in place at university and at work to identify and mitigate these risks. In particular these findings highlight the need for student access to mental health education,
support services and interventions at university to detect, diagnose, treat and minimise the long-term impacts that untreated mental health disorders may have.

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DESIGNING AN APP FOR MANAGING STRESS IN THE CONSTRUCTION INDUSTRY

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High levels of stress at work, great responsibilities, hazards and lack of balance between tasks and deadlines are common in the daily lives of many construction workers. Changing the patterns of thinking and behaviours is not an easy mission, and it requires constant support, learning and determination. E-health applications can contribute to this change through their ability to foster continuous interaction with the user. Mobile phone apps have shown promising results in the field of ‘e-health and wellbeing’. Accordingly, an App is being designed as a self-help system for stress management which will enable construction workers to 1) detect the onset of stress quite early, 2) track their stress status, 3) empower persons to cope with stressful and/or demanding situations in an adaptive way, 4) improve and streamline the operability of job tasks, and 5) optimise efficient solutions for the construction industry. The development of this innovative app, known as Streblo, is part of a wider research that is studying stress management in the construction industry. Streblo’s blueprint will match personality traits with coping strategies in real-life situations. Its inputs are being generated from a field study that has commenced, where 23 structured interviews have been used to collect data from construction workers on their 1) personality and 2) behaviours while experiencing stress. Results of the data collection and analysis are being used to develop Streblo (an App) with IT experts. The paper reports the detail development and performance of Streblo’s prototype. Ultimately, users will be able to engage Streblo on electronic devices (mobile phones, tablets, and computers) through both text and image-based communication obtain real-time solutions and feedbacks on their stress status. Streblo will enhance and support attitude and behavioural changes in people who suffer from stress symptoms in the construction industry.

Keywords: stress, tool, coping, app design, Streblo, well-being

INTRODUCTION

The UK Health and Safety Executive (HSE) has defined work related stress as the adverse reaction people have to excessive pressure or other types of demand placed on them. Due to the risky and often problematic environments of construction projects, time management and other crisis-ridden working issues, the construction industry has long been known to be stressful (Bowen et al., 2014; Chan et al., 2018). Stress arises when there is an incongruity between a worker’s estimated capability and resources and actual context to cope with his or her activity (Leung, Liang and Yu, 2016; Haydam and Smallwood, 2016). Stress in the construction industry has been tightly linked to arduous activities, scarce support of relationships, difficult climates, uncomfortable physical environments, work overload, lack of autonomy and conflicting roles. Stress can impact negatively on an individual’s psychological health and performance, and can manifest as

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a simple strain or sense of frustration, low motivation and lesser productivity (Lingard and Francis 2004; Love et al., 2010; Chan et al., 2012; Bowen et al., 2014).

In 2006, a pioneering large study conducted by the Chartered Institute of Building (CIOB) in the UK, showed how stress in the construction industry was extremely linked to inter alia, interpersonal and cultural/organisational factors i.e. lack of feedback (56.8%), poor communication (55.7%), inadequate staffing (55%), too much work (64.1%), ambitious deadlines (59.7%), pressure (59.9%) and conflicting demands (52.2%). On the contrary, site safety, inadequate equipment and poor physical environment were among the lowest scoring factors with over 80% of the survey respondents stating that these were not a cause of occupational stress (Campbell, 2006).

Stress impacts not only on individuals’ physical and emotional status, but also on their job and general performance in terms of efficiency, outputs, teamwork and collaboration (Leung, Chan and Cooper, 2014; Enshassi et al., 2018). Stress in Construction has been associated with a high presence of anxiety and depression, whereby workers spend less time maintaining their health status, take on less personal responsibility, and invest less energy in their work activities (Smallwood and Ehrlich, 1997; Derr et al., 2001; Haynes and Love, 2004; Love, Edwards and Irani, 2010; Enshassi et al., 2018). It is therefore important for players to cope with a challenging construction industry and be able to deal with stress (Bowen, Govender and Edwards, 2014; Chan, Leung, and Yuan, 2014).

‘Coping’ is the psychological description of the ability to deal with stress and it represents the behavioural and cognitive solutions an individual adopts to manage stress (Lazarus, 1966). Coping behaviours may be adaptive (when they help people to find efficient solutions to their stress) or maladaptive (when they cause detrimental effects at the physical and/or emotional levels).

E-Self Management Applications

E-self management applications may represent a valid support to managing stress and they can easily be adapted within the work environment (Wu et al., 2017). An App may contribute to help the worker to manage his/her activities autonomously and prevent any detrimental outcomes. E-self management applications can contribute to monitoring the level of stress and users’ health status through their ability to foster continuous interaction. Particularly, mobile phone apps have shown promising results in the field of ‘self-management, health conditions and wellbeing’ (Payne et al., 2015; Whitehead, and Seaton, 2016) with good results in terms of improved quality of life, reduced need for care and cost efficiency. Different applications have shown significant improvement in health distress and increased self-efficacy and satisfaction (Lorig et al., 2001, Bauer et al., 2014). Support for different health conditions is now feasible through information and communication technology (ICT) e.g. self-management of appointments and check-up visits to doctors, smartwatches, and virtual trainings, social networks and discussion forum. There are also apps that can link vital symptoms with personal health devices and electronic medical record systems (Wang et al., 2014; Årsand et al., 2015). Apps can be implemented in work settings to transmit the unique needs of workers with a mental health condition. Individuals can choose different functionalities of apps toward managing their particular problems and grade of severity. Many apps permit personalization to a specific user's needs and goals (Shaw et al., 2014; Jonkman et al., 2016).

The potential usefulness of apps may be superior for some specific mental health conditions, such as stress. Mobile applications for stress management have been applied in different sectors (e.g. health) with promising results (e.g. Gaggioli et al., 2014; Engel et
al., 2015; Khusid and Vythilingam, 2016). However, no construction-specific application exists. Hence, the aim of this paper, based on an underpinning research, is to attempt to describe the design of an interactive App for construction professionals for coping with stressful events at the workplace. The overall goal of this tool is to detect:

1. Early signs of stress; that is the mental and physical state resulting when the resources of the individual are inadequate to cope with the demands and pressures of the situation.
2. Stress consequences that can undermine the achievement of goals, both for individuals and for organisations; monitor these; and propose innovative solutions to overcome problems for construction workers.
3. Signs of stress that can be seen in people’s behaviours. Responses to stress may be in the areas of feelings (e.g. anxiety, depression, irritability, fatigue), behaviour (e.g. being withdrawn, aggressive, tearful, unmotivated), thinking (e.g. difficulties in concentration and problem solving) or physical symptoms (e.g. palpitations, nausea, headaches).

METHODS

The development of the Streblo app (prototype) included participatory design (interviews) with inputs from different construction workers (N = 20) and IT academic staff (N = 3). The interviewees consisted of 5 operational managers and 15 supervisors while the academic staff consulted were two informatics engineers and one specialist in the Build Environment.

Brief structured Interviews facilitated the assessment of users’ needs and afforded potential consumer input into the app’s focus and features. Table 1 describes the content of these brief interviews.

Table 1: Interview guide

<table>
<thead>
<tr>
<th>Construction workers’ questions</th>
<th>IT academic staff’s questions</th>
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</thead>
<tbody>
<tr>
<td>Open question: Which are the main features that a technological tool should have to help persons to cope with stress?</td>
<td></td>
</tr>
<tr>
<td>Which are the technological requirements for a good app?</td>
<td></td>
</tr>
<tr>
<td>Which services an app should provide?</td>
<td></td>
</tr>
<tr>
<td>How to incorporate graphical aspects?</td>
<td></td>
</tr>
<tr>
<td>How to design a tool feasible for construction workers (office based and site based)?</td>
<td></td>
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</tbody>
</table>

The interview is part of a larger study about stress management in the construction industry characterised by the collection of both quantitative and qualitative data. The results described below are inspired from the results of the interviews and form the large qualitative study based on an ethnography research at 3 Construction sites: this lasted 6 months and involved more than 50 observed participants at work.

A Delphi approach (Delphilike) was applied in which a forecasting method based on the results of questions is sent to a panel of experts (Benarie, 1988; Nevo and Chan, 2007). The responses generated during the interviews were transcribed and summarised, manually.

RESULTS

The suggestions generated from the analysis led directly to the development of Streblo’s features and content. For example, some research participants requested tools that they
could use easily at the workplace (e.g. for remembering previously inserted or stored user-data). Some participants also wanted the app to provide a record of the suggestions received. Employing this user-centric design procedure was intended to develop an app that would be most relevant to the users’ needs and provide functionalities that were most attractive to them. Streblo is being designed to be used either as a stand-alone psychological and self-management tool or to cope efficiently with stress at the Construction workplace.

Results of the preliminary data collection have permitted the delineation of the main features of the Streblo app (Table 2).

Table 2. Features of Streblo

<table>
<thead>
<tr>
<th>Main features</th>
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<tbody>
<tr>
<td>Fully integrated in their usual smartphone</td>
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<tr>
<td>Customizable (lay people with no programming skills should be able to use all the functionalities);</td>
</tr>
<tr>
<td>Discreet (the application should not interfere with normal mobile phone usage or with normal working routine activities).</td>
</tr>
<tr>
<td>Multilevel usability (the application is connected to an icloud system permitting the user to use the App on smartphone, IPad or PC according to personal requirements and/or laws, e.g. a user working on site may use the application on his/her PC because the law does not permit the use of smartphone during routine activities).</td>
</tr>
</tbody>
</table>

The Streblo App

Design Principles

The following design inputs and principles generated through the research were applied in developing the prototype web-based stress management system:

Social connections. New information and knowledge are shared when different workers are invited to online conversations. Also, people with previous situation of stress, who have managed to recover from difficult situations in construction job activities, can contribute with their insights. By this, both strong-tie and weak-tie relationships are made possible.

a. Self-Learning on Stress. Through questions and practical experiences, users can get help in their learning processes and become more aware and more confident to cope with them.

b. Wide range of solutions. The system should help the users to enhance their strategies in order to cope with stress better and positively. This can be through an array of behaviours, such as advice on how to approach a specific stressful situation, and how to interpret a particular event and demanding requests.

c. Constant e-Learning. Continuous efforts are needed for people who want to change maladaptive coping behaviours and patterns of actions. Therefore, it is important that the system has tools for ongoing help in everyday events at the workplace.

d. Practical A. The inner architecture of the system is learning based on the users and their experiences. By identifying good solutions and adaptive behaviours, feedback on what goes on in the users' lives is available, and the system can be adjusted when necessary. For example, exercises can be tailored to better fit the needs of the user for a circumstance.
e. Multimedia Tutorial. E-learning between the user and the system is mediated by using a tutorial. Breathing exercises can, for example, be easily demonstrated through online video clips. Likewise, other exercises can be recommended to mitigate stress.

**Web System Components**

The app consists of four major sections:

1. **Who are you?** This section provides psychological information about personality (e.g., symptoms, prevalence rates, how stress develops) and various types of behaviours that are available. It includes information about habitual behaviours, cognition and emotional patterns.

2. **Self-Assessment:** This section includes the Streblo COPE Inventory version (a well-validated, widely used self-report that measures the ways to cope with stress). After completing the COPE, users are provided with interpretive feedback about the efficacy of their coping strategies (adaptive, maladaptive strategies or alerting information). Users can also track their strategies over time by viewing a line graph of past assessments. Finally, users can schedule future assessments at regular intervals (e.g., monthly).

3. **Manage stress:** This section provides solutions to help address stress symptoms and manage difficulties at the workplace. When a coping behaviour is selected, the user is invited to check if the coping solution adopted is adaptive or not. If not, the system offers solutions to the user. Depending on the problem selected, the user is offered a psychological-based coping tool (e.g., paced breathing, progressive muscle relaxation, concentration exercises, engage in pleasant events) or an organisational-based coping tool (e.g., divide your task into subtasks, identify priorities). If users do not like a solution presented to them, they can choose another option. Table 3 illustrates an example of adaptive, maladaptive coping behaviour and associated solutions.

4. **Find Support:** This section allows users to easily reach out to sources of support when needed, including their GP, NHS mental support and other allied organisations that offer help for managing stress. Streblo also provides users with a variety of links and phone numbers to facilitate finding face-to-face interaction with qualified professionals.

**DISCUSSION AND CONCLUSION**

There is a considerable body of existing research regarding mobile interventions for self-management; however new research is also required to test the effectiveness of these new instruments in the field, such as in the case of the construction industry. Meanwhile, new studies are also required to evaluate how such applications can determine a positive change over the time in managing a health condition in different settings, such as stress at work. In this context, Streblo represents a prominent and innovative solution for stress management with potential important impact on personal wellbeing and quality of life. While previous research in construction management has mainly focused on the effect of stress and its influence on the performance of an individual and project outcomes, very few studies have touched on the stress experience (Sutherland and Davidson, 1993, Leung et al., 2008).
### Table 3: Coping behaviours and solutions in Streblo model

<table>
<thead>
<tr>
<th>Coping</th>
<th>Behaviours</th>
<th>Examples of actions</th>
<th>Evaluation</th>
<th>Solution/s proposed</th>
</tr>
</thead>
</table>
| Use of instrumental social support | Asking for advice, and help or information from your colleagues | Ask for the collaboration of colleagues. Ask for the support of own supervisor/boss. | Green | The team exercise (applicable when working in a team):  
• Set precise timelines and deadlines for others.  
• Set false, early deadlines, to make it more probable that they’ll actually finish on time.  
• Communicate your frustration with others’ behaviour, if necessary. |
| Active coping | Taking action to decrease or get rid of a stressor or its consequences. | Reframing the meanings of problems. Seeking more information. | Green | The exercise of priorities (1):  
Prioritize your tasks:  
• A tasks: Critical and time-sensitive  
• B tasks: Important, but slightly less time-sensitive than A Tasks  
• C tasks: Not time-sensitive—yet  
• D tasks: Optional—nice, but neither important nor time-sensitive  

The exercise of priorities (2):  
Set priorities:  
1. High payoffs. Which tasks will provide the best return on investment for your time and energy?  
2. Essential to your goals. Which tasks are absolutely critical for meeting personal and professional goals?  
3. Essential to your company’s goals. Which tasks will most benefit your company, providing it with the best return on investment for employing you?  
4. Essential to your boss’s goals. Which tasks does your boss regard as most important?  
5. Can’t be delegated. Which tasks can be done only by you? These will be high priorities. |
| Denial | Ignoring, refusing to acknowledge the problems | Avoid the problem. Delegate the resolution of the problem to someone you can trust. | Yellow | Stress can present itself in many different forms. When you are hit by a stressful situation, an emotional storm is likely to whip through your mind and body, tossing painful thoughts and feelings in all directions. Do not escape!  
Here’s what you can do to survive and thrive:  
S.T.O.R. exercise  
SLOW your breathing |
The emergence of mobile self-management and wellbeing solutions heralds a new era in personal management, and it is particularly pioneering in the field of construction management. The research described in this paper aimed to assess a prototype innovative app for the management of the common stressors faced in construction projects. Streblo has been developed using a robust, bottom-up, qualitative approach that included consultation with as many stakeholders as appeared to be necessary. The first prototype of the app is based on documented knowledge to provide a firm foundation for subsequent refinement which will require inputs from expert stakeholders on fitness-for-purpose. At its future operational level, Streblo will be tested among different construction workers to measure acceptability and efficacy prior to its public diffusion.

**CONCLUSIONS AND RECOMMENDATION**

The negative effects of stress at work in terms of emotional disorders and organisational difficulties have urged the need for new tools and solutions, especially direct-to-user tools such as mobile applications. The use of Streblo should orientate the better management of health and safety issues in Construction.

An important aspect of Streblo is that a user does not just make an assessment to see if they have a problem with stress in the workplace, but the app also helps them to eliminate or at least ameliorate the potential impacts of any identified stressor. The potential of Streblo is thus wide and in line with the actual and current needs of professionals working...
in the construction industry. The study underpinning Streblo is investigating how technology has been used to influence adaptive coping behaviours and synthesize key aspects into a conceptual model for creating a new mobile application. The conceptual model provides further knowledge of key aspects to consider when developing persuasive tools that aim to encourage more efficient ways of coping with stressful events in construction.

So far, published mobile phone applications have shown promising results. In this paper, we have presented a new prototype of a mobile phone app for stress management associated with a web-based system. This preliminary work will be followed-up by user-based evaluations to identify the needs to be addressed in the next iteration of the design. The research reported in this paper constitutes a significant step towards the understanding and management of potentially stressful situations and their influence on the efficiency and effectiveness of construction industry participants. Similarly, there are triple bottom line implications for all concerned. In particular, those most likely to be exposed to high stressors may expect to at least receive some serious consideration from their managers and advice for self-help. New data as well as new hypothesis on coping modalities, consequences and wellness at work are expected from this study. These data should give relevant insights for training, education and more work policies in general.

ACKNOWLEDGEMENT

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REFERENCES


INSTITUTIONALISING CONSTRUCTION MANAGEMENT RESEARCH?
COMPARING RESILIENCE IN ORGANISATIONS AND PROJECTS

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Organisations (permanent) and projects (temporary organisations) need to manage disruptions adequately by maximizing opportunities for mitigating threats to continually maintain infrastructure and contribute to the economy and the society. However, the employment of the resilience construct which holistically enables the management of disruption has been conflated in literature especially at the project and organisational levels. This is due to the little consideration given to the context specific nature of resilience. Given that organisations and projects are structurally different, and organisations employ project-based approach to promote innovations and effectiveness, it is essential to identify and clarify the meaning of resilience in projects and organisations.

The aim of this paper therefore, is to compare resilience in organisations and projects. This is to identify the similarities and differences in the definitions, dimensions, antecedents and consequences. To achieve the aim, a critical review of literature on organisation and project resilience are carried out and compared. Findings show that, resilience in these two forms of organisations differ. This is due to the routine and transactional approaches that exists in permanent and temporary organisation respectively. From the findings, resilience in organisations can be defined as the capability to respond to and prepare for disruption, whilst project resilience can be defined as the capability to respond to, prepare for and reduce the impact of disruption caused by the drifting environment and project complexity. Common dimensions of resilience identified include coping ability, flexibility and persistence but these manifest differently, whilst proactivity is the different dimension identified in projects. The consequence of resilience in organisation is vulnerability reduction, whilst for projects, it is recovery. These findings are critical to advancing research in resilience and disruption management in organisations and projects.

Keywords: project organisations, resilience, recovery, vulnerability reduction

INTRODUCTION

The classification of organisations, as temporary or permanent influences the management of disruptions. Permanent organisations which can be defined as stable associations of people engaged in concerted activities directed to the attainment of specific objectives (Bittner, 1965) employ routine-based and future anticipation approaches to manage disruptions and deal with uncertainties (Saunders and Ahuja, 2006). Temporary organisations also known as projects, on the other hand comprise a set of diverse skilled people working together on a complex or unique endeavour in a competitive and uncertain environment over a limited period (Stringer, 1967) and utilise transactional approaches in disruption management. Over the past five years, research in projects across disciplines have doubled since its initial research by Miles (1964) and suffers from the conflation and adoption of theories applied in permanent organisations.

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which are challenged by temporality. Given that, some permanent organisations employ project-based approaches in carrying out its endeavours because of the innovation and efficiency projects provide (Lundin and Söderholm, 1995; Grabher, 2002), it is essential to clearly differentiate theories in these forms of organisations. Out of the theories employed in organisations and projects, is the theory of resilience in managing disruptions. The complexity of organisations and projects and their significance in maintaining infrastructure and contributing to the economy and the society, requires disruptions to be adequately managed and opportunities of mitigating threats maximised (Giezen 2013; Seville et al., 2006). As such, the notion of resilience as employed in these two forms of organisations is explored to identify the similarities and differences in the definitions, dimensions, antecedents and consequences. The question addressed in this research therefore is; ‘what are the differences and similarities in antecedents, dimensions and consequence of organisation and project resilience?’ These findings are to provide clarification for the employment of resilience in projects and organisations.

METHODOLOGY

To identify the dimensions, antecedents and consequences of resilience in projects and organisations, a critical review was carried out to analyse, evaluate and synthesise the diverse conceptualisations of project and organisational resilience. This study followed the critical review approach by Booth, Sutton and Papaioannou, (2016) and Grant and Booth (2009). Keywords such as project resilience, organisational resilience, resilience in temporary organisations, vulnerability in organisations and projects, adaptability in organisational and projects, project recovery, agile projects and organisations and disruption management in projects and organisation underpinned the search during the review.

Within the review, it was identified that, the conceptualisation of the notion of resilience within projects and organisations varied. For instance, within organisational resilience, there were four ways in which it had been presented; (1) as a positive adjustment to disruption response (example Sutcliffe and Vogus, 2003), (2) as response to disruptions (example Burnard, 2013; Fiksel, 2006), (3) in terms of its barriers and enablers (example McManus, 2008) and (4) defining what organisational resilience is (example Seville et al., 2006). Across these perspectives, a common term used in describing organisational resilience was capability. Capability as defined by Helfat and Peteraf (2003) is an ability of the organisation to perform coordinated tasks with the use of resources from the organisation to achieve a goal. Therefore, identifying common capabilities across the multifaceted conceptualisation of organisational resilience enabled the identification of dimensions of resilience for both organisations and projects.

To identify capabilities manifested in managing disruptions, this research employed a capability lens by Sen (1993) which focuses on one’s actual ability to achieve various valuable functioning as a part of living. The findings of the definitions and dimensions of resilience within projects and organisations are compared and discussed in this paper to identify the similarities and differences. Similarly, enablers, referred to as antecedents to these capabilities in projects and organisations deduced from the critical review of resilience in organisations and projects are discussed in the subsequent sections.

DISCUSSION

Organisational and Project Resilience

From the findings, organisational resilience can be defined as the capability of an organisation to respond to and prepare for disruption. The notion of organisational
resilience which follows the engineering resilience perspective, relies upon the permanent organisational processes, routines, resources (especially human), structures and practices which are developed over a period to positively endure and adjust during unexpected situations (Oppong Banahene et al., 2014). Project resilience on the other hand can be defined as the capability of a project to respond to, prepare for and reduce the impact of disruption caused by the drifting environment and project complexity. Project resilience follows the ecological resilience perspective and the key compositional difference identified between organisational resilience and project resilience is the level of situational awareness.

In terms of situational awareness, McManus (2008) and Burnard (2013) highlight that, the level of awareness in organisations is directly proportional to the effectiveness of disruption management. This is because awareness reduces sensitivity (Smit and Wandel, 2006), and sensitivity reduction in turn reduces vulnerability despite the exposure (Gallopín, 2006). However, this level of awareness is experienced in a stable environment, whilst in projects, the level of situational awareness to disruption management is experienced in a drifting environment. Thus, projects have a high level of awareness of its drifting environment and incorporates continual measures to respond to disruptions through continual identification of risks and training to ensure readiness. The continuity of increasing awareness despite being vulnerable to emergent disruptions leads to the employment of proactive measures such as continual monitoring of processes and communication to ensure recovery. Thus, situational awareness which is defined in organisational resilience as a measure of an organisation’s understanding and perception of its entire operating environment (McManus et al., 2008), in project, is defined in this research as ‘the knowledge of the drifting environment of the project and the readiness to employ proactive measures to enable the project recover from disruption’.

Furthermore, the prior knowledge of complexity in projects enables a higher level of awareness which is driven by continual employment of measures such as motivation and monitoring (risk management and workshops) and thus, reduce the negative impact complexity may breed. This follows the complexity theory by Baccarini (1996) which emphasise that, complexity influences procedures and measures in projects. This is similar to awareness in organisational resilience where risk management procedures (Burnard, 2013) are aimed at getting the organisation back and reducing vulnerability, however, project resilience aims to ensure recovery (Blay, 2017). Thus, not necessarily reverting the project to the original position (as organisational resilience) but, to the best possible position to ensure a successful completion.

**Dimensions of Organisation and Project Resilience**

Whilst dimensions (capabilities) of organisational resilience include adaptive capacity, coping ability, persistence and flexibility, dimensions of project resilience include proactivity, coping ability, persistence and flexibility. Capabilities manifested in organisational resilience are enabled by the organisation’s adaptive capacity and for project resilience, capabilities are enabled by proactivity. Despite common antecedents such as coping ability, flexibility and persistence, their manifestations differ.

**Adaptive capacity of organisations versus proactivity in projects**

Adaptive capacity is a measure of the culture and dynamics of an organization that allow it to make decisions in a timely and appropriate manner (McManus et al., 2008). Adaptive capacity within organisations promotes learning, flexibility to adopt novel solutions and develop general responses to a wide range of challenges (example combine experiences and knowledge and respond to changing drivers) (Burnard and Bhamra,
Three essential factors that shape adaptive capacity are cultural, political and economic factors. The driving force of adaptive capacity is consciousness (Knight, 1921). Consciousness in organisation resilience is presented as situational awareness (Seville et al., 2006). As such adaptive capacity builds on the situational awareness of the organisation to react to disruption and thus, reduce vulnerability through coping, flexibility and persistence.

Capabilities manifested within projects on the other hand, go beyond reacting to the disruption based on awareness but responds to disruption and shows readiness and vulnerability reduction to ensure recovery. This is mainly through proactivity. Proactivity for this research can be defined as an anticipatory capability that the project takes to influence their endeavours. Projects focus on enhancing proactivity due to its awareness of its drifting environment. Within the projects, this future-focussed capability is through project management mechanisms, procedures and experience which also enables capabilities such as coping ability, flexibility and persistence (Blay, 2017).

**Coping ability in organisations and projects**

Coping ability which can be defined as the ability to manage and deal with stress caused by disruptions in organisations is through psychological and structural domains. Like organisational resilience, psychological coping is identified in projects. However, psychological coping in organisations is enabled by relationship and driven by trust and learning (example; McManus, 2008; Seville et al., 2006) whereas in projects, psychological coping is through responsibility coping and regulative coping. The difference in coping within organisations and projects are due to the culture and transactional relationship that exist respectively. For instance, in organisational resilience, the cognitive, emotional and relational sub-dimensions of the psychological dimension are identified to be organisational culture influenced (Lengnick-Hall, Beck and Lengnick-Hall, 2011). Also, the relational sub-dimension is developed amongst the team by enabling more social functions and having more social areas within the organisation to prevent transactional relationship. This main significance of the relational sub-dimension is to ensure the organisational culture and aim is maintained and thus, evident in decisions whilst coping to promote communal continual attaining of organisation set goals during disruptions. In project resilience, the existence of transactional relationship drives responsibility and regulative coping. Whilst responsibility coping is defined as a role driven approach of coping whereby one accepts responsibility in doing things right (Haynes and Love, 2004), regulative coping is the ability to cope by controlling ones feeling and attitude towards a disruption (Haynes and Love, 2004). In projects, responsibility coping is presented in three different ways; responsibility allocation, responsibility taking and responsibility acceptance and driven by the contract, whereas regulative coping is enabled by training, experience and contingency (Blay, 2017).

Furthermore, for structural coping, the contingencies and ad-hoc problem-solving networks sub-dimensions amplifies organisation competence by increasing available alternatives to problem resolution and allow problems to be directed towards experts in the organisations respectively (Sutcliffe and Vogus, 2003). The social capital and relationship development nature of these organisations enable them to tap into their networks during disruptions for assistance and insight (McManus, 2008). Coping ability identified in organisational resilience literature leads to increasing awareness, reducing vulnerability and increasing adaptive capacity and hence, business continuity; which can be defined as the uninterrupted availability of key business resources during disruption periods in order to return the organisation to the state before the disruption (Burnard, 2013).
Flexibility in organisations and projects

Flexibility can be defined as a capability to manage disruption by allowing change but ultimately ensures that the aim is maintained. That is, it provides an ability to adjust to change and promotes renewal, re-organisation and development (Starr, Newfrock and Delurey, 2003). Within organisational resilience, flexibility is manifested by accommodating (Keong and Mei, 2010) through communication and collaboration (Burnard and Bhamra, 2011a) and adapting through training, to develop the capacity required to manage a disruption (McManus, 2008; Rice and Sheffi, 2005). Due to the relative stable environment of organisations, flexibility is identified by the relaxing of the organisations stringent procedures comprising relaxing roles and responsibilities, communication lines, set out collaboration rules, contingency allowed, and learning required together with the training provided. These enable organisations to respond, be ready and reduce the impact of disruptions.

Within projects, flexibility is mainly manifested through accommodation and promotion of innovation in drifting environment in which they exist. Accommodation is manifested through open-mindedness, contingencies and planning, whilst innovation is by creating and allowing new opportunities once it promotes cost and time savings (Blay, 2017).

Persistence in organisations and projects

Persistence can be defined as the capability to continue despite difficult situations. This is due to the functional capacity of the system which aids it to withstand and dynamically reinvent strategies as the system encounters disruptions. From organisational resilience literature perspective, persistence is enabled by striving (Burnard and Bhamra, 2011b), persevering (Burnard, Bhamra and Young, 2012) and reinventing (Hamel and Välikangas, 2003) driven by trust. Persistence in organisations is focussed on continual preparation to ensure that the intended/ initial objective of the organisation is achieved despite the disruption to enable vulnerability reduction.

In project resilience, persistence focusses on the entire project’s working ability to ensure that the endeavour is completed irrespective of objective met once it works towards meeting the goal. It is promoted by continual monitoring (re-inventing and continual moderation ability of the project), continual planning and negotiations.

A comparison of the above discussed definitions and dimensions of resilience in projects and organisations is captured in Table 1. The stable structures available within the organisations enable the efficient employment of these antecedents (Burnard, 2013) and enable the development of more than one dimension of resilience.
Table 1: Comparison of organisational resilience and resilience in projects

<table>
<thead>
<tr>
<th>Key Characteristics</th>
<th>Organisational resilience (OR)</th>
<th>Project Resilience (PR)</th>
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<tbody>
<tr>
<td>Definition</td>
<td>Follows Engineering resilience definition</td>
<td>Follows Ecological resilience definition</td>
</tr>
<tr>
<td></td>
<td>Standard/Static objective; Initial organisation objective influences how works are carried out and thus makes it situational awareness focussed</td>
<td>Dynamic objective; Emergent issues changes objectives and thus, how works are carried out</td>
</tr>
<tr>
<td>Dimension</td>
<td>Increasing Adaptive capacity; Focus on developing adaptive capacity using capabilities; coping ability, flexibility and persistence which are achieved by organisational culture (resources and processes).</td>
<td>Increasing Proacticity; Focus on enhancing proactivity due to its awareness of its drifting environment. Proactiveness enables coping ability, flexibility and persistence through the utilising of project management procedures, mechanisms ('best practice') and experience to manage disruptions.</td>
</tr>
<tr>
<td></td>
<td>Coping ability; Coping ability is mainly focussed on adjusting through relationships existing/ created in the organisation aided by the organisation culture.</td>
<td>Coping ability; Coping ability revealed here is mainly focussed on adjusting through responsibility allocated (responsibility coping) and regulatory coping. These are enabled by using experience and project management procedures and mechanisms (specifically contingency, training and contract).</td>
</tr>
<tr>
<td></td>
<td>Flexibility; Due to the stable environment of the organisation, flexibility is identified by the relaxing of the organisations stringent procedures comprising relaxing roles and responsibilities, communication lines, set out collaboration rules, contingency allowed, and learning required together with the training provided.</td>
<td>Flexibility; Flexibility captured here is mainly through 'accommodation' and innovation due to the ever-dynamic nature of projects.</td>
</tr>
<tr>
<td></td>
<td>Persistence; Persistence focusses on continual preparation to ensure that the intended/ initial objective of the organisation is achieved despite the disruption. It is mainly promoted by motivation</td>
<td>Persistence; Persistence focusses on the entire project's working ability to ensure that the project is completed irrespective of intermittent objective met, once it works towards meeting the goal. It is promoted by continual monitoring, planning and negotiation.</td>
</tr>
</tbody>
</table>

Within organisations, incentives are put in place to motivate workers to develop capabilities to manage disruptions adequately (Bhamra et al., 2011). The incentives are to enhance the persistence of the system to disruptions through the rewards and subsidies put in place to motivate when experiencing disruptions (Seville et al., 2006). Future learning enhances persistence, coping ability and flexibility (Vogus and Sutcliffe, 2007; Weick and Sutcliffe, 2001) whilst redundancy is made possible due to the competitive and business continuity nature of organisations (motivation to commit more resources), to gain competitive advantage (Hamel and Valikangas, 2003). The commitment of more resources ensures the redundancy required to attain stability (Giezen, 2013) in the face of disruption. This enables dimensions such as coping ability and flexibility. Training such as team building enables the collaboration from workers to attain a specific goal. Training also comprises ad-hoc solving networks and understanding established roles and responsibilities.

Project resilience antecedents include project management procedures such as a contract, training personnel and monitoring of threats and disruptions, project management mechanism such as contingency and experience (Blay, 2017). The contract in a resilient project promotes collaboration and sets out the relationship for the project clearly from the start. The training provided in a resilient project empowers the team, promote collaborative understanding and calmness. Monitoring within a resilient project is through risk, uncertainty and opportunity management. This is enabled by a realistic plan.
Resilience in Organisations and Projects

A realistic plan influences projects to respond to the disruption through the allowance for contingencies within the plan to enable the project to be prepared. Contingencies allowed for within the method statement and project databases enable efficient response. Also, continual planning in a resilient project enables early risk, uncertainty and opportunity identification, early warning identification, continual cooperation and continual work execution before and during the disruption. Furthermore, a resilient project requires experience. Experience enables projects to be ready through the open-mindedness, curiosity and self-motivation based on the fore-knowledge of solutions and empowerment experience provides. Experience in a resilient project contributes to the creation of innovative solution to minimise time and quality loss (Blay, 2017). A summary of the comparison and commonality (in italics) are captured in Table 2.

Table 2: Comparison of antecedents of organisational and project resilience

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Organisation</th>
<th>Antecedent Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptive Capacity</td>
<td>Knowledge sharing (learning)</td>
<td>Contract, training, monitoring, contingency, open-mindedness, innovation</td>
</tr>
<tr>
<td>Proactivity</td>
<td>Future learning, contingency, ad-hoc networks</td>
<td>Training, experience, contingency, responsibility allocation and responsibility taking</td>
</tr>
<tr>
<td>Coping ability</td>
<td>Accommodation (clear roles and responsibilities, contingencies and communication and collaboration) and adaptation (training and learning)</td>
<td>Accommodation (open-mindedness, planning, continual monitoring, innovation)</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Training, innovation, motivation, experience</td>
<td>Monitoring, motivation, innovation, negotiation</td>
</tr>
<tr>
<td>Persistence</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Consequence of Organisation and Project Resilience

The consequence of organisational resilience is vulnerability reduction whilst for projects its recovery. Organisational resilience focusses on vulnerability because of the ease in identification of its risk and uncertainties due to its stable environment. Thus, resilient organisations work towards reducing areas of identified vulnerabilities using capabilities; coping ability, flexibility and persistence. Project resilience focus on recovery rather than reduction of vulnerability as captured in permanent organisations with the help of capabilities together with utilising proactive procedures and measures. The ever-vulnerable nature of projects makes it focus more on recovery rather than reduction of vulnerability only with the help of capabilities together with utilising proactive procedures and measures.

Vulnerability reduction in organisational resilience utilises capabilities to minimise effect of disruption and its occurrence (Burnard, 2013). For instance, the ability to cope utilises the established relationship within the organisation to reduce vulnerability (Trim and Lee, 2008). This established processes which aids coping (McManus, 2008) reduces the sensitivity and thus, exposure to disruptions. Furthermore, flexibility of the system enables it to move to another stable state within the same basin of attraction and thus, reduces the organisations vulnerability. This is enabled by the communication, collaboration, clear roles and responsibility, contingency and training of the organisation (Bhamra, Dani and Burnard, 2011; McManus, 2008). Also, the continual preparation,
innovation, experience and motivation which ensures persistence reduces the sensitivity and exposure to disruptions (McManus, 2008; Seville et al., 2006). This ability to continue despite difficult situations through withstanding and dynamically reinventing strategies reduces vulnerability to disruptions also. Vulnerability reduction is enabled by the manifestations of the capabilities which are seen in the organisation’s response. Response lead to learning to live with uncertainty, combining different types of knowledge for learning and creating opportunities for self-organisation (Seville et al., 2006; McManus, 2008).

In project resilience, recovery is by readiness, response and vulnerability reduction. Readiness can be defined as the preparedness of the project to the disruption through roles and responsibilities, communication and contract (Blay, 2017). Response is the reaction to the disruption through training, contingency and contract. Reduction is the minimisation of the level of vulnerability or the impact of the disruption through contingency, contract, innovation and continuous monitoring. Unlike permanent organisations which aims to respond to initial organisational objective, project drift to varying or new set of objectives within the project evolution. Capabilities in organisations to ensure resilience may in project terms ensure vulnerability reduction only (Blay, 2017).

CONCLUSIONS

There is lack of theoretical clarity between resilience in organisations and projects and this challenge the employment of dimensions and antecedents of resilience in managing disruptions. As such, literature on resilience in organisations and projects have been critically reviewed to extract the dimensions, antecedents and consequences. The findings from the review have been compared to identify the similarities and differences. The comparison of resilience shows that, disruptions in organisations and projects are to be managed differently due to their structural differences. These findings challenge the adoption of project resilience into organisations and vice versa. Despite the identification of common capabilities from the review, resilience manifests differently in projects and organisations. Common dimensions of project and organisation resilience includes coping ability, flexibility and persistence exist, with varying dimensions include proactivity and adaptive capacity in projects and organisations respectively. Within organisations, the identified capabilities are enabled by the routine based organisational processes whilst in projects the capabilities are enabled by the transactional relationship that exist. The comparison of resilience in projects and organisations shows that project resilience goes beyond the vulnerability-reduction only based approach of managing disruptions as focussed on in organisations and ensures recovery.

The implication of this research to theory is the aggregation and comparison of resilience in projects and organisations. The findings confirm that, resilience is a context-specific concept (example Horne and Orr 1997; Braes and Brooks, 2010) and thus, requires a context-specific conceptualisation prior to it being employed. The dimensions and antecedents presented provide a theoretical basis for factors and indicators required to manage disruptions in projects and organisations. The findings from the research contribute to practice by presenting the disruption management approaches and highlighting areas for directors and managers to develop within their organisation and team to manage disruptions.
REFERENCES


INFRASTRUCTURE INVESTMENT THROUGH PUBLIC-PRIVATE PARTNERSHIPS
TRACKING PUBLIC PERCEPTION OF PUBLIC PRIVATE PARTNERSHIP PROJECTS

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Understanding public opinion is vital for public agencies and policy makers to ensure successful implementation of a public private partnership (P3) project. In many cases, though, the access to public opinion is a serious challenge due to very limited public outreach efforts or conflicted poll results, which are often conducted within the same time frame. This paper presents a new method to examine public perception of private financing and tolling. This social media based method applies sentiment analysis to define the positive or negative polarity in each message. With Twitter data collection on the California High Speed Rail Project over 16 months, this paper reports a daily tolling acceptance by three measures, i.e. tweet, user, and influence. Event and user profile analysis is performed along with the definition of toll acceptance. The analysis identifies the group with higher potential to change opinion P3. Insights are offered for policy implementation.

Keywords: PPP, public perception, social media, sentiment analysis

INTRODUCTION

America’s infrastructure is aging and in dire need of repair and improvement. The 2017 infrastructure report card from the American Society of Civil Engineering (ASCE) graded America’s infrastructure overall a “D+” with a range from a B for rail to a D- for transit. To fix the problem and upgrade the asset condition, more than $4.59 trillion is needed over the next ten years (ASCE 2017). While the US government at all levels has made efforts to invest more in infrastructure, these efforts do not come close to the amount in needs. Under a wide range of budget shortfall, additional investment in infrastructure becomes a grand challenge for governments if the current fuel tax based funding model remains unchanged. Therefore, alternative financing mechanisms, especially public-private partnerships, have been proposed and embraced by an increasing number of state and local governments in lieu of a gas tax hike.

Public Private Partnership (P3) features three key elements in infrastructure development. It involves project finance to leverage limited public funds. The project follows an outcome based life-cycle management approach that integrates planning, finance, design, construction, and operation and maintenance. Lastly, the success of a P3 project relies on mutual trust and extensive collaboration between public and private organizations through risk sharing and incentive mechanisms. While the advantages are obvious, the public resistance to tolled public facilities operated by a private company has been observed in many P3 projects. For example, it has been headlined and criticised for years when the

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rush-hour toll on the 14-mile I-495 HOT lanes in Virginia exceeded $30. Along with a public concern about high toll for using public infrastructure, there is wide criticism of toll roads being double taxation.

The Presidio Parkway project in California is another example of how public opinion can affect P3 projects. The project was set to replace the historic south access road to the Golden Gate Bridge in San Francisco because the road was structurally and seismically deficient. However, it experienced an unexpected delay for almost a year as well as more than $90 million overrun due to the lawsuit brought forward by the Public Engineers in California Government (PECG), who viewed the P3 project as anti-union and anti-public engineers. Since its start, the $650 million I-77 Express Lanes project, a $650 million between Charlotte and Cornelius in North Carolina faced numerous inquiries about a private foreign company operating and tolling commuters. The concerns resulted that the North Carolina House overwhelmingly passed a bill to cancel the contract (Morrill, 2016).

It is vital for public agencies and policy makers to address this public relationship challenge. Existing studies often show conflict results about public acceptance on tolling or P3. More people become sceptical of public opinion polls after the 2016 presidential election. This paper, instead, proposes a social media approach to examining public opinion toward tolling and P3. This method uses messages in social media to judge an individual’s opinion on tolling and therefore, can eliminate potential bias while providing continuous monitoring of public opinion.

**Current Method for Public Perception**

Traditionally public acceptance assessments were part of citizen participation and public consultations, a process that gives citizens the opportunity to influence the decision making of public affairs. In the context of projects, this process can be beneficial in reducing financial risk, reducing direct costs, and increasing market share and social benefits. There are many techniques and methodologies available that can raise the awareness of the environmental and social impacts of projects, including brochures, advertising, exhibitions, polls, focus group interviews, public hearings, etc.

Public hearing is a widely used method to collect public opinion and engage interest groups. It is one of the most traditional methods to allow people to be involved in government activities and projects. A public hearing serves four distinct functions, i.e. the informational function to inform citizens about the project, the cooperation function to give people an opportunity to complain about the project, the ritualistic function when the hearing is demanded by law but not by the public, and the interactive function, the ideal function when the agency actually seeks public opinion and responds accordingly. Even though public hearing is a method extensively relied upon in the US, its problems cannot be overlooked. These include possible low participation due to inconvenient location, technical terms unfamiliar to the public, and limited representation (Checkoway 1981). Kemp (1985) argued that the outcomes of public hearings are likely not rational and objective, and are manipulated for the benefit of dominant groups. The potential bias in the results of public hearings is critical to address the effectiveness on predicting public acceptance. For infrastructure projects, interest groups have various channels to have their voice heard. Public acceptance assessment should reach out to the general public who are affected by the project to mitigate any discontent and address issues of concern.

Another traditional method to assess public opinion is the opinion poll. Evolved from the straw poll, which is an informal and unofficial vote to assess public opinion. Polls
conducted by newspapers, television networks, or other professional organizations attempt to reveal how people view controversial topics such as presidential approval or elections. Public opinion polls are also applied to infrastructure projects and policies. The WSDOT conducted several polls to assess public opinion on congestion pricing including seven 90-minute focus group sessions, executive interviews with opinion leaders, a telephone survey and a group survey targeting a wider audience in the next phase (Ulberg 1995). The sample from an opinion poll is frequently unrepresented due to a lack of demographic distribution of the targeted audience before the survey implementation. Another major defect is its cost and lengthy process to collect, process, and analyse data. More importantly, it is difficult to obtain true opinions from interviewees because of ambiguous interpretations or insufficient knowledge.

**Social Media Approach: Framework**

As social media grows rapidly, it provides another channel to access public opinion. According to Pew Research Center (2017), more than 69% of Americans used at least one social media site in 2016. Popular social media sites like Twitter, Facebook, Instagram, Pinterest, and Linkedin allow people to freely share their stories, pictures, and videos, and communicate with each other on common issues. With a considerable size of users in these social networking sites, freely expressed opinion can be collected and used for policymaking purposes. In comparison with a survey-based method, a social media based approach shows great advantages for public opinion analysis. First, it is almost free to collect data. For example, Twitter provides various APIs for users to obtain tweets about a certain topic, by certain user or any specific search term. Second, opinion data can be fetched at almost real time. Such time series data sets offer a great potential to track and analyse how people change opinion on a specific issue. Third, social media has a much better representation of the general public given its million or billion users. Twitter, for example, has more than 320 million monthly users globally. Additionally, early studies showed very promising results from social media based opinion analysis. O’Connor et al., (2010) used Twitter data for consumer confidence and president approval analysis and produced similar results in compared to well-designed traditional polls.

This paper presents a social media based framework for evaluating public opinion on P3 projects. The purpose of the framework is to provide a data driven P3 acceptance evaluation, including public opinion collection, public opinion analysis and tracking, and people feature identification. The framework covers architecture, the choice of tools, and a standard process (Figure 1).

**Framework**

A few web crawler applications need to be developed to fetch real-time data from Twitter and other proprietary data sources. Crawler is a software program which pulls data automatically from web pages to create a local repository (Cho and Garcia-Molina, 1999). For the Twitter crawler, the user could use one or multiple search terms to query Twitter API for relevant tweets. The search terms are provided by the user and typically contain keywords, user accounts and/or hashtags. The user account search (the @ sign) is used to search for tweets related to a certain user; the hashtag search (the # sign) is used to search for tweets of a certain topic, and the keyword search is a general purpose search. The selection of these key terms may significantly influence the quantity and quality of data collection. Currently, there is no detailed study on what is the best strategy. A general rule from this study is that the keywords and terms must align with the project and allow some misspellings. For example, this study followed a combination of keywords: "california high speed rail", user account: "@CaHSR", the official organization account,
Public Perception of Public Private Partnerships

and hashtag: 

On top of the Twitter crawler, additional crawlers for enriched data dimensions are also required depending on the analysis to be performed. The original website URL and its title is crawled to enable the grouping of web pages. Google Maps is also used to geocode location information within user profiles.

The data storage module is essentially a database management system which provides a repository for data input and output. It is responsible for storing the raw data from crawlers, running extract, load and transform (ETL) processes to prepare and join data, and assisting metric calculate for various analyses. It is also responsible for serving various requests from the data analysis module by providing data in the desired format.

The data analysis module is the core component of the framework. There are three key parts in this module: the data to be analysed, the analysis methodology, and the knowledge library. The data is provided by the data storage module with proper aggregation, filtering and sorting. The analysis methodology is dependent on the specific evaluation. For example, semantic analysis uses various national language processing (NLP) techniques and machine learning techniques such as neural network (Collobert and Weston, 2008). Sentiment analysis uses lexicon based or machine learning based techniques (Pang and Lee, 2008). Other analyses include topic analysis, word frequency analysis, user segmentation and even manual screening etc. The framework user is responsible for choosing the methodology best suited for the analysis.

Figure 1 Public Perception Evaluation Framework Using Social Media

The knowledge library is a user defined model to describe features and characteristics of the analysis target and result interpretation. For example, our case study initializes the effort of establishing an infrastructure specific dictionary for sentiment words to be used for tweet sentiment analysis. We also define public acceptance in the context of social media and infrastructure project, and the calculation based on tweet sentiment analysis. Furthermore, we model social media event, opinion leader, opinion follower, original contributor and user demographic model, all of which contribute to the content of the knowledge library.

Sentiment Analysis

Sentiment analysis, also referred to as opinion mining, is a field of study which applies machine learning, natural language processing, and text analysis to identify “what other people think”. It fits naturally with public acceptance evaluation which is based on the positivity and negativity of the public opinions. Sentiment analysis is typically conducted at three different levels: document level, which identifies the sentiment expressed in a
whole document; sentence level, which determines the polarity of each sentence and/or the subjectivity of the sentence; and entity and aspect level, also called feature level, which identifies not only the sentiment of the expression, but also the specific target of the sentiment (Liu, 2012).

Generally there are two types of sentiment analysis techniques: unsupervised and supervised. (Turney, 2002) created an unsupervised learning technique and (Pang, Lee, and Vaithyanathan, 2002) reviewed three supervised machine learning techniques including Naive Bayes, maximum entropy classification, and support vector machines. While these research studies are focused on document level sentiment analysis, (Hu and Liu, 2004) proposed an opinion summarization technique for sentence level analysis.

This research focuses on sentence level sentiment analysis because Twitter once had the limitation of 140 characters per tweet. Although there have been changes made to relax this limitation, it is still valid to the corpus obtained in this research. This research also develops a lexicon based sentiment analysis process similar to the one proposed by (Hu and Liu, 2004). This application treats tweets as bag of words and does not require training datasets to work effectively. There are a few sentiment dictionaries publicly available for research use. In this research, we uses the dictionary maintained by (Hu and Liu, 2004), and tries to adapt the dictionary to infrastructure projects to yield better results. In future work, more tuning will be performed to build a domain specific sentiment dictionary for all infrastructure projects. With the calculation of sentiment polarities for all tweets, a public acceptance evaluation model is also developed to assess public acceptance in a time series. Public acceptance can be measured by a one-vote-per-tweet model or by a one-vote-per-user model. Details of the public acceptance model are demonstrated in next section where a case study and the application of different public acceptance models are discussed.

**Event Analysis**

It is observed that public acceptance fluctuations are often triggered by massive retweet of certain web pages such as news articles and announcements. In addition to public acceptance analysis, it is interesting to analyse the events behind the scene which drives the burst of tweets and how they influence public acceptance. Taking advantage of the web page crawler which restores tiny URLs to original URLs, the tweets can be grouped by web pages to analyse the group behavior. The framework allows the development of event model that defines, detects, and categorizes events, as well as reaction strategies to mitigate the impact of negative events and enhance that of positive ones.

**User Analysis**

Twitter is not only a collection of tweets, but a dynamic network of tweets and their posters. The user is the agent who spreads the events and causes public acceptance changes. Users in social media are not merely strangers or virtual accounts, they have their own behaviours and characteristics which can be revealed by social media itself. Taking advantage of the abundance of data generated by social media, different groups of users and their behaviours and influence can be analysed.

Two possible analyses is proposed by this research to cluster users in different groups. The opinion leadership model, which is based on the number of retweets of a certain user, is designed to discover opinion leaders, opinion followers and original contributors. The user profiling model, which is based on multiple demographic attributes including sentiment, popularity, institution and location, is developed to describe user attributes.
User analysis is an important study to find out the leading people in the world of social media for targeted campaigns and lobbies.

**CASE EXAMPLE**

The California High-Speed Rail (CAHSR) is the first high-speed rail system in the US. It connects San Francisco to Los Angeles and San Diego, as well as major cities in the state. At an estimated cost of $68 billion, the system will have a total length of 800 miles with up to 24 stations. It is one of the most highlighted infrastructure projects in the US, which is expected to be controversial and newsworthy on both traditional media and social media. Citizens for California High Speed Rail Accountability (CCHSRA), an organization of people affected by the CAHSR project, led the lawsuit of *John Tos, Aaron Fukuda, County of Kings v. California High Speed Rail Authority*. This lawsuit cost the project about $63 million and 17 months of delay (The Fresno Bee, 2016). There were other lawsuits concerning environmental certification, the use of cap-and-trade money; and the pre-emption of enforcing the California Environmental Quality Act.

**Public Acceptance Analysis**

The public acceptance measures whether the general public supports or opposes an infrastructure project. Provided that social media is able to feed real time data flow, the public acceptance in this framework is designed to be a time series metric which depicts the level of support and opposition over time.

The public acceptance is defined as a ratio of positive counts over the summation of both positive and negative counts. The breakeven point for this formula is 50%, where the number of positive votes is the same as negative ones. Neutral class is not included in the formula for simplicity, hence the public acceptance can be interpreted as the supporting ratio, and the difference between 1 and the public acceptance is the opposing ratio. It is still important for the algorithm to be able to identify and exclude neutral tweets. Intuitively, daily sentiment should be used to calculate daily public acceptance. However, counting tweets on a specific day returns volatile public acceptance. The data volume, number of tweeters, and sentiment could all change dramatically, resulting in drastic fluctuations. By following the same methodology used in public opinion polling as (O’Connor et al., 2010), daily sentiment is replaced by the weekly moving average to smooth the Public Acceptance ratio \( PA_t \), as shown in below.

\[
PA_t = \frac{\sum_{i=0}^{6} PS_{t-i}}{\sum_{i=0}^{6} PS_{t-i} + \sum_{i=0}^{6} NS_{t-i}}
\]

where \( PA_t \) is the public acceptance ratio on time point \( t \). \( PS_t \) is the positive score and \( NS_t \) is the negative score on time \( t \).

Different definitions of \( PS_t \) and \( NS_t \) can be derived from different perspectives. It is common to use tweet volume i.e. the number of messages as an indicator of public acceptance, for example, (Jiang et al., 2015). This is different from the electoral equality principle of “one person one vote” used in public polls. Although there is a clear difference in the determination of public acceptance, both methods can be valid and reflect two classic perspectives on the role of media and polls on public policy, i.e. elite model and pluralist model. The elite model assumes that elite groups dominate politics and society and therefore, public opinion is subservient to political elites. Whereas, the pluralist model assumes that power is dispersed throughout society so that no one group dominates. As such, public opinion should be independent from political influence (Robinson, 2008). It remains unknown how variant public opinion can be viewed.
through these methods. This research considers both methods and defines \( PS_t \) and \( NS_t \) by tweet, user, and user influence (Ding 2018).

**Analysis Result**

The result is generated by applying all three models on the whole case study dataset. There is no random sampling process involved since the tweeters are already a sample of the whole population, and the big data technology allows us to quickly process the data of such volume. This analysis results in three sets of daily metrics \( PS_t \) and \( NS_t \), which are used to calculate 7-day moving total respectively, which is then used to calculate the daily public acceptance using equation (1). The fluctuation of public acceptance under all three methods is plotted in Figure 2.

![Figure 2 Public Acceptance Analysis by Tweet, User and Influence](image)

This daily tracking of public acceptance provides a real-time impact monitor of relevant events. For example, there are several peaks and valleys where public opinion moves toward an opposite direction. Relevant tweets and events may explain why public opinion has shifted on a specific time point.

2016-07-12, Diana Gomez from @CaHSRA explains the progress and challenges of building high-speed rail in California! #IWillRide

2016-07-19, @CaHSRA From construction to outreach, take a look at everything CAHSRA has accomplished in the last 6 months. #Iwillride

2016-08-30, High-speed rail critics question the first route segment, which will end in an almond orchard.

2016-08-31, #Californias #CapandTrade Program is sick and will take #HighSpeedRail down with it via @Forbes #Env #Transit #OpEd

2017-06-22, @CaHSRA Congratulations on writing a great California Government Tweet: (Ranked 43rd for Jun 20.)

2017-07-10, @CaHSRA: Another reason connecting the Silicon Valley to the Central Valley is so important... better access to more affordable housing.
Several interesting observations can be made according to Figure 2. As clearly shown, public acceptance by tweet is more volatile than the other two. The measurement can jump from 35% to 85% in 7 days, or from 85% to 13% in 3 days. Even though a moving total is used to smooth the curve, the flip of the acceptance polarity is still very frequent. This is attributed to the lack of memory of this approach, i.e. the public acceptance only considers the tweets of a given day, when the number of tweeters and tweets are mostly random. On the contrary, the other two approaches keep a user’s vote until it changes, therefore old tweets could still have impact on future days, resulting in much lower volatility and steadier curve.

There is still some consistency among all these methods. Some choppy uptrend of the by tweet approach is represented by a stable increase in the other two. They rise and dip due to the same set of events, but the magnitude of the by user and by influence approaches are significantly smaller than the by tweet approach. ANOVA analysis shows a significant difference among acceptance by tweet, user, and influence. On average, public acceptance towards CAHSR is around 28% using the by user and by influence approach, but the by tweet approach disagrees and is reporting a 53% acceptance. Again the memoryless feature of this approach drives the difference. Under this approach, a major event generating hundreds of retweets has only a few days of impact, and been overridden by later lesser events. The overall public acceptance is expected to be negative. And by user and by influence approaches are believed to be more accurate in this case.

Three models discussed above provide different flavours on public acceptance measurement. Acceptance by tweet tracks sentiment of any given day, acceptance by user remembers any users’ last vote, and acceptance by influence takes user’s influence (followers) into consideration. Considering both accuracy and simplicity, acceptance by user is the recommended model for public acceptance calculation.

CONCLUSION

The paper presents a framework to track public perception using social media. The California High-Speed Rail project is selected due to its scale, controversy, and coverage in social media compared with other infrastructure projects. The data characteristics of infrastructure projects are typically lower volume in tweets. The study also initialize the contribution to customize a domain specific sentiment dictionary for infrastructure projects. The customized algorithm is applied to the whole corpus to obtain the sentiment over 16 months. Observations are made regarding the event-based nature of public sentiment fluctuation and the distribution among positive, neutral and negative polarities. This study offers a new direction for construction and project management scholars to conduct data-driven empirical studies.

Based on the tweet sentiment analysis, the public acceptance model is developed by defining the measurement using the number of positive and negative tweets within a moving window. Three public acceptance models, by tweet, by user, and by influence, were proposed, applied, and examined using the case study. The by user model and the by influence model generate more smooth curves than the by tweet model. They also result in statistically significant public acceptance readings than the by tweet model, and the former measurement is closer to reality. The by user model is the most favourable model of public acceptance in consideration of accuracy, curve smoothness and simplicity.
Research limitation exists for opinion studies based on social media data. One key issue is the representativeness of public opinions from social media data analysis. People may not be serious and tend to very biased when posting on social media. The group may be also selective and don’t represent the entire voting population. While the debate will continue and call for more studies, the application of social media data becomes rapidly popular for opinion analysis, especially after successful prediction in the political field.

**REFERENCES**


PFI AND VALUE FOR MONEY: EXPLORING THE OPERATIONAL PHASE IN HEALTHCARE PROJECTS

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The UK government started using PFI in 1992, and by 1997 it became the preferred procurement method to finance major infrastructure projects. This decision was frequently based on the potential of securing ‘value for money’, a metric that compares long term forecasts of whole life costs with the operational efficiency to be gained from sharing risk and rewards with a private sector service provider. Previous research investigating the development stages of PFI from the strategic business case through to the early operational phase of the project have claimed that PFI has successfully minimised construction risks and delivered projects with high certainty in time, cost, quality, and client satisfaction. However, concerns were raised that such results were not always consistent and many projects made changes to costs, time and client requirements in the development stage which could have adversely affected the predicted value for money. While the development stages of PFI projects have frequently been studied, there is gap in knowledge to ascertain that the anticipated project benefits and efficiencies are realised in operational contracts. This paper investigates the operational stage of PFI projects in the UK, to assess how PFI performance compares with non-PFI during this period. Operational performance data was collected through a formal request for information under the Freedom of Information Act from the Department of Health from NHS trusts with PFI and those without PFI, for comparative analysis. Findings better illuminate the operational challenges of PFI if it claims the long term prospects for value for money throughout the project lifecycle.

Keywords: healthcare, operational performance, PFI/PPP, value for money

INTRODUCTION

When PFI was introduced in the UK in 1992, the government sought to accentuate accountability in decision making for major infrastructure projects. The inspiration for private sector involvement in large infrastructure projects emerged from successful risk management from privately financed projects such as the Channel Tunnel (Grant, 1997). At the time, the UK government had suffered bad experiences, with serious overruns to construction projects costing taxpayers millions of additional pounds, and they therefore sought to reverse the trend. Consequently PFI was introduced to support the responsible procurement of projects, able to clearly demonstrate their value for money.

Between 1992 and 2016, more than £35billion was invested in 435 projects across three major sectors in the UK: Education, transport and hospitals. Of these, 150 project are hospitals with overall capital value in excess of £14billion. Healthcare project vary in size and individual capital values range from £1.1m to £1.2Billion. Education is the

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second largest sector with 217 projects and total a gross value of just under £12billion. The transport sector has fewer projects, but of much large capital investment. Projects under this category include highways, streetlights, trams and underground railways totalling 68 projects. Roads and road maintenance project are medium to high value project ranging from £9.0million to just under £1.0billion. Streetlight project are low to medium value ranging from £9 - 300million. Trams and underground railway have a value between £264 - 540million.

Despite the reduced use of PFI after the 2008 financial crisis and change in government, private finance has remained relevant and a significant procurement method contributing to nearly 10% of the government’s capital investment. In 2012 PFI was succeeded by PF2 (Private Finance 2) implying a shift in policy direction, seeking better value for money amid the growing concerns of increasing costs to sustain PFI. The core argument for PFI rests on the potential for value for money. Projects are financially tested for overall cost and risk transfer in anticipation that client’s output specifications will be delivered and the project will demonstrate good value when they become operational.

The decision to procure under PFI rests on the claim of long term benefits to be realised (HM Treasury, 2006; Grimsey and Lewis, 2005; National Audit Office, 2003). A follow-up report by the national audit office (NAO, 2018) reiterates the strong incentives for continuing to use PFI including the achievement of cost certainty, improved operational efficiency for operating the asset and higher quality and well-maintained assets to be gained from harnessing the risk management skills of the private sector.

However, new evidence has also begun to emerge that questions the fundamental argument for PFI. For example, in Scotland 17 PFI schools suffered from significant defects including wall collapse, thereby questioning the design quality and robustness of the new buildings. The earlier call from the government revealed that PFI contracts had a potential to achieve efficiency savings in excess of £6billion, however Whitfield (2017) points to a number of PFI projects that have terminated operational contracts, thereby questioning operational efficiency and service continuity. According to Whitfield, 20 PFI contracts were terminated by early 2017, and 54 others experienced major problems or a buyouts. 14 out of the 74 affected projects were healthcare projects which could not cope with the dwindling funding, changing levels of demand and operational changes in service delivery.

There is scope for researchers and academics to further evaluate this performance, and here performance data is analysed to validate this value for money (VFM) claim at the operational stage within healthcare projects.

Operational Performance and Value for Money

PFI can be seen as a preferred procurement option, able to demonstrate better value for money at the procurement stage and has the potential to provide efficiency gains during subsequent operation. The challenge, however, is how such performance can be assessed objectively in absence of a like for like criteria. Performance is linked to compliance with the agreed output specifications and where the contractor or service provider falls below expected service standards, deductions are made to compensate for unavailability of the service. Yet Robinson and Scott (2009) observed the presence of low level of performance deduction in operating projects which are linked to both 'good performance' and the need to act in good faith amid unclear output specifications.

Operational VFM is complex to assess and evaluate. Lavy and Shohet (2009) looked at the historic development of the role facilities management play to meeting organisational
objectives. This included the traditional responsibility to manage both soft and hard facilities, and strategic development aiming at improving productivity and competitiveness and the integration of people, place, process and technology. Information on FM expenditure is readily available and Nesje (2002) examined the distribution of FM expenditures at St Olavs Hospital in Norway. According to Nesje hard and soft facilities management including maintenance, energy and cleaning costs each account for one third of the total operation costs of the hospital but there were appropriate indicators for FM resource allocation. In order to make such evaluations, easy to measure performance variables need to be in place. To achieve this, Lavy and Shohet (2009) suggest measures such as maintenance efficiency, functional condition, maintenance expenditure and building performance index be used. Though these measure are cost-based, there is limited correction with VFM which considers both cost and quality variables. An alternative suggested by Lop et al., (2016) is that operational VFM be measured in similar ways to the construction phase, including time, cost and quality metrics in addition to health and safety, environment; resource allocation and utilisation; good governance, interface management and facilities management. However, records of these measures may not be readily available for access through the NHS and requesting such data through the freedom of information act is likely to bear no fruits.

In a previous study, Henjewele et al., (2014) used changes made in the operating phase as an indicator of the ability to sustain value for money. Where more costly changes were made, there was highly likeliness that value for money would be in jeopardy. Yet this does not mean that projects demonstrated better VFM if they had no changes. Indeed, changes in the operating phase on their own cannot provided sufficient evidence to claim better or worse VFM achieved. It would be easier to agree that VFM should be appraised earlier in the development stages and subsequently tracked and validated (Henjewele et al., 2011).

It is therefore evident that no consistent measure of operational VFM currently exists, and different scholars have chosen to use what finds best fit with the purpose of their analyses. VFM is a topical issue in clinical studies and indicators such as whole hospital performance, hospital reference cost index, cost-effectiveness measures for individual treatments, average length of inpatient stay for selected treatment are common (Smith, 2009, Bassi and Lau, 2013). These are typically categorised into three groups: input cost analysis, economic analysis, and cost-related outcomes (Bassi and Lau, 2013).

**Research Methods**

VFM is a comparative concept (Henjewele et al., 2012). In the early stages of evaluation, comparison can be made between PFI and a public sector comparator of a hypothetical project procured using conventional routes. Yet in the operational phase, the project has no comparator to benchmark with, therefore the National Audit Office recommend techniques such as benchmarking, market testing and cost reviews which are gauged against an established baseline to assess potential savings. There is however a lack of comparable data consistent with specificity of an individual NHS, and for this reason a viable option would be to compare a PFI wing against a non-PFI wing within a single trust, where such data exists.

Operational PFI projects are themselves challenging to investigate due to the facts that the built asset is managed by private sector service provider. The NHS facility manager provides the much needed bridge between asset the management and end-users (clinical staff, patients and visitors), and evaluate performance in accordance with the service standards of the NHS. On the other side, the PFI contractor assesses their own
performance using the agreed output specifications. This analysis focuses on the client side and therefore the investigation uses measures as defined by the NHS in the UK.

Two sets of secondary data were collected and analysed:

- 19 full business cases provided by the project teams in response to request under the Freedom of Information Act to provide an indication of how VFM would be measured during the operational phase.
- Quantitative data from the Estates Returns Information Collection (ERIC) from the NHS (NHS, 2016). The information include all NHS Trusts in England provide a rich source of cost for maintaining the estate.

ERIC was the main source of secondary data, collection guided by the list of PFI projects from the HM Treasury published in March 2016 (HM Treasury, 2016) to identify trusts with PFI services. The outcome of this sorting exercise was a spreadsheet containing performance data for 226 NHS trusts in England grouped into two categories: (1) Trusts with PFI service providers and (2) Trusts without PFI service providers. Where the investigator was unsure of the correct category the trust was excluded from the analysis.

Three potential performance factors were identified from literature review: cost performance, management effectiveness and building performance. Attempts were then made to link the defined factors with the standard reports produced by NHS for comparison. The examination of full business cases for 19 PFI hospitals observed there was no consistency on the way projects planned to monitor and control VFM in the mature operational stage. In fact only two of the trusts had benefit realisation plans clearly indicating when, how and the frequency by which the performance would be measured. No projects specified baseline targets for benchmarking.

**ANALYSIS AND FINDINGS**

Quantitative data from NHS trusts were analysed with the aid of a statistical package for social science (SPSS-20). The analysis used simple descriptive statistical methods such as frequency and cross tabulation to compare the performance of trusts with PFI and those without. Inferential statistic such as non-parametric Spearman's correlation was performed to clarify interaction between factors. The comparison used the following factors:

- Cost performance factors.
- Management effectiveness factors.

**Sample of the Trusts Involved**

A total of 226 NHS trusts from England were analysed for comparison. Of these, 105 (46%) trust have services provided by PFI and 121 (54%) are trust with no PFI. This number excludes trusts which could not be categorised with certainty.

**Comparison of Cost Performance**

Cost performance analysis compared five parameters: (1) Capital investment for new build, (2) Capital investment for improving existing buildings; (3) Capital investment for equipment, (4) Investment to reduce backlog maintenance and (5) Cost to meet NHS Premises and Facilities Assurance action plan. These five parameters can be used to determine the overall demand for new builds and maintenance backlog.
Results for cost comparison are presented in tables 1, 2 and 3. All the three tables highlight a small difference in terms of both the number of NHS trusts and overall cost needed to provide and maintain hospital facilities. Table 1 reveals that NHS trusts with no PFI components were more likely to require both capital investment for new build and for improving existing buildings. On the other hand, trusts with PFI components were more likely to invest in equipment rather than in buildings.

**Table 1: Difference between Trusts with and without PFI**

<table>
<thead>
<tr>
<th></th>
<th>Trusts with No PFI</th>
<th>Trusts with PFI</th>
<th>Comparison (£’000)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No investment</td>
<td>Investment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>trusts</td>
<td>needed (£’000)</td>
<td></td>
</tr>
<tr>
<td>Investment for new</td>
<td>52</td>
<td>43%</td>
<td>466,549</td>
</tr>
<tr>
<td>build</td>
<td>49</td>
<td>47%</td>
<td>395,571</td>
</tr>
<tr>
<td>Improving existing</td>
<td>0</td>
<td>0%</td>
<td>546,620</td>
</tr>
<tr>
<td>buildings</td>
<td>1</td>
<td>1%</td>
<td>399,141</td>
</tr>
<tr>
<td>Investment for</td>
<td>12</td>
<td>10%</td>
<td>119,354</td>
</tr>
<tr>
<td>equipment</td>
<td>11</td>
<td>10%</td>
<td>175,478</td>
</tr>
<tr>
<td>Total cost</td>
<td>1,132,523</td>
<td>970,192</td>
<td>2,102,715</td>
</tr>
</tbody>
</table>

**Table 2: Extent of backlog maintenance**

<table>
<thead>
<tr>
<th></th>
<th>Non - PFI trusts</th>
<th>PFI Trusts</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not required</td>
<td>Investment</td>
<td>Not required</td>
</tr>
<tr>
<td></td>
<td>trusts</td>
<td>Required</td>
<td>trusts</td>
</tr>
<tr>
<td>Backlog maintenance</td>
<td>7</td>
<td>6%</td>
<td>175,381</td>
</tr>
<tr>
<td>Premises and</td>
<td>95</td>
<td>79%</td>
<td>7,548</td>
</tr>
<tr>
<td>Facilities Assurance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>action plan</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3: The extent of investment to reduce backlog**

<table>
<thead>
<tr>
<th>Number of project with a backlog (£’000)</th>
<th>&lt;£100</th>
<th>£100 - 300</th>
<th>£300 - 500</th>
<th>£500 - 800</th>
<th>&gt;£800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trusts with no PFI</td>
<td>57</td>
<td>6</td>
<td>8</td>
<td>5</td>
<td>45</td>
</tr>
<tr>
<td>Trusts with PFI</td>
<td>53</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td>110</td>
<td>7</td>
<td>10</td>
<td>12</td>
<td>87</td>
</tr>
</tbody>
</table>

From the backlog maintenance perspectives (Table 2) show that backlog maintenance is common to all trusts. Only under 10% of all trusts have had no backlog activities. In comparison, trusts with PFI were better off by three percent points, while 93% of trusts with no PFI projects had a backlog.

Table 3 clarifies the magnitude of this backlog. Most trusts' backlogs were either lower (under £100,000) or higher (over £800,000) therefore adding to a significant cost burden to the NHS. This trend is comparable for both types of trusts.

Capital investments for improving existing buildings positively correlates with both investment to reduce backlog maintenance (\( \rho = 0.558; \rho<0.01 \)) and capital investment for equipment (\( \rho = 0.286; \rho<0.01 \)) which suggests the possibility of double accounting, as these investment both actually aim to reducing the existing backlog.
Management Effectiveness

Management effectiveness relates to strategic and planning roles in the operating phase. NHS trusts are expected to comply with government commitment to reduce carbon and waste. Measures such as carbon reduction strategies and its subsequent monitoring can be benchmarked to indicate effectiveness. As discussed, one of the reasons for PFI is the potential for effective management of facilities to attain better VFM. In making cases for PFI most trusts claimed PFI would save them cost during operations due to management effectiveness and potential for efficiency gains from private sector skills. To substantiate the claim we analysed 5 measures: (1) Estates and Facilities savings from Cost Improvement Plans, (2) Estates and Facilities planned savings from Cost Improvement Plans, (3) Income from services provided to other organisations - catering, (4) Income from services provided to other organisations - laundry and linen, (5) Income from services provided to other organisations - other.

Table 4 demonstrates the potential for cost saving on estates and facilities for NHS trusts with PFI projects.

Table 4: Potential for cost saving

<table>
<thead>
<tr>
<th></th>
<th>Non - PFI trusts</th>
<th>PFI Trusts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No saving</td>
<td>Total saving (£'000)</td>
</tr>
<tr>
<td>Estates and Facilities savings from Cost Improvement Plans</td>
<td>11 9%</td>
<td>96,200</td>
</tr>
<tr>
<td>Estates and Facilities planned savings from Cost Improvement Plans</td>
<td>14 12%</td>
<td>97,843</td>
</tr>
<tr>
<td>Income from services provided to other organisations - catering</td>
<td>76 63%</td>
<td>17,751</td>
</tr>
<tr>
<td>Income from services provided to other organisations - laundry and linen</td>
<td>81 67%</td>
<td>9,400</td>
</tr>
<tr>
<td>Income from services provided to other organisations - other</td>
<td>42 35%</td>
<td>229,218</td>
</tr>
</tbody>
</table>

Results show that only 5 trusts with PFI services did not realise any cost saving. On the other hand, as many as double the number of trusts without PFI realised no savings at all. Similarly, number of trusts with no PFI that did not expect to save cost in the future was three times more as those with PFI. Trusts with PFI generally had better likeliness to realise cost saving but had limited chances of receiving additional income from other sources. Results show trusts with no PFI receive an overall additional income amounting to £47 million in excess of trusts with PFI. Most of this additional income (£35million) came from other services than catering and laundry provided to external organisations. The presence of prohibitive PFI contracts likely reduced the flexibility of the trust to use buildings and service outside the agreed terms of the contract (Whitfield, 2017).

Management effectiveness ensures that core business objectives are fully met and the plans are in place. NHS trust facilities management should therefore have in place strategies and plans for sustainability that include healthy transport, carbon reduction
management, adaptation and estates development. The results in table 5 indicates that NHS trusts with PFI underperformed in all four indictors. Adaptation planning is the biggest weakness of trusts with PFI. Only one in three trusts with PFI have an approved adaptation plan while more than twice as many of their non-PFI counterparts’ plans are approved. This may suggest some institutional dynamics which should be investigated further.

66 NHS trusts with PFI projects have a carbon reduction plan with clear targets to be achieved but only 41 of these are on track to be met. On the other hand, 77 trusts with no PFI had approved plans with specific targets, and 48 of those trusts were on track to meeting the target.

**Table 5: Management effectiveness**

<table>
<thead>
<tr>
<th>Estates Development Strategy developed?</th>
<th>Trusts</th>
<th>Number of NON-PFI Trusts</th>
<th>Number of PFI Trusts</th>
<th>% available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>95</td>
<td>26 79%</td>
<td>Yes 80</td>
<td>25 76%</td>
</tr>
<tr>
<td>No</td>
<td>51</td>
<td>58%</td>
<td>No 62</td>
<td>43 59%</td>
</tr>
<tr>
<td>Healthy transport plan developed?</td>
<td>86</td>
<td>35 71%</td>
<td>Yes 35</td>
<td>70 33%</td>
</tr>
<tr>
<td>Adaptation Plan approved by Board?</td>
<td>70</td>
<td>51 58%</td>
<td>No 62</td>
<td>43 59%</td>
</tr>
<tr>
<td>Sustainable Development Management Plan</td>
<td>88</td>
<td>33 73%</td>
<td>Trusts</td>
<td>72 69%</td>
</tr>
<tr>
<td>Healthy transport plan developed?</td>
<td>33</td>
<td>33%</td>
<td>No 62</td>
<td>43 59%</td>
</tr>
<tr>
<td>Adaptation Plan approved by Board?</td>
<td>33</td>
<td>33%</td>
<td>Yes 35</td>
<td>70 33%</td>
</tr>
<tr>
<td>Sustainable Development Management Plan</td>
<td>33</td>
<td>33%</td>
<td>Trusts</td>
<td>72 69%</td>
</tr>
</tbody>
</table>

**DISUSSION AND CONCLUSIONS**

This analysis investigated the claim of VFM in operational PFI projects. It builds upon previous research which predominantly focused on the procurement stage through to the end of construction stages, and provides additional findings to the few studies exploring the early operating stage of PFI. Secondary quantitative data from both the NHS and HM Treasury were analysed to inform the comparison on a like-for-like basis, so that the attainment of VFM could be evaluated. Two key indicators identified from previous studies were used for comparison. Results show that Trust with PFI services on average outperformed trusts with no PFI. Notably, trusts with PFI services performed well in the following areas:

- Lower backlog maintenance. The overall capital investment to reduce backlog was lower for trusts with PFI than those without, implying that PFI provided additional resources and better maintained facilities. Analysis shows that trusts with no inputs from PFI require an excess of £33million more than their counterparts.
- Lower investment for new build and improving existing buildings. Trusts without PFI services need £200 million more of capital investment than those with PFI funding to sustain the level of services they provide.
- Higher cost saving from improved estates and facilities improvement plans. Trusts with PFI options are likely to realise efficient gains from improved estates and facilities amounting to nearly £15million per annum.

There are however areas that trusts with PFI services need to improve including:

- Management effectiveness. This analysis suggests the presence of institutional barrier to effectively manage strategic issues. Fewer trusts with PFI services had completed their estates development strategy and carbon reduction plans. Completion of adaptation, was even worse with only one in three trusts having the plan approved by the board.
Contractual inflexibility has a knock on effect on trusts with PFI. Trusts are with PFI services lose nearly £46million every year from the inability to earn income from services they provided to other organisations.

The results from this analysis are tentative, and based on analysis of secondary data collected by the NHS for a different purpose. Measures used to benchmark VFM in this analysis do not necessarily reflect operational performance of PFI projects, instead they substantiate the influence PFI has to trust's overall performance. Evidence from this analysis suggest that PFI has had both positive and negative effect on performance of NHS trusts in England. A detailed analysis using segregated data would be required to accurately gauge the influence PFI has on performance. It is recommended that further analysis is undertaken of hospitals running parallel PFI and non-PFI services to provide further empirical insight.

REFERENCES


PROCUREMENT FOR SUSTAINABLE INNOVATION
PROCUREMENT OF RAILWAY MAINTENANCE: COLLABORATION FOR INNOVATION

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²Department of Business Administration, Technology and Social Sciences, Luleå University of Technology, 971 87 Luleå, Sweden

Railway maintenance is highly important for a sustainable transport system. A popular choice in Europe is to outsource the railway maintenance obligation through a public procurement process. Public procurement of railway maintenance has gained relatively little attention in research despite that the competitive tendering approach implies several challenges, especially related to collaboration and innovation. Hence, the aim of this study is to explore public procurement of railway maintenance, with a particular focus on how various factors support or hinder collaboration and innovation. A multiple case study approach is used, including interviews with client and contractor representatives and a multidimensional framework on partnering as supply chain integration guides the analysis. Tentative findings indicate that there is potential in strengthening the supply chain integration in the studied context. Findings provide theoretical contribution to supply chain integration, for example by pinpointing the importance of addressing informal relationships at the individual level in maintenance contracts. Furthermore, a practical implication for managing transport infrastructure maintenance contracts is the importance of addressing collaboration depth by allocating sufficient human resources to the client organisation.

Keywords: collaboration, supply chain integration, railway maintenance

INTRODUCTION

Outsourcing infrastructure maintenance, for example roads and railways, to increase efficiency has been an increasingly used strategy in several European countries (Olsson and Espling 2004). When public client organizations outsource infrastructure maintenance there is a need to develop new knowledge on how to procure and manage contracts and contractors. Railway maintenance is complex and there are a number of factors to take into consideration when procuring maintenance contracts. Important challenges are for example that: (I) maintenance is a long-term and continuous process with contract periods of five to seven years (II) infrastructure conditions will change with time due to age and use etc. (III) it is difficult to exactly assess infrastructure condition before, during and after the contract period (IV) and there is major dependence between client and contractor, which makes the contractor’s engagement, knowledge and flexibility essential and critical factors (Olsson and Espling 2004). There is also change in train traffic intensity to take into consideration, which affects time allocated for maintenance work (Forsgren et al., 2014).

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To ensure the expected daily service in terms of punctuality and safety, both planning and performance of railway maintenance is crucial (Baldi et al., 2016). Previous research on railway maintenance includes, for example, studies on planning methods (Baldi et al., 2016), competitive tendering and cost impact (Odolinski and Smith 2016) and contract design (Abdi et al., 2014). Previous research (e.g. Olsson and Espling 2004) has shown that contractor’s low flexibility for coping with unforeseen events during contract periods has been expensive for the client and has in some cases led to adverse relationships between the parties.

While there is extensive research on collaborative approaches (e.g. partnering) to avoid adverse relationships and improve communication and innovation in construction projects (Bygballe et al., 2010, Eriksson 2010), procurement strategies and collaborative approaches in public procurement of railway maintenance has gained relatively little attention (Aldenlöv et al., 2017). This is despite the fact that innovation and productivity improvements are essential ingredients to gain value for money in the transport infrastructure sector. It is also argued that maintenance has greater need for flexibility than construction (Olsson and Espling 2004) why procurement strategies and collaborative approaches developed for construction projects may not be appropriate for railway maintenance.

The Swedish Transport Administration (STA) has outsourced railway maintenance since 2002. Later, STA developed its procurement of railway maintenance with the intention to motivate contractors to become more innovative and develop their processes. The underlying assumption was that less restrictions and specifications of how the maintenance should be performed would drive innovation and process improvement among contractors (Vass and Karrbom Gustavsson 2017). Hence, the change process was based on increasing the contractors’ freedom in performing maintenance services.

The aim of this study is to explore public procurement of railway maintenance, with particular focus on how collaboration and innovation is supported or hindered. A multiple case-study approach is used, including interviews with client and contractor representatives. A multidimensional framework on partnering as supply chain integration by Eriksson (2015) is used to map and categorize the findings related to collaboration. Tentative findings indicate that there is potential in strengthening the supply chain integration in the studied context. Findings provide theoretical contributions to literature on supply chain integration and practical implications for the development of procurement strategies for improving collaboration in transport infrastructure maintenance contracts.

**LITERATURE OVERVIEW**

**Partnering in Construction Projects and Maintenance Contracts.**

The construction industry has a history of conflicts, disputes and a perceived reluctance to change (Laan et al., 2011). Public clients have been encouraged to initiate and drive innovation in the construction industry and its supply chains (Kulatunga et al., 2011). Traditionally, construction clients rely on competitive tendering involving several bidders that prepare lump sum contract proposals based on requirements set ex ante by the client and their consultants. In bid evaluation, the lowest lump sum is typically awarded the contract. This type of procurement has received increased criticism for causing disputes and adversarial relationships (Pesämää et al., 2009).

A client-initiated change that has gained increased interest during the last decades is partnering, which is a collaborative approach based on new procurement strategies for
integrating supply chains, drive innovation, improve performance and increase productivity (Bygballe et al., 2010, Eriksson 2015, Lahdenperä 2012). Clients are encouraged to take on the important role to create renewal through innovation and learning (Ingemansson Havenvid et al., 2016) and to facilitate group work by involving suppliers and contractors early (Kulatunga et al., 2011). Partnering relationships have been found to improve coordination and flexibility, which is beneficial in contexts characterised by complexity and uncertainty (Anvuur et al., 2007). However, there are researchers arguing for a suitable balance between cooperation and competition depending on the project and the context (Eriksson 2008). In their study, Pesämaa et al., (2009) argue that increased cooperation is desirable in contexts characterized by high complexity, customization, time pressures and uncertainty. However, establishing cooperative relationships is not easy (Bresnen 2007) and there seems to be a lack of understanding among clients of how to implement partnering (Eriksson 2008).

In their study on partnering in railway maintenance, Olsson and Espling (2004) suggest a general framework of partnering for infrastructure maintenance based on combining early partnering literature (e.g. Barlow et al., 1997) and key characteristics of maintenance. They conclude that key factors to consider are: the requirements for partnering, the partnering process, success elements and measurements (Olsson and Espling 2004, 245). Their recommendations for successful partnering in maintenance contracts are partly similar to those general for project partnering (e.g. Barlow et al., 1997) but there are also aspects that are specific for maintenance contracts. The general recommendations include: A gain-sharing mechanism and financial incentives, rules for justification of changes in target cost, top management commitment and involvement, a facilitator to coordinate and facilitate implementation, a team of key personnel from client, contractor and important sub-contractors, continuous communication between all parties, commonly agreed and ranked objectives and an agreed strategy for meeting partnering objectives. These aspects are very similar to findings in studies on partnering in construction projects, such as Eriksson (2010), Laan et al., (2011). The requirements that are specific for maintenance include: clear goals in connection to end users, agreed strategy for developing the maintenance process and a strategy including all personnel in the partnering process, especially those on the floor (Olsson and Espling 2004, 247).

**THEORETICAL FRAMEWORK**

**Partnering As Supply Chain Integration**

In the supply chain management literature, partnering and collaboration are often discussed in terms of supply chain integration (SCI). SCI is a concept that originates from a manufacturing industry context and corresponds to the concept of partnering, which is commonly used in the construction industry (Eriksson 2015). While partnering can be seen as a cooperative approach to procurement, SCI can be defined as the degree to which a focal company strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organizational processes (Flynn et al., 2010, 59). In order to enable a more detailed and systematic understanding of internal, contractor and customer integration, Eriksson (2015) has developed a multidimensional conceptual framework on SCI. The framework includes four interdependent dimensions: strength, scope, duration and depth of integration and is useful for analysing collaboration in specific projects.
The *duration* dimension is dependent on how long the partners will collaborate and jointly utilize integrative activities and technologies, for example integration across subsequent projects and/or project stages. The *scope* dimension involves the nature and number of companies involved in the integrated supply chain. That is, which organizations that will jointly perform the integrative activities and technologies, for example clients, contractors and consultants.

The *strength* dimension measures the degree of integration, which is dependent on the extent to which integrative activities and technologies are utilized, for example collaborative procurement and contracting related procedures, teambuilding activities and a joint project office. Finally, the *depth* dimension is dependent on the integration of different types of professionals at different hierarchical levels within each partner organization. Due to the interdependences and interaction effects among different SCI dimensions, it is important to manage all four dimensions simultaneously and systematically and not one by one in isolation (Eriksson 2015). Integrative activities and technologies (strength) must thus be implemented together with the right companies (scope), at the right time (duration) and with the right people involved in the companies (depth).

**METHOD**

The research that underpins this paper involves a multiple-case study of three railway maintenance contracts procured and managed by three different divisions of STA: one in the northern part of Sweden, one in the middle and one in the south. The research approach is qualitative and the empirical material is created during interviews with representatives from client and contractor. This approach enabled the researchers to develop a deeper understanding of how project participants perceive the contract, collaboration and performance. Each interview lasted between one and two hours and allowed for understanding the individual’s views and understandings. When put together and analysed against the theoretical framework, the interviews provide a possibility for understanding patterns of behaviour and perceptions, hence providing a broader understanding.

The three cases were selected based on geography (i.e. organizational spread) and time. It was perceived that it would be best if the contracts were signed approximately at the same time and were in late stages or recently have ended and that different divisions of STA had procured them. Respondents were selected to represent at least the project manager from STA and a regional or site manager from the contractor (see Table 1). All interviews were semi-structured and all but one were recorded. One of the respondents did not want to be recorded and hence, careful notes were taken instead. Most of the interviews were performed by two of the researchers in order to gain better understanding of the situation at hand. The analysis began with mapping the empirics on collaboration in relation to the multi-dimensional framework by Eriksson (2015). Hence, the findings are categorised based on duration, scope, strength and depth (see Table 2).

**Case Descriptions**

Case 1 is based on a railway maintenance contract in the northern part of Sweden. The contract is a Design-Build contract with an incentive mechanism. The incentives focused on reducing overall train delays. The idea was that the contractor should work more proactive than reactive. The contract was initiated in 2011 and had a duration of 5 years, with an option for additional 1+1 years. In this specific contract, the two option years were accepted by STA and the contract ended after 7 years in 2017. The contractor was
initially a joint venture between two contractors who planned to gain benefits by collaborating. However, one of the contractors faced problems and the contract was renegotiated and the other contractor took over the whole contract. Factors contributing to additional complexity in this contract were winter conditions with a lot of snow and the joint venture that didn’t work out as planned. In addition, there are only a few contractors active in the northern part of Sweden.

Case 2 is based on a railway maintenance contract in the middle part of Sweden. The contract is a Design-Build contract including a partnering approach. The partnering approach involved a start-up workshop where the client and contractor defined common goals. During the rest of the contract these goals should then be evaluated to make sure they are fulfilled. It was initiated in 2013 and has a duration of 5 years, with an option for additional 1+1 years. In this specific contract, one of the two option years has been accepted by STA and the contract is still on going. The contractor is the same contractor who took over the whole contract in Case 1. Factors contributing to additional complexity in this contract are the high traffic intensity on the infrastructure.

Case 3 is based on a railway maintenance contract in the southern part of Sweden. The contract is a Design-Build contract including a partnering approach, the same as in case 2. It was initiated in 2011 and had a duration of 5 years, with an option for additional 1+1 years. In this specific contract, both option years were accepted by STA and the contract ended after 7 years in 2018. Factors contributing to additional complexity in this contract were the old and fragile infrastructure.

Table 1: Interview Data

<table>
<thead>
<tr>
<th>Role</th>
<th>Organization</th>
<th>Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Manager</td>
<td>STA, North</td>
<td>1</td>
</tr>
<tr>
<td>Procurement Manager</td>
<td>STA, North</td>
<td>1</td>
</tr>
<tr>
<td>Regional Manager</td>
<td>Contractor 1a</td>
<td>1</td>
</tr>
<tr>
<td>Project Manager</td>
<td>STA, Middle</td>
<td>2</td>
</tr>
<tr>
<td>Regional Manager</td>
<td>Contractor 1b</td>
<td>2</td>
</tr>
<tr>
<td>Supervisor</td>
<td>Contractor 1b</td>
<td>2</td>
</tr>
<tr>
<td>Project Manager</td>
<td>STA, South</td>
<td>3</td>
</tr>
<tr>
<td>Procurement Manager</td>
<td>STA, South</td>
<td>3</td>
</tr>
<tr>
<td>Site Manager</td>
<td>Contractor 2</td>
<td>3</td>
</tr>
</tbody>
</table>

FINDINGS

In this section, we describe and compare our findings related to collaboration in the three contracts, based on the four dimensions of SCI: duration, scope, strength and depth.

Duration - Time for Collaboration

From a formal contractual perspective, the duration of collaboration is rather long, since the contract period is five years followed by one plus one year as option. The argument for five-year periods, according to the client’s project managers in Case 1 and Case 2, is that shorter periods are problematic for contractors because of their investments in machinery, personnel and equipment and longer periods would hamper the client’s flexibility. The criteria for if an option year will be used or not is based on the client’s project manager’s perception of the contractor’s delivery.
Option? Well, it has to do with if you are satisfied with the delivery or not. I would say it is based on gut feeling (Project Manager, Case 2).

However, the duration of collaboration is not mainly dependent on the formal contract period. Railway maintenance is a continuous process and does not have the construction project characteristics, including a definite start and end. Infrastructure assets and personnel are not temporary, but continuous. For example, the contractors that won the contracts in Case 2 and Case 3 were the same contractors as in previous contracts and, especially important when it comes to collaboration and expert knowledge, the key personnel remained mostly the same.

Yes, it was the same contractor as in the previous contract who won the new contract and it is the same persons…We know each other well, we have camped together in many crises…and thanks to their experience of the infrastructure, their asset knowledge and local awareness, they can do a good job(Project Manager, Case 2).

This show that duration have an informal relational dimension that in some cases (for example Case 3) is very long - 14 years or longer. In addition, duration also has a geographical, or physical, dependency. The infrastructure, i.e. the railway, is built many years ago and will remain at the same location for many years to come. When a new contractor wins a contract, personnel usually switch employer, from the previous contractor to the new one, while continuing the maintenance work on the same infrastructure. This way, the name of contractors might change from one contract to the next, but the key personnel - and the relationships between client and contractor representatives - often continues. This is how expert knowledge about the infrastructure is developed over time.

When personnel switch employer, they bring the tacit knowledge with them (Project Manager, Case 1).

To conclude, duration as time for collaboration in railway maintenance has less to do with the formal contract period and more to do with informal relations and physical closeness. The duration of collaboration may therefore be very long, far exceeding the contractual period of 5-7 years, at least at the individual level.

When we lost the tendering, our contract manager meets with the contract manager of the new contractor, just to sort out the terrain and personnel situation. We do not stand in the way for anyone who wants to change employer (Regional Manager, Case 1 and 2).

**Scope - Nature and Number of Collaborating Companies**

The scope dimension includes the nature and number of actors or companies involved in collaboration. In the three studied cases, the scope of collaboration is rather limited as the contract is only a matter between the client and contractor. No other actors or companies are directly involved. However, all three contractors use sub-contractors to perform maintenance work and contractor representatives mention the sub-contractors occasionally during the interviews, for example when time in track is mentioned (e.g. the time when there is no traffic and maintenance work can be done). The contractor’s supervisor (Case 2) also raised the issue of including the sub-contractors more in the collaboration because of the importance of keeping them and their specific expert knowledge. Motivating them to stay in the business of railway maintenance and not change to other jobs, is perceived as very important, especially since there is a perceived shortage of experienced personnel.
The strength of collaboration is heavily dependent on the extent of collaborative activities and technologies used. The question of applying partnering arrangements or not seems to have been up to each project manager but there also seems to have been a wide spread scepticism towards a partnering approach.

It was optional to work with partnering at that time. Now it is mandatory. It was up to the project manager...Several project managers, at least on maintenance, were sceptic toward partnering. Many of them don't like that way of working because they only see it as additional work that don't give anything back (Procurement Manager, Case 1).

However, both Case 2 and Case 3 are procured as partnering contracts including the ambition to collaborate more extensively. Both contracts began with engaging an external partnering facilitator and having joint workshops but these collaborative activities did not continue for very long.

We began the contract with rather high ambitions, saying that this time it will not be only empty words and we had a workshop and a kick-off. But it faded away almost directly (Project Manager, Case 2).

Representatives of both clients and contractors explain that they already know each other and have long-term relationships. Hence, collaborative activities and technologies are not perceived important. They have their regular meetings and reach each other by phone when needed. Also, they use inspections to gain understanding of the infrastructure condition. Case 1 used an incentive model that turned out to be a complicated history (Regional Manager, Case 1). The incentive model was aimed to drive innovation and performance but was perceived by both client and contractor as too complicated.

It has worked but it has been difficult to interpret and it is hard to read in STA systems... (Regional Manager, Case 1).

The infrastructure is old and fragile in Case 3, which makes it difficult to decide on the infrastructure condition. This has made the client, contractor and user (i.e. operator) to initiate joint study visits to gain a better understanding of the condition and to include the user’s perspective. Even though these safety rounds were first considered as a waste of time, it gave the contractor a broader perspective on safety issues.

The professionals that collaborate during contract management are the client’s project manager including a project engineer and the contractor’s site manager including supervisors and technicians. Hence, the contractor usually has numerically more representatives at the meetings than the client. The imbalance of the client and contractor sides of the collaboration is something that one of the client’s project managers has raised
as a concern, especially when it comes to negotiations. To conclude, the depth of integration is limited to a few professionals and there seems to be little, or no, collaboration internally between those who manage the procurement and those who manage the contract.

Table 2: Mapping of the four SCI dimensions in the three contracts

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract type</td>
<td>DB-contract with functional requirements.</td>
<td>DB-contract with functional requirements. Partnering</td>
<td>DB-contract with functional requirements. Partnering</td>
</tr>
<tr>
<td>Complexity</td>
<td>High organizational and external complexity (joint venture and winter).</td>
<td>High operational complexity (high traffic intensity on track).</td>
<td>High technical complexity (old infrastructure).</td>
</tr>
<tr>
<td>Duration</td>
<td>Contract: 5+1+1 years. Relations: New contractor, mostly same key personnel.</td>
<td>Contract: 5+1+1 years. Relations: Same contractor for several succeeding contracts. Mostly same key personnel.</td>
<td>Contract: 5+1+1 years. Relations: Same contractor for several succeeding contracts. Mostly same key personnel.</td>
</tr>
<tr>
<td>Scope</td>
<td>Client and contractor(s).</td>
<td>Client and contractor.</td>
<td>Client and contractor.</td>
</tr>
<tr>
<td>Depth</td>
<td>During operation: Project manager, site manager, supervisors and technicians.</td>
<td>During operation: Project manager and project engineer. Site manager, supervisors and technicians.</td>
<td>During operation: Project manager and project engineer. Site manager, supervisors and technicians.</td>
</tr>
</tbody>
</table>

**DISCUSSION**

Research on partnering (e.g. Eriksson 2015) argues that all four dimensions of SCI are needed in a successful partnering approach and since the dimensions are interdependent, they need to be combined in order to achieve successful inter-organizational collaboration and facilitate innovation. Our findings indicate that duration and strength are the two most developed dimensions in the studied contracts, while scope and depth are dimensions less developed. The lack of scope might hinder innovation when relevant sub-contractors are not included in collaborative activities. Also, the lack of depth, exemplified by the lack of internal collaboration between client personnel (e.g. procurement management and project management), is a potential hinder for development and innovation because of difficulties in implementing gained knowledge and experience. The lack of human resources at the client side also creates an imbalance that reduce the collaboration strength; there are few people at the client side for the contractor to discuss and collaborate with. Furthermore, while long-term relations support collaboration strength, they might also be a hinder for developing new ways of working (i.e. for innovation). Findings thus indicate that all four dimensions of SCI were not addressed in the studied contracts. In addition, comparing the findings to the framework on partnering in maintenance contracts, developed by Olsson and Espling (2004), confirms that neither the general partnering recommendations, nor the special partnering requirements in maintenance were implemented in the studied contracts.

To conclude, our findings indicate that collaboration in the studied contracts is supported by informal long-term relationships based on physical dependencies rather than a formal collaborative procurement approach, as recommended by Eriksson (2015).
Representatives from the client and contractor know each other well after having worked many years on the same infrastructure. This stability in personnel and expert knowledge can be understood as a way to keep expert knowledge but it can also be a hinder of innovation. Findings thus indicate that railway maintenance contracts procured in the period 2011-2013 are procured in a way that sustains industry norms and traditional ways of working rather than driving innovation and performance.

CONCLUSIONS

The aim of this paper was to explore public procurement of railway maintenance, with a particular focus on how collaboration and innovation in railway maintenance is supported or hindered. Mapping empirics from three cases with the four dimensions of SCI (Eriksson 2015) provides a deeper understanding of what supports or hinders collaboration and innovation in railway maintenance contracts. This understanding contributes to procurement research, in particular on procurement of maintenance. Findings indicate that the duration-dimension is especially central in maintenance contracts, both due to the formal length of contracts and the informal relationships at the individual level. Hence, when analysing maintenance contracts, the aspect of informal relationships on the individual level need to be added to the SCI framework developed by Eriksson (2015). An important practical implication of our findings is that the lack of human resources in the client organisation hampers collaboration depth and in turn collaboration strength, because the contractor staff doesn’t have sufficient amount of people to discuss and collaborate with. STA has recognized this shortcoming and in future collaborative contracts more human resources will be allocated.

The identified lack of collaboration and integration in railway maintenance contracts, indicate challenges to drive innovation in railway maintenance by applying established collaborative approaches. Our findings thus indicate that established project partnering and SCI frameworks don't fit well with the special characteristics of railway maintenance contracts and that there is a need for more research on how procurement of railway maintenance should be performed to achieve much needed innovation and increased performance.

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EXPLORING ENTRY BARRIERS IN THE PUBLIC INFRASTRUCTURE MARKET

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There is a perceived need to attract foreign contractors to secure capacity and keep up competition in the Swedish infrastructure sector. An increased understanding of barriers associated with the procurement and execution of public infrastructure projects with new foreign contractors is therefore important to achieve. The purpose of this study is to explore entry barriers, related to both client and contractor perspectives, in multi-national infrastructure projects. A multiple case study of five transport infrastructure projects procured by the main public client of infrastructure in Sweden (i.e. the Swedish Transport Administration) was conducted to fulfil the purpose. Semi-structured interviews with respondents from both the client and contractor for each project have been conducted to gain a broad perspective on perceived challenges. The study has identified challenges related to entry barriers such as; policy related norms and country standards, utilization of in-house design competences and technologies, and lack of suitable contacts and networks at the supply market. The findings extend current knowledge on barriers when procuring and executing multi-national infrastructure projects, but may also be of relevance to other sectors within the construction industry.

Keywords: entry barriers, foreign contractor, procurement, tendering, transport

INTRODUCTION

The number of domestic contractors within the Swedish infrastructure sector is low, whereas the volume of planned and ongoing transport infrastructure projects is high. Johansson (2000) points out that domestic competition is rather weak and there is a need to attract new foreign contractors to secure capacity and enhance competition in the construction industry. Stronger competition could also be an effective tool to improve efficiency (Cheung and Shen 2017). The major public client of transport infrastructure in Sweden is the Swedish Transport Administration (STA). As a public authority, STA must follow the public procurement act that clearly states, as two of the main principles, that all suppliers should be treated equally and without consideration to native country. Hence, there cannot be any formal barrier for foreign contractors to submit tenders and conduct transport infrastructure projects in Sweden where STA is the client. Nevertheless, the market is dominated by a few native major contractors, meaning that the competition is rather low and existing contractors may lack incentives to improve.

Similar situations can be recognized in public procurement all over the European Union (EU) where the average rate of direct cross-border procurement awards is as low as 1.4 percent for all goods and services (Kutlina-Dimitrova and Lakatos 2014). The average rate for construction is a bit higher at 12 percent, but still rather low. A quantitative study in the UK, involving several different industries, found that multiple barriers faced

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suppliers in public procurement (Uyarra et al., 2014). The identified barriers were a lack of interaction between tenderer and the public authority, too rigid specifications, low competences of procurement officers, and clients not handling risk in a proper way. More concerns expressed by suppliers included poor feedback, less thoughtful pre-qualification and low appreciation of new ideas (ibid.).

In this paper, Porter’s model of competitive strategy regarding entry barriers (Porter 1980) is used to study challenges when a new contractor submits tender in the Swedish transport infrastructure sector. Other studies in the construction industry have used this model to identify competitiveness (e.g. Cheung and Shen 2016; Ho 2016). Further, Cheung and Shen (2016) emphasized the inconsistency in findings regarding entry barriers in the construction industry. Whereas some (e.g. Seymour 1987; Fleming 1988) described the entry barriers as low, other highlight the difficulty for small firms to compete with larger contractors (e.g. Ball 1988), especially when entering a new geographical market. There is a huge need for financial funding for contractors that want to compete and sustain at an international construction market (Preece et al., 2016). Johansson (2000) points out that even if Porter’s model is concerned with entrance to a domestic market, the barriers might be even more applicable for entrance to a new foreign market. A new entry faces both challenges and reaction from existing contractors. This could result in high entry barriers or sharp retaliation, which may discourage an entry (Porter 1980). The barriers to enter a public market is of relevance also for the client side, as the client has an interest in lowering existing barriers in the procurement and execution of a project.

In prior research, there seems to be a lack of studies regarding entry barriers for publicly procured transport infrastructure projects. To increase competition among contractors in the EU, an increased understanding of challenges related to new foreign contractors entering new markets in the infrastructure sector is thus needed. More specifically, this study addresses barriers and challenges that contractors meet when trying to get access to a new public market in the European Union within the transport infrastructure sector. Further, the study also identifies barriers that the client might face when inviting and working with new contractors. The purpose of this paper is therefore to explore entry barriers experienced when conducting transport infrastructure projects in Sweden, where the client has procured a new foreign contractor. To get a good overview of the phenomenon, the perspectives of both the client and contractor have been important to highlight, in the tendering and execution stages. The paper is based on a multiple case study of five infrastructure projects in which new foreign contractors participate.

ENTRY barriers in the construction industry

According to PPA, a procuring authority have to make sure that the barriers to submit tenders are low, while still seeing to that quality and ability to deliver according to desired outcome is reached. A procuring authority can demand high quality as long as it is in proportion to what is reasonable. It is also a possibility for a procuring authority to choose language, reward system, contract form and likewise when purchasing according to PPA. However, the possibility to eliminate the entry barriers for new entrants at a public market has limitations due to both equal treatment and laws regarding competition. Porter (1980) has identified eight barriers (Economies of scale, Product differentiation, Capital requirements, Switching costs, Access to distribution channels, Cost disadvantages independent of scale, Government policy, Expected retaliation) when entering a new market. These entry barriers have also been found and explored in prior construction literature (Langford and Male 2001; Male 1991; Cheung and Shen 2016).
Some has criticized the use of Porter’s model for the construction industry (e.g. Fellows 1993, Flanagan et al. 2007) for being too narrow and not considering both the demand and supply side. The entry barriers are a part of Porter's five-force model that Fellows (1993) states are based on a perfect competition-monopoly continuum, which usually is not the case for the construction market. However, the entry barriers in Porter's model for competition support the analysis of challenges when entering a new market regardless of the form of competition in that particular market. Other theoretical models are focusing on more factors than barriers, e.g. export, market segmentation, product positioning, pricing (Johansson 2000) which are more connected to the entire strategic decision for entering new markets and not only barriers.

The entry barriers by Porter (1980) are:

Economics of scale is the decrease in unit costs of a product when the absolute volume increases. The barrier that this entails is that a new entry needs to produce large volumes to lower costs and be able to compete with existing companies with large volumes.

Product differentiation is the term used to describe the brand identification that existing companies have that a new entrance must overcome to be able to switch the customers’ loyalty. This usually requires much marketing investments to establish the new product. Male (1991) has identified this barrier in the construction industry at the stage of prequalification, in terms of requirements of managerial capabilities and financial capital.

Capital requirements are related to the financial investments necessary to start up, for example facilities, inventories, and customer credit. Depending on the market, the need for working capital varies. Rooke et al. (2004) point out the low capitalization in the construction market, which has resulted in a culture of claims from the contractor against the client, turning a loss into a profit needed to survive. This entry barrier is connected to the need for capital and therefore only larger firms can afford to hire the expertise necessary to be successful in claims resulting in that smaller firms cannot compete during the tender phase due to the risk of not being able to calculate with claims (Rooke et al., 2004). Male (1991) connects this barrier to human capital in the construction industry where available and trained labour is an issue.

Switching costs is a barrier that the customer faces when changing from one supplier’s product to another’s. This could be new equipment, training cost, product redesign and employee retraining when switching to a new supplier. In the construction industry, Male (1991) describes the switching costs for a client as a barrier when only a few contractors are qualified for a project, costs for switching contractor would therefore be high.

Access to distribution channels regards the ability to access existing channels to retailers, store and other areas to be able to sell to the end-customer. In construction, this is seldom relevant due to that distribution to end-customer is not needed. However, construction projects often involve a large number of small specialist subcontractors (Cheung and Shen, 2016), resulting in a need for accessing subcontractors in a new market.

Cost disadvantages independent of scale meaning that there are a number of different factors that a new entry on a market cannot replicate only by economies of scale and size. These are product know-how, patents, design, access to raw materials, locations, government subsidies, learning curves - the last one meaning that when a task is performed a number of times improvements are made in for example methods and layout due to cumulative experience.

Government policy is related to the limitations or control that a governmental authority can use to hinder a new entry, for example access to raw materials, pollution limitations,
Entry Barriers in the Public Infrastructure Market

standards for product testing and weight limits for transports. Male (1991) points out license requirements or particular technology requirements as a barrier in the construction industry.

Porter (1980) has also identified expected retaliation as an entry barrier. Existing companies can react and use different methods and response patterns for trying to prevent new entrances and making it unpleasant to stay in the market. This could be monopoly in distribution channels, lowering prices or other actions to hinder access to the market. Table 1 summarizes the identified barriers in the literature review.

Table 1: Entry barriers identified in literature review

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Economics of scale</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product differentiation</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital requirements</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Switching costs</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access to distribution channel</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Cost disadvantages independent of scale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government policy</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Expected retaliation</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**METHOD**

The empirical data collected for this study involves a multiple case study of five transport infrastructure projects with somewhat different characteristics. However, the projects are similar in that they are all procured and managed by the STA and involve foreign contractors. The fact that all five contractors were new to the Swedish market was the main criteria for selecting cases due to the purpose of examining entry barriers.

The main data source for the study was semi-structured interviews with 4-5 respondents playing key roles in each project. An exception is Project 3, in which we were unable to get access to any contractor respondent. The roles of the respondents have been project manager, procurement officer, project director, project engineer, site manager and the total number of interviews are 22. The length of the interviews have been from 27 to 449 minutes. Fourteen interviews have been with respondents from the client side and eight from the contractor side.

An interview guide was established and used to maintain consistency in the data collection and to enable the subsequent analysis. The questions included initial subjects such as project characteristics, procurement strategy, innovation work, project outcomes, barriers and collaboration and can be framed as an abductive approach (Miles and Huberman 1994). The respondents have been free to express opinions outside the guide during the interviews to gain a richer data set and to capture their interpretations and reflections. All interviews were recorded and transcribed to enable investigator triangulation (Patton 2002).

The analysis follows the proposed steps for qualitative research by Miles and Huberman (1994): data reduction, data display, and conclusion drawing and verification. Data reduction was done by first transcribing interviews and transferring relevant data concerning entry barriers into a document as a first step in organizing the data. This was followed by a thematic analysis where the empirical data on perceived barriers was coded.
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into more detailed categories and put into the studied context, based upon the theoretical framework proposed by Porter (1980). During the data analysis, iterations between emerging results, theory, and empirical data for the study were performed, in terms of discussions between the researchers, to strengthen the developing conclusions (Yin 2013). Table 2 summarizes information about the studied projects.

Table 2: The studied projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
<th>Duration (years)</th>
<th>Delivery system</th>
<th>Contractor size (employees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Construction of a road and a bridge crossing a smaller river. The project is a rather small infrastructure project and can be characterized as a conventional road project.</td>
<td>1</td>
<td>DBB</td>
<td>350</td>
</tr>
<tr>
<td>2</td>
<td>Construction of a tunnel under a large river in urban environment. The project is part of a mega-project and can be characterized as complex due to geotechnical conditions.</td>
<td>7</td>
<td>DB</td>
<td>85 000</td>
</tr>
<tr>
<td>3</td>
<td>Construction of two tunnels that connect the mainland with an island. The project also entails construction of temporary structures such as harbours to ship out masses. The project is rather complex and part of a mega-project.</td>
<td>10</td>
<td>DB</td>
<td>Consortium</td>
</tr>
<tr>
<td>4</td>
<td>Construction and reconstruction of a railway that entails a tunnel, which will increase the capacity for commuter trains in a large city. The project can be characterized as complex and is part of a mega-project in a large city.</td>
<td>10</td>
<td>DB</td>
<td>8 000</td>
</tr>
<tr>
<td>5</td>
<td>Reconstruction of an existing road junction including a new bridge and a roundabout. The project can be characterized as a conventional road project.</td>
<td>3</td>
<td>DB</td>
<td>6 000</td>
</tr>
</tbody>
</table>

CROSS-CASE ANALYSIS

Challenges related to each of the eight entry barriers have been identified. Findings from the cross-case analysis are presented to accumulate case knowledge, and to compare and contrast the individual within-case findings.

Economies of scale

Transport infrastructure projects are often complex endeavours and the client is thus often risk averse and not willing to step outside known routines and patterns. The fact that new foreign contractors enter the Swedish market means that they do not have any existing project portfolio in the new geographical market. Consequently, they lack economies of scale and costs for preparation and establishment need to be covered by the first project (or by a series of subsequent projects), which is an entry barrier compared to the established contractors. The project size was mentioned as a challenge by several contractors and is exemplified by a project director at one contractor (Case 1):

….if we change our geographical area, then we need a project that is large enough, it should at least be two years and it needs to be worth +150 million [Swedish crones].

However, one of the respondents also mentioned that the project should not be too large since this entails risks that a new contractor is not able to handle due to large uncertainties at the new market.

Product differentiation

PPA stipulates that the public client cannot ask for a specific brand when procuring goods or services. This means that there should not be any obstacles for a new contractor to
enter a public market due to product differentiation. However, the demands in the tendering documents can according to a project director at one contractor (Case 1) be written “with a specific contractor in mind” and therefore indirect exposing brand loyalty at the client. This has consequently been discussed as a barrier in one of the studied projects since e.g. proposed technical solutions by the new foreign contractor does not fit into the mind-set of the client. The same respondent highlights that this procedure by the client is not unusual in public procurements and acts as a challenge for entering a new public market since the client has no knowledge about the new foreign contractors and their way of designing structures.

Capital requirements
Entering a new market costs money and requires extensive financing, which may act as a barrier for new foreign contractors. A project manager (Case 5) pinpoints that “All those things you have to know before you start cost money. You need a bigger company that is willing to cover those costs”. Examples of expensive issues that need to be handled are getting to know the new market, finding domestic networks and learning the procedures of the new client. This challenge of entering a new market is discussed by both the client and contractors in cases 1 and 5.

Switching costs
Working with foreign contractors entails some switching costs for the client, in terms of learning and a stronger need for providing support. Some respondents from the client highlight that working with new contractors requires a bit more resources in the client’s project organization. The challenges for the client relate to the fact that new contractors may be unaware of current norms and regulations and how the client usually goes about certain procedures. New contractors, especially foreign ones, cannot be expected to take care of certain things on their own without proper support from the client. Hence, the client must be prepared to invest some resources and money to provide support to contractors that are new to the Swedish market. A project director at the client (Case 5) pinpoints that:

I think we should be very positive about the fact that we have an interest for our projects in Europe and then we should be prepared to be supportive. New contractors need more help than established ones. And since they work for us, they must get all the help they need. It is not an opponent we have invited but it is a contractor who works for us

Several respondents, from both the client and contractors, discussed how this support is crucial and that the client’s project organization also needs to inform and educate new contractors that work in the market for the first time. A procurement officer at STA (Case 5) highlighted that:

If we get a foreign contractor, we need to educate the contractor in our culture at the same time as the project is running.

Access to distribution channels
Access to distribution channels such as retailers and stores is not a valid barrier to investigate in this context (due to on-site production of a product procured by one specific client). However, contractors need other networks and contact channels (e.g. subcontractors, designers and domestic staff) to be able to conduct transport infrastructure projects. This is the most commonly mentioned barrier (mentioned by four out of five contractors) in this study. The difficulty to get access to know-how regarding design and competent personnel, which might be required to be able to submit tenders, and to collaborate properly during the execution stage in the project, is a major concern. This barrier may be especially critical in Sweden, since the Swedish market is rather small and
relies on domestic norms that might be difficult to understand for new contractors. The access to material suppliers has also been identified as a barrier in one of the projects. Native suppliers are dependent on the established contractors and therefore do not want to risk these relationships by signing up with the new contractors. Access to proper resources throughout the project therefore poses a major challenge for new contractors entering the new market. A procurement officer from the client (Case 2) pinpoints this by stating that:

….they have a problem with hiring the right persons because it is a small market and the established actors are very keen on keeping their best resources. So it is not the easiest of jobs to succeed in hiring staff when they are new.

Due to the rather small size of the market, a new entrance needs to attract employees from already established contractors if they want to hire domestic personnel, but also see to that their employees stay with them throughout the project, which might be challenging since established actors with large project portfolios might be more attractive to work for than new contractors.

**Cost disadvantages independent of scale**

Barriers due to cost disadvantages not connected with the volume are found in four out of five studied projects (cases 1, 2, 4 and 5). The most common barriers are access to know-how regarding design and competent personnel, and learning curves related to both the submission of tenders to the client and how to improve during the execution stage in the project. Unlike Swedish companies, many foreign contractors have strong and extensive in-house design competences and resources. This often results in designs that are new for Sweden, although they may have been used in other European countries before. The challenge is related to the introduction and use of these new designs, for example getting permits to implement them. Furthermore, the access to raw materials has also been identified in one case. Even with higher quality of the raw material, it is still a problem to find subcontractors, for example regarding asphalt and gravel. A project director for a foreign contractor (Case 1) reflects on their need of raw material and subcontractors:

> We have guys laying the asphalt, we have guys delivering the pipes we put into the ground and /.../there is the gravel and stuff like that. We are buying all of that and that's often 60-70% of the project.

**Governmental policy**

Governmental rules, regulations and standards have been identified as a barrier for new contractors in all studied projects. The extensive and context specific regulations, norms, and standards in Sweden are a challenge to understand and adhere to for new foreign contractors. This barrier is twofold; firstly the sheer volume of these documents that the client refers to in the tendering documents is massive, and secondly they are also country specific and different from similar standards and codes in Europe (EuroCode). Many respondents in STA mention misunderstandings and misinterpretations based on foreign contractors’ lack of knowledge about Swedish norms, regulations and practice. A project manager for a foreign contractor (Case 5) clarifies their challenges resulting from the extensive referring documents:

> STA’s construction market is regulated by codes and standards in a way I have never seen in any other country. For foreigners it is very complicated that the referring documents are so huge; you will never be able to know everything about AMA-codes and the Swedish standards. That is a big problem.

**Expected retaliation**

One of the barriers when a new contractor enters a market is the reactions from the established actors, who generally do not want increased competition and might take
actions to make it more difficult for new actors. One example that is mentioned is the handling of masses where the other competing tenderers (established contractors) own all facilities and equipment. A project director from the client (Case 4) states

…we were worried that the new foreign contractors would not be able to compete with the established ones. We think that it might be difficult to, during the tendering phase, get a grip of the market for e.g. rock crushing plants and get a proper price [from the established contractors]

An action to keep out new entrance, mentioned by the contractors in several projects, is consequently for the established contractors to either own or tie up needed resources so that the access to specific markets is difficult to achieve for the new contractors.

CONCLUSIONS AND DISCUSSION

Overall, the findings of our multiple case study indicate that there are major challenges for new contractors to establish themselves in the Swedish market. Challenges related to all entry barriers proposed by Porter (1980) have been identified. However, some of the entry barriers of Porter’s model are not directly applicable for the specific studied market due to, e.g. the public procurement act (PPA) and the structure of the market. The client as a public authority is obligated to see to that there is no barrier for any tenderers within the European Union to either submit tenders or to deliver according to the contract in the light of PPA. When Porter (1980) discusses governmental policies it is rules and regulations regarding taxes, load weight for trucks, etc., it's not regarding being both the writer of the policy and the client referring to the same, as being in the case in this study in some regards. The client in this market therefore has a major direct effect by formulating many of the policies and at the same time procuring projects that adhere to these policies. One barrier identified related to this is that established contractors have an advantage in relation to new contractors due to the fact that the client has enhanced their demands over the years and established contractors have had the opportunity to prepare for the increasing demands over time in a slow pace. Public clients that manage projects with foreign contractors must therefore be prepared to put extra efforts in terms of support and education to balance the competition between new and existing contractors.

In line with prior construction literature (e.g. Preece et al., 2016; Langford and Male 2001), one major challenge found in the study is the need for financial funding. The findings indicate that establishment on a new market needs vast investment in both time, staff and capital. Consequently, economies of scale, meaning that the project has to be of a certain size, is identified as a major barrier.

Prior literature also suggest that governmental policies may act as an entry barrier (Male 1991). Findings from the conducted study confirm this and highlights that governmental norms, country specific rules and regulations act as major barriers for new foreign contractors at the Swedish infrastructure market.

The findings from the multiple case study contribute to the literature on entry barriers by both confirming prior literature (Langford and Male 2001; Male 1991) but also by proposing some new barriers previously not identified in construction, such as access to subcontractors, domestic staff and consultants due to the vast need of external resources when execution projects in this sector. A unique feature in this study is the dualistic focus on both client and contractor perspectives on entry barriers. The traditional way to identify entry barriers has been from a strategic business approach - from the contractor’s side (Chen et al., 2016, Preece et al., 2016). In the infrastructure sector however, the public client has a vast influence on some of the entry barriers and their perspective is therefore of importance.
The findings also have managerial implications by increasing the understanding of the barriers new contractors encounter and how they can handle them. These findings may also act as a basis for actions taken by the client to lower the entry barriers and attract new possible contractors that are needed to meet the increasing demand.

The authors believe that the presented study generated several insights that warrant attention, but some limitations should also be noted. A major concern is that the study is limited to the Swedish market settings. This limited scope may limit the possibilities for generalizations to other countries. However, there was a recognized need for explorative, rather than confirmative studies, due to the limited previous research on this topic, especially in the public market setting. Thus, the number of projects seems sufficient to highlight challenges that require further attention. Another limitation regards the decision to focus the analysis on the entry barriers identified by Porter (1980). Another type of challenge that was identified in all projects but not included in the analysis (due to space limitations) is related to language, communication and culture. Even with translation to English or using English as the work language nuances could be lost due to the fact that in many projects neither the client nor the contractor has English as its native tongue. Therefore, communication could be regarded as an entry barrier that might need further attention within the studied context. Difference in business culture could also both deter from submitting a tender and be a reason for conflicts. The choice to not focus on language, communication and culture are because these usually are challenges that occur after entering the new market and during the execution phase. Nevertheless, the authors believe that this paper provides a step towards understanding the barriers that exists when new foreign contractors try to establish themselves in a new geographical market.

REFERENCES


INTRODUCTION

It has been stated that construction management has moved away from its applied, technological, past and moved towards contribution to mainstream debates in social sciences (cf. Harty and Leiringer 2017; Koskela 2017). This paper is an effort to connect more mainstream political science debates concerning public sector reform to those of construction management. During the last decades reform of local government has been taking place under the umbrella of New Public Management (NPM) entailing market inspired logics and values that subsumes political and democratic ambitions. NPM are well researched with some significant gaps. In particular, of studies concerning the politics of public procurement. In this paper we present an analysis where public procurement is understood more broadly as an instrument of governing associated with the rationalities of marketization and competition. We assume that as such a technology it is not a neutral tool. The case we present is based on interviews with civil servants, consultants and politicians working with public procurement in Swedish local government. With the perceptions of our respondents as a base, we construct a narrative where three themes emerge as important: public procurement expansion; organizational change and centralization, and: the procurer as bureaucrat. We conclude that the importance and scope of public procurement within the larger local government organization has rapidly expanded, public procurement has been centralized and, perhaps most importantly, we witness the emergence of a new bureaucrat representing values not compatible with traditional Weberian understandings.

Keywords: local government, sustainability, public procurement, bureaucrats

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In Sweden, local self-government is a central principle within the welfare state (Montin
and Granberg 2013) where municipalities have extensive governing rights and levy
income tax to provide welfare functions for their citizens. While this function still stands
strong the last decades have brought significant changes under the umbrella term New
Public Management (NPM) creating a market-oriented logic that potentially subsumes
political and democratic ambitions (Montin 2016).

In the early 1990s some of the first and still most influential works where published
focusing on the shift from ‘old public administration to new public management’ (Aucoin
However, soon the death of NPM within public organizations was declared (Hood and
Peters 2004; Dunleavy et al., 2006). Others tried to develop new perspectives bridging
the literatures of NPM and governance coining the term New Public Governance (NPG)
(e.g. Osborne 2006; 2010; Montin and Granberg forthcoming). Thus, NPM is still a
prominent feature in public organizations and it continues to be well researched.
However, studies of the politics of public procurement are scarce and research in public
procurement is dominated by judicial issues, economic effectiveness and detailed studies of
specialized issues (Furusten 2015) and this is especially true for the public procurement
of construction (buildings, infrastructure, etc.).

In this paper we address this research gap. Hence, we present an analysis with a broader
understanding of public procurement. We assume that public procurement is not a neutral
tool, but rather designed to realize particular understandings of how to govern and
specific effects of this (Miller and Rose, 2008). We argue that it is important to create an
understanding of how public procurement is perceived and understood by those working
with it in public organizations and that this understanding is relevant outside the fields of
public administration and political science such as the research field of construction
management.

Public procurement is important for the Swedish public sector with a volume of 642
billion Swedish crowns, amounting to 17 percent of the gross national product of which
public procurement of construction accounts for 91 billion Swedish crowns (17 percent of
the total of the public procurement) (Upphandlingsmyndigheten 2017). The regulation of
all public procurement is an important factor for the understanding of local government
policy and implementation (Montin and Granberg 2013: 18; EU 2004; EU, 2013; SFS
2007:1091; SFS 2007:1092). The NPM rationalities that have been rolled out in Swedish
municipalities is in stark contrast with how public organizations used to be steered and
controlled historically (Montin and Granberg forthcoming) with a potentially substantial
impact on the role of civil servants and for external actors interacting with these civil
servants. Focusing on this tension, Swedish municipalities is a good case to study.

This paper is based on interviews with civil servants, consultants and politicians working
with public procurement in Swedish local government. We construct a narrative where
three themes emerge: 1), the expansion of public procurement and associated practices;
2), the organizational change and centralization (including the fusion of public
procurement of construction into centralized procurement departments); and, 3), the
 procurer as a new bureaucrat.

While our data does not allow for empirical generalization we argue that the case can be
viewed as paradigmatic (Flyvbjerg 2006) as it illustrates broader tendencies and themes in
the contemporary paradigm of marketization impacting public administration in general
and public procurement in particular. Thus, we see the case as a prototype for
understanding how public procurement is experienced as a practice by those who exercise
it as well as how it has changed the public organization in which it is situated. In sum then, the purpose of this article is to investigate how public procurement, as expression of NPM, is practiced in Swedish municipalities.

Case Context: Swedish Municipalities and Public Procurement

The Swedish government system is an integrative central-local government system, where municipalities have substantial constitutional, financial, political and professional resources (Montin and Granberg 2013; Montin 2016; Granberg 2018). Sweden can be perceived as a ‘least likely’ case for utilizing market mechanisms and, accordingly, as a paradigmatic case worth of critical inquiry (cf. Flyvbjerg 2006: 229).

The municipalities are responsible for a broad range of functions, from childcare to economic development. However, the concept of strong local government ensuring efficient public production of welfare services aiming at securing the well-being of its inhabitants and facilitating the functions of representative democracy, has been increasingly challenged over the last decades by reforms primarily focused on increased economic efficiency and based on market approaches as well as models used in the business sector (Montin and Granberg 2013; Montin 2016; Granberg 2018). This development can be observed through freedom of choice-reforms and policies focusing on competition, opening up local services to private businesses as external service providers whilst also subjecting internal municipal service provision to both internal and external competition (Montin 2016). This has entailed a change in the use of government intervention through regulation. Regulation concerns government intervention in markets to facilitate positive outcomes and control potentially adverse consequences as identified by the processes of representative democracy.

In the contemporary Swedish debate on state (national or local) intervention, conventional regulation is considered as negative path dependency, limiting the scope and flexibility of market action and also undermining competitiveness (Montin 2016). Today, regulation is considered a tool for stimulating market responses leading to economic growth and reinforced economic competitiveness for both public and private actors (Montin, 2016; Granberg 2018). Accordingly, municipalities act in a context characterized by high demands for efficient welfare production within a frame of market rationalities and competition as its fundamental features of governing (Montin and Granberg 2013; forthcoming; Montin 2017; Granberg 2018). Competition between market actors has become an integral part of public sector activities. Hence, municipalities have developed a more complex implementation process as outsourcing of public welfare functions has increased.

Public procurement has entailed an increased importance of contracts and negotiations influencing the preconditions for political steering and control (Hall, Löfgren and Peters 2015; Montin 2016). Private entrepreneurs increasingly handle the actual provision of public functions and services, funded by tax contributions and with local government taking the overarching political and democratic responsibility (at least in principle).

It has been stated that public procurement is a policy tool with the potential to handle problems and accomplish change much faster than traditional policy tools and legislation (Dallhammar and Leire 2012: 9). As public procurement has a long tradition in the built environment (Sporrong and Kadefors 2014) this is especially valid for public procurement of construction in relation to the strive towards sustainable cities through city redevelopment, including issues like the redevelopment/refurbishment/retrofits of housing, the development of smart grids (electricity and energy), city environments (flood
and landslide risks, pollution and heat stress, etc.) and safe cities (mitigating a variety of disaster risks) (Dallhammar and Leire, 2012; Bulkeley et al., 2011). Hence, public procurement has the potential to create strong incentives for procurement in the private sector by stimulating the development of new products and services and by creating new standards and criteria for “green” products etc.

It needs to be stated here, however, that public procurement as a policy tool for sustainable development has far from being realized to its full potential (Dallhammar and Leire, 2012: 17). It is important to acknowledge that public procurement has to be understood in relation to other policy measures and practices (taxes, legislation, national policy objectives, market incentives, influencing public opinion, institutionalized practices, etc.) forming Swedish local government. This often results in multiple and conflicting goals. These goal conflicts are more pronounced when it comes to more ambitious political goals such as those associated with sustainable development (Sporrong 2014: 2).

Contextualizing is important in order to grasp the processes, practices and goal conflicts of public procurement. Organizationally, there has been shift of municipal procurement of construction-related services from technical departments to central departments of procurement and this has had significant impacts on procurement processes and roles of actors in terms of increased regulative complexity, stricter control and outsourcing of wider ranges of municipal services (Sporrong and Kadefors 2014) and this development has great relevance for construction management.

METHODOLOGY AND DATA GENERATION

In the following analysis we draw on interviews conducted between spring 2015 and early 2017 with 16 respondents in four Swedish municipalities. Our sample includes four municipalities ranging in size from very large to mid-sized using a Swedish frame of reference. In terms of inhabitants this means that they span from roughly about 1 million to 100 000. The respondents all work with public procurement in different positions within the municipalities and among them are procurers, politicians and consultants from different departments within the municipalities. Moreover, the sample is diverse in terms of hierarchy and experience since we have interviewed heads of departments as well as ‘ordinary’ procurers, some of which have been involved in procurement for decades and others just a few years. When selecting our interviewees, we also paid particular attention to building and construction departments. Since the principle of local autonomy is important in Sweden, the departmental structure differs among municipalities and corresponding ones may have different names. Regardless of this, the building and construction sector is one where lots of rather complex procurement practices occur and for this reason all municipalities in our sample are organized so that the department responsible for those issues maintain their own procurers. Therefore, we wanted to include at least one respondent from the building and construction part of the municipal organization in each of the municipalities, however, in one of them this was not possible.

Swedish municipalities also utilize municipal companies. These are public businesses competing on the market and therefore they are subject to special forms of legislation that structures the way they are set up. For historical reasons, some of the most important municipal companies are public housing companies that together own about half of all rental apartments in Sweden. They are important actors in terms of public procurement of construction since they, like the departments of building and construction, plan their own procurement processes and employ their own staff. Therefore, we have included interviewees working with procurement of construction in public housing companies.
The interviews were carried out by a team of four researchers and all of the interviews were recorded. The most common set up was for two researchers to be present during the interviews together with one respondent, however, in a few instances this varied. Two of the interviews had two respondents present, which means that while the number of respondents is 16 the number of interviews is 14. In the following analysis, the quotes used have been translated into English by the authors of this paper.

The interviews themselves was semi-structured and we used two different interview guides. One was designed specifically for those respondents who work with procurement of construction in the municipal companies or building and construction departments, while the other was used with civil servants working in the central procurement units, other departments as well as with politicians. In essence, the guides were designed to capture four topics: 1) the respondents views on the evolution and current state of the procurement function within their organization, 2), their interpretation of political steering of procurement practices, 3), their perception of building and construction in relation to procurement and, 4), what they consider important general challenges in the future for the public procurement practice.

As stated above we argue that this case allows for interesting insights into current procurement practices in Sweden. We see what we are studying here as a paradigmatic case and argue that this ‘…highlights more general characteristics of the societies in question’ (Flyvbjerg 2006: 232) and among these more general tendencies is the marketization and transformation of the public sector in Sweden (and beyond). Hence, the themes, topics and articulations made by the respondents can probably be recognized throughout the Sweden and in other national contexts.

**Public Procurement in Swedish Municipalities: Perceptions of a Practice**

The interviews have provided us with a material that spans over a number of issues and features relating to public procurement, however, among these articulations some are more salient than others. As indicated in the introduction, we wish to draw attention to three major themes that are prevalent among the respondents as they reflect upon the role of public procurement within their organizations and in relation to their own positions. These three themes emerged during the retroductive coding process where the movement back and forth between our theoretical assumptions and the data resulted in a set of codes and categories that we label expanded procurement, organizational change and centralization as well as the procurer as a new bureaucrat. Thus, we may think of the major themes presented here as ones that are prevalent and manifest to a high degree in the data, but also as the ones that structure, steer and guide other themes and topics in more implicit ways. Hence, while the themes do not encompass or exhaust the data, we argue that they are important, and indeed central, for understanding the general discussion concerning public procurement in Swedish municipalities today. As such, they both express, and are an expression of, the general changes and reforms in Swedish municipalities over the last decades guided by NPM and marketization.

**Expanded Procurement**

Perhaps not surprisingly, respondents describe the practice of public procurement, its importance and recognition within the larger municipal organization as rapidly expanding over the last ten or fifteen years. Indeed, some articulations limit this time frame to just the last couple of years as they describe a very intense recent period and argue that we are in the midst of an expansion that we have not seen the end of yet. In fact, as stated by one of the senior procurement managers, we have recently experienced the dawn of a new era for municipal public procurement:
Local Government and Public Procurement

... I started this position in 2008 as Vice President for the procurement unit ... and so much have changed! When I started there were 24 of us, now we are close to 60. I mean the world we were working in back then in 2008... It was a dawn of a sort.

Similar stories arise in all of the four municipalities that we have studied as respondents describe an expansion of public procurement in terms of resources, personnel and sectors. Over time, it is not just the actual numbers that have increased, but public procurement has also expanded in more qualitative ways. Not least, our respondents account for how they struggle to handle, and implement, new policies and strategies relating to public procurement that are becoming more and more complex and comprehensive. Thus, the respondents reflect upon the impact of new drafts and plans for public procurement strategies in the municipalities and how these are entangled and nested into other policies at different scales. Not least, the new public procurement legislation that became effective in 2017, and the work leading up to it, is something that affects the everyday practice of procurers and entrepreneurs, as well as politicians, in the municipalities. One senior procurement officer argues that contemporary practice cannot even be compared with what was going on just a few years ago:

I mean you can't even compare [with before] at all. It's a real journey that we have made from a time when we were focusing on 'lowest price', and then, I mean, quality starts to become part of it so 'lowest price at best quality'. Now it's like lowest price is something of a bad word ... So we have gone from 'lowest price' to 'sustainable society' ... We work with social responsibility, we work with ethical demands, we work with ecological ... we work with everything there is.

The respondents argue that the political steering and expectation of procurement is increasing and that, in addition to making good business, procurers are expected to help achieve social and environmental goals as well. For instance, increasing social responsibility through procurement is something that respondents working in managerial position discuss extensively in the interviews, and it is also something they struggle to implement in their organizations. Environmental issues seem to have been more accepted and particularly by those working in the departments of building and construction as well as the respondents from the public housing companies that find this to be a common aspect of procurement of construction.

Public procurement has become a governmental function that is intended to administer, control and fulfil an array of political goals and ambitions in ways that it did not do before. In our interviews, organizational change is a prominent theme and while the respondents mainly focus on their closest organizational setting rather than the entire administration, their reflections also tell us something about important changes to the wider organization.

Organizational Change
Closely related to the expansion of procurement practices is the theme of organizational change that relates to new and shifting ways of procurement. We see two different expressions of this in our interviews. Firstly, as respondents account for the significant changes that have been going on during the last years in the practices of public procurement, they generally account for different forms of organizational changes, often in terms of centralization. In three of the studied municipalities they have set up centralized procurement units aiming at concentrating procurement expertise serving municipal organization as a whole. It is only in the largest municipality where such a centralized unit does not exist, however, we argue that this, at least to some extent, is a question of scale.
While no central unit has been instated, respondents from that organization still feel that the organization around procurement practices have changed, and that they have been centralized to the top levels of the departments. Thus, in all municipalities respondents speak of a striving to find a good setup for public procurement functions. The solution with more centralized functions is often driven by a need to develop judicial expertise and other skills among civil servants within public procurement. This, in turn, is driven by the expansion we accounted for above in the sense that public procurement today is a complex practice where different political goals are to be realized, while following a detailed and sometimes very complicated regulation. Secondly, a less tangible form of organizational change relates to the processes of marketization that is integral to public procurement.

We find that the spoken language of our respondents is filled with terms and expressions borrowed from the business world. In addition, our respondents also highlight the use of award ceremonies, best-practice networks and a need to distinguish themselves as great assets when it comes to doing 'good business' and achieving the 'good affair'. One way that this mindset comes to life in at least one of the municipalities is in an explicit goal to be an 'attractive tenderer'. For the respondents, this means that they strive to be an organization that can beat all other public organizations in terms of being a good business partner that private companies want to work with. They feel that they are in competition with other municipalities and organizations and simply must be the most attractive one in order to prosper and survive. One public procurement manager argues:

Maybe someone else has got something that we don't have, but in the end, we need to attract our consultants and entrepreneurs. That is, they need to choose us … and they should do that because they really want to work with us and because that would be both fun and profitable. It shouldn't cost them any unnecessary time or resources and we should have a very businesslike relationship. And when I say businesslike, I mean it's one thing to attract them during a single tendering, so that they actually place a bid, but we also need to make sure that we maintain our businesslike conduct during the entire process. We have really long projects and contracts and so the business will be with us a long time and we must ask how are we relating to each other? How do we represent our selves, how do we cause each other costs and what understandings do our procurers really have for the business …?

In sum then, our respondents convey how the expanding public procurement also have concrete effects in terms of organizational structures. Intertwined with this changing form, focus and ethos of the organization, our respondents also account for 'the procurer' as a form of bureaucrat that is increasingly important. Thus, we turn to our third major theme that we have reconstructed from the interviews.

**The Procurer as a New Bureaucrat**

A prominent theme in the interviews relates to what constitutes the role of 'the procurer' not only in terms of background and education, but also with respect expectations, skills and competences. Within procurement there is a frequent use of consultants. These consultants can move in and out of various projects and be part of the administration, yet at the same time sit beside it. This causes issues of how they fit into the normal hierarchy of the administration, sometimes challenging steering and control:

As I said, these one hundred, who work directly with these issues, but then there are 500 consultants as well, and how are they to be steered and controlled? … I mean here you cannot give orders to anyone since you live in a contractual relationship with them and a contract is a very … equal relation.

Moreover, some of our respondents speak of working with public procurement as part of a career strategy rather than a long-term commitment. They may start off as working with procurement within private organizations who are bidders for contracts offered by
the public sector. As part of gaining experience and understanding they may work a few years, or do consulting, within the public organization, but with the goal of coming back to the private sector better equipped and more competitive for senior positions. It is also clear that procurers need to be well versatile with current law. Indeed, when we asked managers as well as the procurers themselves what the most common background was they said business, law and engineering. This could be both in terms of previous work experience as well as education and while this naturally is not a problem per se, it can be hard to find people who understands the values of a public organization. One manager explained:

I think that many sales-people think like 'hey I can work on the other side since I know how to sell to them'. I tell them that what they think of is an entirely different competence, being a good sales-person … So I mean public procurement and purchasing … you need to have understanding for a politically governed organizations ... For instance, we work under the Public Access to Information and Secrecy Act, that we are accountable in relation to tax payers and that, I mean, you are a civil servant.

This has the effect that respondents also speak of consultancy firms as the real winners in the ongoing expansions. Not only do they bid on profitable contracts they are also the most prominent providers of education and sellers of courses, modules and instruments that the public organizations buy in order to raise the competence of their own staff.

**CONCLUDING DISCUSSION**

We observe a clear expansion of municipal procurement. It is clear that public procurement is a governmental function that is intended to administer, direct and control an array of political goals and ambitions in ways that it did not do before. We may speak of an expanded process of marketization in the sense that new forms of markets are produced not only in terms of products and services, but also with respect to rules and functions as well as the overall confidence in the market as a political solution. With this expansion follows new rationalities and logics that marks the practices tied to public procurement and, as a consequence of the expansion, these may intertwine with other parts of the administration and spread throughout the municipal organizations.

The development of public procurement has an impact on the organizational structure, aside actual expansion. While different municipalities may be set up in various ways to handle their public procurement, it is clear that they are now working actively to find ways to make it work in line with strategies and goals that are broader than ever before.

We can observe the image of a new form of bureaucrat that in many respects represent values that are not part of traditional Weberian understandings. An example is the 'business language' that is common place for most of the respondents in our sample indicating the impact of business perspectives and ideas. It also is common to hire consultants on short term contracts to do procurement work for the municipality. At the same time, the articulations within our material point to what we may call expressions of increased judicial and economic power. Not only are the new bureaucrats that procurers represent educated within those areas, but it's the specific expertise that often is sought for is precisely knowledge of law and a business mindset. Hence, the role of the public procurer within an expanding and changing organization is not simple or uniform and the procurer emerges as a hybrid figure within the municipal organization. We end by stating that this development is highly relevant for construction management and its actors that regularly interact with public actors such as procurers. The connection between more mainstream political science debates concerning public sector reform to those of
construction management is relevant in order to understand the implications that this development potentially has for construction management.

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WALKING THE TALK: MOVING BEYOND WORDS
SUPPORTING DECONSTRUCTION PRACTICES WITH INFORMATION SYSTEMS USING ETHNOGRAPHIC-ACTION RESEARCH

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Socio-environmental pressures motivate the construction industry to adopt working practices that enable the reuse of building elements. Deconstruction, as an alternative to demolition, is a major lever for more efficient resource management and enables closed-loop material cycles. Information systems have potential benefits for deconstruction practices, but their implementations are limited by a lack of understanding on how demolition workers create, exchange and communicate information and what artefacts they thereby use. This research has therefore two goals: understanding on-site information requirements in deconstruction projects and exploring how information systems can be iteratively developed and implemented into these project contexts. Through applying an ethnographic-action research methodology on a real-world deconstruction project, two information systems are iteratively developed and implemented: (I) a virtual environment to support tagging façade elements, and (II) a 4D model to support deconstruction planning. Insights are provided - firstly - into deconstruction routines and the tacit knowledge that demolition workers possess and use to deal with these routines, and - secondly - into how the two information systems supported the practitioners in their ongoing project works. These ethnographic-action perspectives provide new ways for researchers and practitioners to support deconstruction practices with information systems.

Keywords: deconstruction, ethnographic-action research, information technology

INTRODUCTION

Resource scarcity, sustainability challenges and stringent policies motivate the construction industry to adopt working practices that facilitate the reuse of building elements. Deconstruction management is a major lever to enable closed-loop material cycles. As an alternative to knocking down buildings with crushing force, Kibert (2016, 480) describes deconstruction as “construction in reverse” in which a building is disassembled for the purpose of reusing its elements. Deconstruction preserves the embodied energy of building elements and can lead to reduced carbon emissions, costs and pollution (Iacovidou and Purnell, 2016). A shift from demolition to deconstruction seems imperative given that end-of-life activities generate one of the largest single waste streams worldwide (Cheshire, 2016). Up to date, however, the end of life for a building typically consists of the complete elimination of all of its parts (Thomsen, Schultmann, and Kohler, 2011).

Adopting a non-conventional deconstruction strategy necessitates a number of changes in the design and planning of these types of projects. Design factors favouring the

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disassemble-ability of a building include the use of prefabricated components, modular components, an open building plan, a layering approach, a standard structural grid and retractable foundations (Akinade et al., 2017). Building materials need to be durable and non-toxic with bolt/nuts joints (i.e. mechanical connections) instead of gluing. Planning for deconstruction involves assessing the effects of various parameters like cost, energy use, travel distances and carbon footprint (Akbarnezhad, Ong, and Chandra, 2014). Research into these areas is, however, mostly conceptual and often lacks substantial evidence from practice.

To further disassembly and reuse, a detailed understanding of demolition workers’ (best practice) routines in deconstruction is urgently needed. Practitioners rely heavily on practice-based learning (Löwstedt, 2015) and the majority of their constructability knowledge is not explicit but implicit (Phelps and Horman, 2009). Dominant construction methodologies, largely rooted within the positivist tradition, are limited in capturing the tacit knowledge, materials and socialities implicated in the on-site work practices of these workers (Pink, Tutt, Dainty, and Gibb, 2010). Few studies have sought to understand the situated body of construction knowledge that demolition workers possess, and which is mobilized mainly in practices on a site. Little is thus known about how demolition workers create, exchange and communicate information and what artefacts they thereby use.

Understanding the information requirements in deconstruction projects opens up possibilities to implement relevant information systems. For related industries, Olorunniwo and Li (2010) found that information sharing and collaboration practices positively affect a company's ability to handle product returns. Promising benefits in the design, planning and construction of new buildings has also fostered the construction industry's interest in (new) information systems, such as Building Information Models (BIM), which represent physical and functional characteristics of a facility in a virtual model (Eastman, Teicholz, Sacks, and Liston, 2011; Succar, 2009). BIM implementations in demolition/deconstruction projects are nevertheless scarce (Volk, Stengel, and Schultmann, 2014). Research into end-of-life activities focuses mainly on (BIM-based) information systems for existing conditions modelling or pre-demolition audits and frequently lacks empirical reflections (cf. Won and Cheng, 2017). Consequently, little is known about how information systems can be implemented in real-world deconstruction projects.

This study’s research goal is therefore twofold: understanding on-site information requirements in deconstruction projects and exploring how information systems can be iteratively developed and implemented into these project contexts.

RESEARCH METHODOLOGY

This research adopts an ethnographic-action research approach for the development of two information systems. This approach integrates techniques from both ethnographic and action research methodologies (Hartmann, Fischer, and Haymaker, 2009). Ethnography is traditionally deployed by anthropologists to describe a human culture from a native’s point of view (Spradley, 1980). Action research aims at building and testing theory within the context of solving an immediate practical problem in a real setting (Azhar, Ahmad, and Sein, 2009). Developing information systems can benefit from both methodologies: ethnography allows researchers to develop a detailed understanding of the practitioners’ information requirements and through action research they can program and customize new information systems. Hartmann et al., (2009) describe the ethnographic-action methodology as an iterative, four-stage research cycle of
Supporting Deconstruction Practices

(1) ethnographic observations, (2) identification of work routines, (3) information system development and (4) information system implementation on the project.

The research methodology was applied on a real-world project: the deconstruction of a nursing home in the Netherlands. A general contractor, specialized in temporary and semi-permanent buildings, had constructed this two-story building - with a gross floor area of approximately 2400 m2 - in 2012. The firm has systematized its production and, as such, assembles buildings mainly with prefabricated, modular elements. Foundations, floors, roofs, columns and façade elements can be ‘mixed and matched’ well, which enables the firm to take back its own elements at the end of one life-cycle and use them in another project. To that end, it hired one (fixed) demolition contractor for disassembling the nursing home and organizing the necessary transports. Most of the building’s structural elements were planned to be reused for the construction of a school in another part of the country. To support the demolition contractor with on-site deconstruction practices, we developed and implemented two information systems on this case project. Data was collected and analysed in various ways. The first mentioned author obtained access to the building site after passing for an official health and safety course for construction works (VCA-VOL), which the general contractor and the demolition contractor both demanded from him. While spending approximately 250 h on the site, he closely observed deconstruction practices during the entire project. The researcher also sought to understand the demolition workers’ information requirements by doing what they were doing. Consequently, he became an “active participant” (Spradley, 1980, 80) in a wide range of tasks such as installing construction fencing, removing suspended ceiling, moving equipment around, cutting cables, stripping isolation, sorting materials, and rigging/hoisting loads. He kept a field diary to note important observations and took over 800 pictures and movies, which is in line with “recent innovative approaches to doing ethnography” (Pink et al., 2010, 649). The researcher also conducted semi-structured interviews with key informants and collected many project documents from both contractors, including the (original) construction drawings and the deconstruction schedule. He recorded (and later transcribed) the practitioners’ interactions with, and discussions about, the two information systems that were developed during the course of the project. His analysis of the obtained data focused on integrating an (ethnographic-oriented) understanding of the on-site information requirements in deconstruction projects with an (action-oriented) understanding how information systems can be iteratively developed and implemented into these project contexts.

RESULTS

Deconstruction practices can be dirty, dusty and dangerous. The usage of digital tools and technologies at these sites is very limited. Demolition workers traditionally rely on 2D drawings, forms and other project documents to plan and execute the work. The site which the leading ethnographic-action researcher visited for many weeks was no different. Its site office had a wall on which several such documents were attached: a project schedule, the (original) floor, foundation and roof plans, a report of the Dutch Cable and Pipeline Information Centre and - for emergencies - a document with travel directions to the nearest hospital. The site supervisor was the only one with a laptop. While he saw benefits in providing the foreman with a laptop (or tablet) as well, upper management had repeatedly declined this request for it being “unnecessary”. In this non-digital environment, the researcher iteratively developed and implemented two information systems: (I) a virtual environment to support tagging façade elements and (II) a 4D model to support deconstruction planning.
Information System I: A Virtual Environment to Support Tagging Façade Elements

“This type of projects is more strategic,” said one of the temporary demolition workers when the ethnographic-action researcher observed how the worker cleaned up the ceiling. The planned reuse of almost the entire façade brought some extra complexities to the deconstruction project. The demolition contractor had, for example, instructed researcher and other new workers on the job to “perform soft-stripping carefully to prevent damage” to the modular façade elements. The demolition contractor also had to tag these elements to enable the general contractor planning and controlling where each element would be assembled in the new building. Interviews with designers and project leaders of the general contractor had revealed a logistical process where a building site is supplied with building elements either directly from a to-be-deconstructed building or indirectly from the general contractor’s warehouse with already deconstructed elements. In the focal project, (only) the façade elements had to be tagged on-site according to a disassembly drawing that one of the general contractor’s designers had made.

An opportunity was identified to support this tagging project routine with an information system (Table 1). The disassembly drawing displayed four exterior views of the building with hand-written codes above or below each façade element. “However, we are always tagging the elements from the inside of the building,” said the foreman when we discussed the routine. The four-digit code on the far left of the drawing must then be written on the element on the far right. “We must [thus] think in mirror image,” complemented the site supervisor. This could be confusing, particularly when also other building elements (like columns) need to be coded as well and one would “need to walk around with multiple drawings.” During this discussion, the researcher proposed to make the required information three-dimensionally available to them. Though reluctant at first, both men decided to “give it a try.”

Table 1: Iterative development and implementation of a virtual environment

<table>
<thead>
<tr>
<th>Research stage</th>
<th>Iteration 1</th>
<th>Iteration 2</th>
<th>Iteration 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethnographic observation</td>
<td>All façade elements need to be tagged (numbered) on site</td>
<td>Façade elements have different destinations</td>
<td>Rainwater is pouring into building: laptop needs protection</td>
</tr>
<tr>
<td>Identification of work routines</td>
<td>2D ‘disassembly drawing’ is used with exterior views</td>
<td>Colours on (original) ‘disassembly drawing’ indicate destinations</td>
<td>Procedure requires multiple hands: navigating and tagging</td>
</tr>
<tr>
<td>Information system development</td>
<td>2D exterior views and numbers are combined in a 3D (BIM) model with company colours</td>
<td>Colour of 3D numbers (Model Text) is updated in line with drawings</td>
<td>Laptop with virtual environment is put on crates on a warehouse cart</td>
</tr>
<tr>
<td>Information system implementation on the project</td>
<td>Demonstration of the virtual environment to foreman</td>
<td>Trial on site with laptop in the hand</td>
<td>Site supervisor uses virtual environment to tag elements on site</td>
</tr>
</tbody>
</table>

The initial result was a virtual environment that integrated the four exterior views into a 3D model. The design of the nursing home had initially (primarily) been represented by 2D drawings. The researcher had, however, also received two BIM models, each containing (only) parts of the foundations, floors, roofs, columns and wind braces. Since one of the models also contained a façade object library (though incomplete), the researcher decided to use that one as a basis to model the (then) existing conditions, i.e. a complete 3D model yet without interior walls. He used a 3D Model Text feature to add the codes from the four exterior disassembly views to the model - using the demolition
contractor’s house style colour. This model was finally exported and prepared for usage into a 3D model viewer, the ‘virtual environment.’

This information system was then iteratively revised in two steps. When the researcher asked the foreman to verify whether he had correctly taken over the numbers from the drawings, the foreman revealed that it would probably be very helpful during the façade tagging routine. He also asked whether it would be possible to use different colours for different codes in the model. The researcher then found out that, next to the numbers, colour coding is important to organize the logistical process: green façade elements were reserved for the construction of the school, blue ones would be stored at a warehouse of the general contractor (until they could be used in another suitable project) and the red ones were classified as waste. He consequently adapted the colour of the 3D codes in the virtual environment. After this, the researcher experienced that it would be impractical to carry around the laptop in the actual building while navigating in the virtual environment at the same time - let alone do the actual tagging. In the hands-on spirit he had observed earlier with the (fellow) demolition workers - “there is a solution for everything” - he found a warehouse cart and a couple of crates that he used to create some sort of walkable desk. The researcher put the laptop (with the virtual environment) on top of this and used a bag to protect it against the rainwater that was then pouring into the building.

This information system replaced the disassembly drawing during the tagging of the façade elements. “Normally,” the site supervisor said, “somebody holds the drawing, [another] walks around with a roll of tape and [a third person] writes down the numbers.” This time, however, the site supervisor first attached some tape on each of the façade elements himself. Apparently not completely confident about how to use the system, he asked the researcher to navigate around in the virtual environment while he would write the codes on the pieces of tape. Soon after they started tagging, the foreman came by to see how everything worked. “It is great,” said the site supervisor and the foreman agreed. While joking about the places that the site supervisor could virtually visit, he tried to navigate in the virtual environment. Even though he accidentally pressed a button that reset the avatar’s position, both men concluded it was very easy to use. The site supervisor then continued tagging all façade elements without the researcher’s further help in navigating within the virtual environment (Figure 1). Afterwards, he reflected that this system helped him to get “a quick overview” of the building and that it worked “easier than a drawing.” The different colours enabled him to see directly where the façade elements would need to be transported to. “I find it all quite nice. I had not expected this.” He also requested the researcher to install the software at his own laptop and suggested that the general contractor could just insert the codes into the model and send it to him. “I think that saves some time.” The information system could be improved by adding two letters that indicate whether a façade has either a left-swinging or right-swinging window.

**Information System II: A 4D Model to Support Deconstruction Planning**

One day, two new temporary demolition workers started on the project. The site supervisor welcomed them in the site office and informed them about safety regulations at the workplace.
He then pointed to two large floor plans and explained how he kept track of the work’s progress: “the pink parts are already finished.” The ceiling still had to be cleaned up so that roof elements could be reused: this is what "the new guys” would be doing today. “I will explain to you how,” said the site supervisor and he went ahead to the nursing home that was being deconstructed. “You can take this,” he referred to rolling scaffolding once inside, “and use it to remove all those things on the ceiling.” The introduction ended with instructions about separating different types of waste. When the demolition workers started with the task they were just assigned to, the site supervisor proceeded to check what other people were doing.

Allocating tasks and progress monitoring was later identified as an opportunity to develop an information system (Table 2). The site supervisor was responsible for the overall deconstruction planning. He had pinned a graphical representation of this planning (Gantt chart) to one of the site office’s walls - visible for everyone. The planning contained 23 tasks like “removing suspended ceiling”, “demolishing internal walls first floor (cleaning up)” and “hoisting façade, timber frame, roofs and columns”. The required number of people (1-6 workers) was written behind each of these tasks.

Next to the schedule, several 2D drawings and floor plans were hanging on which the site supervisor marked parts that were completed. The information needed for planning the nursing home’s deconstruction was thus dispersed over several documents. The site supervisor and/or the foreman (therefore) preferred to allocate deconstruction tasks to the demolition workers “in 3D, outside!”

To provide new opportunities for deconstruction planning, a 4D model was developed by linking schedule information to a 3D (BIM) model. The 3D model that the ethnographic-action researcher created earlier (for the virtual environment) contained foundations, floors, roofs, columns, wind braces, façades and some other elements - all modelled as distinct parametric objects. The researcher decided to connect this model to part of the schedule: hoisting of the façade elements.
Table 2: Iterative development and implementation of a 4D model

<table>
<thead>
<tr>
<th>Research stage</th>
<th>Iteration 1</th>
<th>Iteration 2</th>
<th>Iteration 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethnographic observation</td>
<td>Site supervisor and foreman allocate demolition tasks on site</td>
<td>Sequence of lifting façade elements is determined by a worker on the roof</td>
<td>Perceived difference between practice and theory regarding planning</td>
</tr>
<tr>
<td>Identification of work routines</td>
<td>Gantt chart and 2D drawings attached to the wall represent plan</td>
<td>Two workers on the ground need to detach loads and group façade elements</td>
<td>Planning must be abstract enough to deal with fluctuations in duration</td>
</tr>
<tr>
<td>Information system development</td>
<td>Façade elements linked to distinct disassembly activities in a 4D model</td>
<td>Colour of façade elements updated to indicate destinations (90% transparent)</td>
<td>4D model links product groups and activities to align with overall schedule</td>
</tr>
<tr>
<td>Information system implementation on the project</td>
<td>Presentation of 4D model (of façade) during lunch break with workers</td>
<td>4D model (of façade) is shown to and discussed with site supervisor</td>
<td>4D model (of entire project) is shown to and discussed with foreman</td>
</tr>
</tbody>
</table>

This was then one of the first upcoming tasks. Several demolition workers, including the foreman and site supervisor, estimated that the duration of that task would be two days. The researcher split the task in many sub-tasks (one for each façade element) to create a more detailed schedule. Based on the foreman’s educated guess regarding the likely hoisting sequence, he linked all elements to a sub-task. This resulted in a 4D model that showed the sequenced deconstruction of the façade over time.

Some revisions followed after a demonstration of this 4D model during a lunchbreak with all six demolition workers present that day (including the subcontracted crane operator). Sitting in the site office, the researcher put his laptop in the centre of the table - next to the toaster - explained its purpose and started the simulation. When the last façade element was virtually deconstructed, the workers joked that they already “completed” the project. Then, more serious, they questioned the usefulness of the model. One demolition worker said that “it is not correct any longer if something is delayed” and that the schedule on the wall could “be adapted easier”. The crane operator, though interested in how the researcher had made this 4D model, did not find it helpful in determining which element to hoist first as that was determined by "the guy on the roof" (attaching the rigging components to the load). He “is the CEO of the roof. If [he] decides: we go left, then we will go to the left. And if he goes to the right, we will go in that direction,” said the foreman. This person missed having an overview of the entire project and could not see where the different elements would need to be transported to. Considering these comments, the researcher first added colours indicating the different destinations for the materials. The site supervisor nevertheless gave similar comments on that version. After that, the researcher added more objects to the 3D model, such as the suspended ceilings and internal walls, and linked the overall schedule to the product groups instead of individual elements. This resulted in a (simplified) 4D model for the complete project (Figure 2).

This information system was further field-tested near the end of the project. In a few working sessions, the researcher demonstrated the 4D model and explained potential benefits, like visualizing the deconstruction sequences, progress monitoring or identifying space-time conflicts. However, the practitioners saw little value in it and no decisions were made based on the model. “For planning purposes, it is perhaps nice to show how long it takes us [to disassemble something] … but we [already] know that,” said the site...
supervisor. There is no need to visualize or simulate the impact of potential delays either. “Sometimes, it can happen that a few façade elements are more difficult to disassemble because the screws … do not want to get out. But the guys then automatically work a bit longer.” Regarding allocating tasks to (new) demolition workers, for example those that do not speak the Dutch language, the site supervisor speculated that it may “perhaps be nice for them to watch it.” He and another senior demolition worker shared the view that the 4D simulation “is more something for those working at the office [of the general contractor], to see how things are going in practice.” When the general contractor’s project leader visited the site, he indeed showed great interest in seeing the model. During another meeting, the foreman similarly questioned the value of 4D models for on-site deconstruction planning. However, inspired by the information system, he suggested that they could prepare better for a project if other aspects could be viewed and interacted with, such as the site layout and the position and turning radius of a crane in 3D.

![Figure 2: Snapshots of a 4D model that supports deconstruction planning](image)

**DISCUSSION**

This study’s ethnographic-action research approach enabled us to develop and implement two information systems that support on-site deconstruction practices. On one hand, we provided insights about the local routines and the tacit knowledge that demolition workers possess and use to deal with these routines. On the other hand, we offered insights about how the two information systems supported the practitioners in their ongoing project works. The study thereby offers two main contributions.

First, this research demonstrated that virtual environments can support demolition workers in tagging façade elements. Practitioners need information to efficiently plan and control the reuse of building elements after their disassembly. Demolition workers here established a routine to tag façade elements on-site using a 2D drawing provided by the general contractor. The first mentioned researcher integrated the necessary information (four exterior views, numbers and color-coding) within a virtual environment that runs on a laptop. This information system helped the demolition workers through offering them the required information from their own perspective. The benefits included a quick overview of the building in 3D, no indoor mental translation (mirroring) of the exterior views, insight into the future destination of façade elements, easy virtual navigability and a fast procedure on site.
Second, this work showed that 4D models can limitedly support on-site deconstruction planning. An overall project schedule and a set of 2D drawings on which the work’s progress is monitored are the main artefacts practitioners used to this end. As the established project routine, deconstruction tasks are mainly allocated on-site by the site supervisor and/or foreman with reference to the (actual) building elements. The researcher created a 4D model by linking the drawings (combined in a 3D model) with the project schedule. This information system visualized and simulated the main deconstruction tasks over time. The 4D model gave the demolition workers an “interesting” overview of the planned deconstruction sequences and could potentially inform new workers. However, little to no evidence was found that the information system could support the demolition workers with analysing the impacts of delays, allocating tasks and progress monitoring.

These ethnographic-action perspectives have several implications for research and practice. This paper provides evidence that the research methodology applied is suitable for developing and implementing information systems during the demolition phase. The study thereby provided a better understanding of the information that is created, exchanged and communicated during deconstruction works and of the artefacts that demolition workers use to do so. That highlighted the importance of (as-built) documentation for deconstruction, from which we suggest that construction drawings and other documents need to be maintained, updated and passed on during the entire life-cycle of a building (i.e. not only from the general contractor to the building owner/facility manager) so that the demolition contractor can - eventually - take advantage from them as well. The work also demonstrated that demolition workers can further reap the benefits of information systems when those are customized to their local working routines. More research, including literal replications (Yin, 2013, 327), is needed to further strengthen this study's findings and to identify new opportunities for information systems to support deconstruction practices (like on-site logistics).

CONCLUSIONS

Information systems can leverage deconstruction practices on a building site. The empirical insights of on-site information usages that this study provides, complement previous conceptual studies that focused mostly on design and building material-related factors in deconstruction. Ethnographic methods here revealed that demolition workers need information (I) to tag reusable building/façade elements and (II) to plan deconstruction tasks. Action-oriented methods subsequently provided insights into (I) how a virtual environment can beneficially present the necessary information from a user’s perspective in the first routine and (II) how a 4D model can visualize and simulate deconstruction tasks over time in the second routine. The resulting ethnographic-action perspectives offer a unique understanding of the on-site information requirements in deconstruction projects and explain how information systems can be iteratively developed and implemented into these project contexts.

REFERENCES


The construction management (CM) research community makes limited use of archival sources. A plethora of archival sources exist in the form of documents and visual representations and are often found within project or organisational records. Such artefacts tend to be cast as ‘secondary data’ which are seen as complementary to supposed ‘primary data’ such as that derived from interviews. Despite the increasing recognition of archival sources, there remains a paucity of reflexive dialogue on archival methodology within the CM research community. In particular, the issue of emplotment as it relates to the creation of archives and their subsequent interpretation requires methodological attention. Examples are drawn from the current DEGW archive project which seeks to pilot the concept of a ‘living archive’. Curation is proposed as an archival research method to address the issue of emplotment. A reflexive account of emplotting archival sources is offered based on two empirical vignettes. It is contended that CM researchers should heed the call of organisational historians for methodological reflexivity which goes beyond taking documentary sources at face value.

Keywords: archival research, curation, DEGW archive

INTRODUCTION

Archival datasets are of minority interest within the construction management (CM) research community in comparison to a continued widespread reliance on questionnaire surveys and semi-structured interviews. A search of the ARCOM database of 12,270 abstracts reveals only 50 references to archival research. Moreover, archival sources are often used as secondary data rather than being perceived as primary sources. Dainty’s (2008) analysis of 107 papers from Construction Management and Economics Volume 24 revealed that only three papers adopted ‘document analysis’ as a research method, and these were primarily as part of a broader case study methodology. The dearth of archival research within the CM community has also resulted in a lack of a methodological dialogue around archives. This stands in stark contrast with the diverse methodological discussions which have taken place around case study and ethnographic research. Archival research within the CM community begs its own methodological space. The purpose of this paper is to initiate a methodological dialogue around archival research by discussing empirical accounts of working with the DEGW archive. Insights are drawn

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2 A search for the truncated keyword "archiv" (to include both terms archival and archive) in the ARCOM database was carried out on 5th April 2018.

3 DEGW is not an acronym, but the name of the firm. Sources from the DEGW archive suggest that the firm used the name ‘Duffy Eley Giffone Worthington’ during 1970s-80s, reflecting the last names of its founders.
from the reflections of organisation historians as they attend to epistemological differences between organisation researchers and historians. In particular, the issue of emplotting archival sources in the research process is unpacked through the empirical accounts. Two empirical vignettes are discussed: Making a chronology and sensing research themes. Particular emphasis is given to the notion of a 'living archive' whereby archival sources are used as a medium for knowledge creation involving the active participation of academia and practice through the mode of curation.

**Need for Reflexivity in Archival Research**

Selected examples of the use of archival sources within CM focus on health and safety practices (Alkilani *et al.*, 2006), adoption of innovative technologies (Azri *et al.*, 2012) and institutional effects on project arrangements (Chi and Javernick-Will, 2011). It follows that archival sources can be analysed to study a wide range of sociological and cultural phenomena, both through qualitative and quantitative approaches. Archival sources have also been combined with a variety of theoretical frameworks, including: Institutional theory (Chi and Javernick-Will, 2011), actor-network theory (Grabowski and Mathiassen, 2013), situated nature of knowledge (Ness, 2010) and systems theory (Azri *et al.*, 2012). Despite this theoretical diversity there is little recognition that research problems pertaining to 'time' and 'causality', which are central concerns of historical explanation, can be investigated through archives (cf. Jordanova, 2006, 41). Archives can be mobilised to study a phenomenon at a certain point in the past (Ruchinska, 1996), or longitudinally over a certain period of time which might even lead up to the present (Gosling *et al.*, 2015), or to compare different temporal states (Ness, 2010). Despite the potency of archival sources a critical and reflexive dialogue on archival methodology is notably absent from the domain of CM research.

A useful starting point for methodological discussion is to probe the very idea of an 'archive'. A professional archivist might define an archive in terms of materials that have been preserved because of the enduring value of the information that they contain (Pearce-Moses, 2005, 30). However, a broader definition might emphasise the quality of 'trace' that can provide meaningful access to the past. Moore *et al.*, (2017) conceptualise an archive as a repository that might not necessarily be in the form of a paper-based document (1). They suggest that an archive can be in a form of other tangible objects such as a building or a website; or an archive might even be in an intangible form such as a discourse of interconnected ideas. Very few CM researchers who cite archival research provide a list of specific archival sources or even discuss the nature of the archive they are studying. Moreover, there is seldom any discussion of how a source is interpreted and what contribution that source makes to empirical or theoretical understanding (as with the case of quoting interview excerpts). Even more notable is the limited extent to which CM researchers who rely on archival sources offer any methodological reflection. Partial exceptions include Rasmussen *et al.*, (2017), Gluch and Svensson (2017), Holt (2016), and Lucko and Mitchell (2009). The limited discussions offered by such authors echo the broader theoretical chasm which exists between historical theory and organisation theory (Rowlinson *et al.*, 2014; Decker, 2016). Rowlinson *et al.*, (2014) identify three epistemological dualisms that tend to differentiate organisation theorists from historians: (i) explanation, (ii) evidence and (iii) temporality. Their framework is not intended to be definitive and is one of many approaches which is used to characterise research occurring at the interface of history and organisation studies (Decker, 2016). However, the framework provides a good basis for methodological reflexivity in the context of CM research. The issue of emplotment within the formation of archives and analysis of archival sources is of particular importance.
Towards an Understanding of Emplotment

It should be stated from the outset that the past is increasingly recognised as an important empirical context amongst CM researchers, not least because of the shaping influence of path dependency (Green et al., 2008; Hemström, 2017; Mahapatra and Gustavsson, 2008). Those influenced by new institutionalism are especially prone to recognise that 'history matters'. Indeed, there has in recent years been increasing interest in the way CM as a discipline has been constituted over time (Green, 2011). There is however a danger that researchers see archival sources, and by extension the past more generally- as repositories of ready-made data. But historical narratives are rarely neutral, and claims to objectivity in the way in which the past is presented are increasingly discredited.

Archives are subject to emplotment at various stages of their life - from their creation and throughout the ongoing process of acquiring new materials. They are also subject to emplotment when researchers chose which sources to use and which to ignore. There are hence two manifestations of emplotment when working with archival sources. First, the sources themselves are emplotted at the time of their making. If archival sources are to be mined for data, it must therefore be understood that they have to a greater-or-lesser extent been 'written'. Moreover, archival sources reveal the idiosyncratic epistemologies of their creators. The past is invariably interpreted with at least one eye on the future (Foster et al., 2017). Conscious choice has been exercised in terms of which artefacts have been kept, and which have been rejected. The artefacts which are judged to be worth keeping are therefore indicative not only of the past, but also of a desired future direction of travel. This idea of bridging between the past and the future is of central importance to the notion of emplotment. It is perhaps a lazy truism to say that history tends to be written by the victors, but a similar bias is evident in the formation of archives. The choices are made by those who are in a position to make them. Hence, the history of medieval England is heavily skewed towards royalty and the clergy. Social history only became possible due to the invention of the printing press. Second, researchers selectively emplot archival sources in the narratives that they construct. Czarniawska (2010) explains emplotment as a logical structure, which is introduced as a thread to make sense of seemingly disparate events. A given set of events could conceivably be woven into a plot in a variety of different ways. Moreover, the events that do get discussed within a research process are contingent upon what can be accessed within the archive. Of particular interest is the emergence of historiography as a distinctive subject area: "the writing of history and the study of historical writing" (Jordanova, 2006). Historiography emphasises questions such as "What kind of history am I writing?" and perhaps more pertinently "What kind of history am I reading?" (Rowlinson et al., 2014). The latter question would seem to be consistently ignored by the CM research community.

Rowlinson et al., (2014) further allude to the distinction between ontological theories that relate to 'history as an object', and epistemological theories concerned with 'knowledge of that object'. Such an argument would be well recognised by CM researchers, and yet rarely are they applied to archival sources. Even time-series statistical sources such as those produced by the UK Office for National Statistics (ONS) are more often quoted in terms of what they say about a supposed objective reality (ontology), rather than in terms of what they say about how such a reality can be known (epistemology). It is contended that this distinction is of critical importance in assessing the potential of archival sources within CM research. In progressing their analysis Rowlinson et al., (2014) point towards three key epistemological dualisms seen to be useful in positioning organisation theory against historiography. It is expedient to touch on each of these in turn.
(i) Dualism of explanation: Narrative or analysis
Organisation researchers are seem to be primarily interested in the analysis of relationships between concepts, whereas historians are more concerned with the emplotment of chronologically related events. Within the domain of CM there are multiple examples of the first, and relatively few of the second. Löwstedt and Räisänen (2012) provide a good example of a recent tentative shift towards narrative approaches with a corresponding emphasis on the importance of emplotment.

(ii) Dualism of evidence: Data or sources
Rowlinson et al., (2014) further observe that organisation researchers use the language of primary and secondary data, whereas historians use the terms primary and secondary sources. CM researchers such as Holt (2016) are especially fond of referring to documentary sources as secondary data with little sensitivity of the distinction between data and sources. Historians lay importance on primary sources that are produced at the time of events being researched, and yet CM researchers tend to view such sources as part of the 'literature', i.e. not comprising empirical data. Source criticism, a critical aspect of historical research, is an undoubted blind spot amongst CM researchers.

Published accounts can comprise either primary or secondary sources depending on the research question (Jordanova, 2006). A good example is provided by the narrative analysis of the quasi-historical account of international contracting produced by the Turkish Contracting Association (TCA) (Duman et al., 2017). The account produced by the TCA is a primary source, and important insights are to be gained by understanding how it is emplotted. Although the use of footnotes is uncommon amongst CM researchers they are crucially important in historical writing, and not just an issue of stylistic convention. Rowlinson et al., (2014) note that historians are committed to emphasising in detail the sources used. In contrast, organisation researchers tend to focus on how the data is constructed and are often obliged to fictionalise the identity of participants for the purposes of maintaining confidentiality. The use of footnotes in historical writing is based on a 'logic of verification'. Footnotes provide transparency to allow peers to verify the efficacy of the arguments made (Jordanova, 2006). The archival sources used in CM research most often form part of a case-study approach which is based on a 'logic of replication'.

(iii) Dualism of temporality: Chronology or periodisation
The third dualism addressed by Rowlinson et al., (2014) elates to temporality. The majority of CM research tends to be conducted in the present. The accepted mainstream research methods are predominantly concerned with interpreting reality as it is 'now'. At best, time is seen as a constant which helps to specify a chronological order of events. But historians see time rather differently in that they are primarily concerned with specifying periods. The identified periods are defined through a process of analysing available sources, not least in terms of how they are emploted. There are relatively few such examples within the domain of CM, Green (2011) perhaps being a notable exception.

The consideration of the three dualisms above is sufficient to problematise the current state of archival research within the CM community. Archives can comprise both primary and secondary sources, but they should not be thoughtlessly delegated to the status of 'secondary data'. Such a designation would say more about the researcher's predisposition to view the past as an 'object' which is waiting to be revealed. It is of course important to derive insights from the materials included in the archive, but it is equally on occasion necessary to reflect on the materials which are missing. Armed with
such sensibilities and through the mode of curation, the research around the DEGW archive strives to understand the practices of DEGW and accessing the worldviews which made those practices meaningful.

**The DEGW Archive as a Living Archive**

DEGW was founded as an architectural and space planning consultancy specialising in workplace design. The origins of the firm can be traced back to 1971 when it began operations as the London offshoot of US space planning firm JFN\(^4\). DEGW progressed to become a prominent actor in shaping the field of office space planning. The legacy of DEGW is alive globally and the methods which they piloted continue to flourish. The DEGW archive at the University of Reading mainly comprises project reports from 1971 to 1997. The archive is complemented by the personal collections of two of the co-founders: Frank Duffy and Luigi Giffone. Engaging with the broader DEGW diaspora provides the basis for linking the archival materials with contemporary issues. The DEGW archive is hence perceived as the nexus of a multi-method research process rather than a static collection of documents. The interpretation of the archival sources therefore co-exists with the sourcing of new materials. The connectivity with the DEGW diaspora is of crucial importance in identifying the significance of the archival sources and in the identification of gaps. The archive is hence conceptualised as a ‘living archive’ (Hall, 2001).

**Curation as Research Method**

Curation is broadly accepted to include scholarly research into the collected artefacts, the selection of new materials and the mounting of exhibitions (Obrist, 2014). In the case of the DEGW archive project, these activities were conducted by the research team in active collaboration with members of the DEGW diaspora. The approach comprises a ‘methodological commitment to collaborative knowledge production for creative public intervention and engagement’, otherwise construed as ‘curating sociology’ (43, Puwar and Sharma, 2012). It is important to emphasise that the mode of curating is not limited to the duration that exhibitions are on display. Curation is seen to be a continuous process that builds on the experiences and learning from one exhibition to another. A series of thematic pop-up exhibitions, workshops, walks and lectures were curated to understand DEGW’s concepts and methods in the light of contemporary concerns. Curation of archival materials continuously acts to enrich the contents of the archive. New materials are discovered, the structure of the archive is unpacked, different theories are explored and alternative accounts are created - through participatory curatorial practice (Huvila, 2008).

**Curating 'DEGW Methods' Exhibition**

The DEGW archive research project started in May 2016. The initial task was ‘to get a feel’ for the archival materials. Three aspects framed the initial acquaintance with the archive. Firstly, the archive was not catalogued. A list of the materials, not based on any

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\(^5\) For an overview of various events and exhibitions that were curated for this project, see http://www.reading.ac.uk/architecture/degw-archive.aspx.

\(^6\) The archive is now catalogued and the catalogue can be accessed via https://www.reading.ac.uk/library/. The two founder's collections are yet to be catalogued. Discussions with the archivists regarding the
particular order, was used as a finding aid. The form of the Microsoft Excel spreadsheet allowed different ways to sort and filter the list. In order to make sense of the archive, it was deemed necessary to create a chronology that was more detailed than the spreadsheet. This provided the basis for a visual chronology of the archive, in form of a 7-metre long roll prepared in consultation with ex-DEGW members. The chronology included key diagrams from the project reports within the archive. A timeline of DEGW’s development as a firm (the legal entity) was also included in the visual chronology.

Secondly, an intensive interaction with the archive was experienced while browsing the archive at an off-site storage facility rather than the reading room from where access to the materials is more controlled. Thirdly, two DEGW publications provided very useful guides for navigating the archive at the formative stage: ‘Design for Change: The architecture of DEGW’ and ‘Managing the brief for better design’. The period covered in the former mirrors the archive as it refers to DEGW’s work from its origins through to 1997 (when DEGW merged with Twynstra Gudde, a Dutch Management Consultancy); it also contains narratives from DEGW members on the development of the firm's key ideas. The latter can be viewed as a catalogue of various briefing methods. The archive provides insights into how DEGW operationalised these methods in their projects.

The ‘DEGW Methods’ exhibition was curated on 27th October 2016 to accompany John Worthington’s public lecture at University of Reading’s new School of Architecture. The lecture and exhibition invitations were sent to DEGW members. The events were also open to members of public; 165 people registered for the lecture and many of them visited the exhibition. Worthington's lecture described the development of key DEGW concepts from 1971 to 2002. The exhibition provided an alternative narrative for the same period, emerging from the archive and linking projects and methods to DEGW’s key concepts. Six methods were presented in the order of their emergence within the DEGW archive: Space standards, space utilisation, building appraisal, analysing change, time utilisation and workplace envisioning. A caption was prepared for each of these methods referring to key projects where the application of that method was evident. Original project reports were displayed next to the captions. Two key DEGW concepts were then linked to the methods: Conceptualising a building as layers of different lifecycles, and bridging between the concerns of the demand and supply sides of the construction industry. The visual chronology roll was also displayed in the exhibition.

FINDINGS

Making the Visual Chronology

The first version of the visual chronology was devised with a framework for categorising the works as either building projects or research projects, with the former at the top of the chart and the latter at the bottom. There are not many reports relating to building projects in the archive, most are in the form of publications and consultancy reports for clients. However, in the process of working through the data, it became apparent that DEGW’s work could not be categorised in accordance with these two labels. Their work blurred

findings from the ongoing research subsequently informed the adoption of a client based cataloguing system.

7 Duffy et al., 1998.
across categories. Another version of the chronology was prepared to capture important projects in the development of DEGW’s concepts and methods. Moreover, it was not possible to accommodate all the projects due to the physical limitation of the chronology roll. Important projects were selected for inclusion in consultation with DEGW members, which also led to the identification of projects not covered in the archive.

Sensing Storylines

Understanding what DEGW actually did in practice was key to unpacking the archive. The exhibition became a site where multiple storylines co-exist. The exhibition and lecture captured four different narratives of DEGW’s development over the period of 1971-1997: John Worthington’s narrative, the development of DEGW as a firm, the development of DEGW’s methods, and the visual chronology of the archive. The latter two storylines emerged from the curatorial research process. Tamboukou (2016) emphasises the situated nature of the researcher in privileging certain storylines, topics or themes over others in the archive. The baggage of the authors indeed shaped the initial impressions of the archive and affinities for certain themes. Several documents in the archive have an explicit section summarising the methods adopted for the project. These include glossaries of terms that depict how the reality was constructed in terms of which aspects were leveraged at the cost of silencing others. Moreover, DEGW’s methods can be imagined as performative of their reality and not just as a set of procedures (Law, 2004). By analysing the methods adopted by practitioners from within DEGW, insights were gained into their worldviews, their concepts and their realities. As Frank Duffy writes in his account of the development of DEGW’s Building Appraisal service, “This paper describes how between 1985 and 1995, in one building type - the office - a form of Building Appraisal became an operational reality in DEGW…” (149)\(^\text{10}\).

DISCUSSION

Making Emplotment Public

The DEGW Methods exhibition demonstrated the important contribution of DEGW in the field of user research and briefing. Elf et al., (2012) note the sparsity of studies into the briefing process and lack of evidence-based information to support the development and evaluation of new facilities. However, the documents in the DEGW archive, which include briefing documents, provide rich descriptions of the methods adopted, evidence gathered and analysis conducted.

The timelines were an important element of the 'DEGW Methods' exhibition. The timelines provide a skeletal narrative with a clear beginning, middle and end (Yakura, 2002). The timelines helped to weave a theoretically-informed narrative between the disparate archival materials. Moreover, the exhibition became a site for gathering new data from DEGW members as they added references to missing artefacts. The exhibition hence made the emplotment explicit - the privileging of certain archival materials over others, certain themes over others, certain research methods over others, certain theories over others, and certain concerns over others. Choices were made at every stage. This indeed was emplotment in action. The timelines also acted as a tool simultaneously to engage different audiences, namely: DEGW members, academics, and members of the public. However, for each audience, the same timeline is enacted differently. Moreover, the timelines used in organisational practices provide an ending to the endeavour that the participants are involved in (Yakura, 2002). However, the timelines in the exhibition do

not have an ending, and flow into the present via audiences continuously linking the past with the future.

CONCLUSIONS

There seemingly remains within the CM research community a strong bias against the use of archival research methods. There further seems to be a recurring tendency to dismiss archival sources as secondary data. Even those who do rely on archival sources pay scant attention to the methodological issues relating to the use of archives. The use of archival sources has been related to the discipline of historiography which emphasises the need for reflection around key questions such as ‘What kind of history I am reading?’ A particular emphasis has been given to emplotment. No researcher can aspire to observe everything within an archive; there are no standard sampling approaches. The very process of engagement with an archive is a process of knowledge creation. To address archives as presentation of a supposed objective past is not only indicative of a misunderstanding of their potential contribution, it is also indicative of a misunderstanding of how reality is constructed.

Curation has been introduced as an archival research method and positioned as an open-ended process of connecting archival materials with contemporary issues. The notion of a ‘living archive’ has been offered as a means of building participative engagement between researchers and interested practitioners. Adopting curation as the essential mode of doing research, archives become a critical site of engagement between academia and practice. Examples of how such a process can be operationalised have been derived from current empirical work with the DEGW archive. Archival sources provide potent opportunities for CM research. However, a critical and reflexive dialogue around archival methodology is currently notable only for its absence. By means of this paper, we have sought to initiate a discussion around archival methodology by drawing on the experiences of working with the DEGW archive. In summary, our clarion call to the CM research community is simple: Archival methods are deserving of more attention.

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GENERAL TRACK
RULES AND VIOLATIONS IN BUYING AND SELLING: 
RETHINKING BENEFITS MANAGEMENT AND 
CONTROL PRACTICES

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Companies tend invest a lot of funds in strategic change yearly with the hope of realising 
benefits that includes continuous improvement and heightened stakeholders’ satisfaction. 
As the rate of change accelerates, these companies tend to gain competitive advantage by 
way of effectively adapting and managing change that breeds biased routines in processes. 
In so doing, benefits management has arguably become a trigger for understanding the 
rules and violations of buying and selling in the Management of Project (MOP). This 
research effort was aimed to understand the strength and weakness of formal and informal 
ties using a dramaturgical approach. Preliminary findings from mapping up and down the 
supply chain of a single case study revealed evidences of confirmatory bias and over 
reliance on established and widely accepted change control tools like earned value 
management (EVM). The full implication of this on-going PhD study points at serious 
tension at change control interfaces that require the rethinking of benefits realisation.

Keywords: Management of Projects (MOP), benefits realisation, change control, 
governance

INTRODUCTION

The practice of benefit management according to Jenner (2010) is a process synonymous 
with portfolio, programmes, and projects that deliver value. This practice is suggested to 
reduce the failure rates in management of projects from a strategic perspective by 
increasing the efficiency and effectiveness of the governance structure (Serra and Kunc 
2015). Zwikael and Smyrk (2011) further emphasised the importance of establishing a 
governance structure and monitoring process to maintain the focus of projects on 
achieving the expected benefits. However, according to Cooke-Davis (2002), these 
validations are yet to be widely engaged or are engaged as subset to other project 
management processes and there's very limited evidence to show its impact on benefit 
realisation.

There has been significant recognition of the importance of benefit management since 
1995 with different processes and tools been developed to help organisations to identify, 
monitor and realise benefits such as (Active Benefits Management by Leyton 1995; The 
Cranfield process model of Benefits Management by Ward et al., 1996; Active Benefit 
Realisation by Remenyi and Sherwood-Smith 1998; Towards best practice to Benefits 
Management by Ashurst and Doherty 2003; Benefit Management in the handbook of 
programme management by Reiss et al., 2006 and Earned Value Management APM 
guidelines 2008). A commonality to all these processes is that they are merely for

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monitoring and evaluations used at the end of the project with lack of drive for benefits realisation pre-contract award and execution stage. More so, the most important aspects are the intangible impacts (such as behavioural and cultural) because it is necessary for organisations to heavily rely on the beneficence of employees; the strong relationships and communications with stakeholders as well as performance of multiple contractors, consultants, and specialists to realise benefits (Mir and Pinnington 2014, p.209).

This research therefore seeks to understand the strength and weakness of formal and informal ties of the project governance and its effect on managing and realising benefits. Granovetter (1973) in his work on the neglected social network distinguished the functions between strong and weak ties. He demonstrated the connection point between a group of individuals and their leaders thus resulting in trust, participation and rapid spread of information. Raising the need to further understand how the governance structure interrelate to the social and behavioural aspects of individuals in a project environment and its actual contribution to intended collaboration in the delivery of benefit realisation (Levina and Vaast 2008). Simply put - where and when is benefit management infused into the governance process to ensure performance remains aligned with expected benefits? What the true role of existing change control processes and tools are; and whether they are used as intended by various individuals in the project environment?

The dramaturgical approach adopted in this paper has not been extensively used in management research, it is adopted to reveal the unspoken behavioural and social norms surrounding project management teams which are directly and indirectly contributing to the rules and violations of buying and selling. Burke (1945) in his methodological approach of dramatism argued that social action is inherently dramatic in that human beings express themselves and relate to one another in much the same way as actors do when playing roles on a stage. Goffman (1959) introduced the concept of dramaturgical metaphor in his search to understand everyday social life and social intercourse in terms of the crafting of theatrical performances. He emphasised on two basic notions of: performances must be addressed to an audience, and that the part played by the audience is critical; and any performance is comprised of two regions - a `front-stage' and a `back-stage'. This concept of Goffman helps raise the questions of the real actors and audience in project environment and their understanding of their roles and responsibilities both in the front and back stages. Though more recently, Mangham (1978) argued that `The dramaturgical model of man is based upon the idea that man improvises his performance within the often very broad limits set by the scripts his society makes available to him.' His distinguished three scripts model has been adhered to provide greater insight into the nature of the challenges surrounding tangible and intangible aspects of benefit realisations.

The remainder of this paper is divided into three sections. In the next section, the literature review was carried out followed by the description and justification of the dramaturgical approach. This is followed by the methodology and presentation of a scoping study. In final section, discussion of the results and conclusions are reported.

**LITERATURE REVIEW**

The concept of benefit realisation is not new according to Simon (2003), it has become an important area since late 1980s and early 1990s, with organisation focusing on delivery of expected business benefits rather than the traditional focus on project’s time and cost (Farbey et al., 1999). Though this traditional paradigm shifts according to Truax (1997), necessitate the need for change from a passively managed benefit to proactive management. In order to maintain a proactive management, Musawir et al., (2018)
proposed a strong governance climate that would encourage the development and leadership of a benefit management process in projects. Effective project governance therefore creates the necessary roles, responsibilities, and accountabilities that are a pre-requisite for effective benefit management (Musawir et al., 2018). It is also designed to predict and ensure consistent delivery of projects within a set limitation of the contract (Muller 2009).

However, this is not always the case according to Fernie and Thorpe (2007), a strong governance structure that emphasises on the partial success criteria of time, cost and quality will not necessarily develop the process of benefit management thus detriment to the process. Sanderson (2012) also explained three problem statements associated with strict governance structure: The first is to do with the underperformance caused by the misinterpretation of costs by the project team from a strategic perspective and optimism bias. The second is the project governance arrangements which often lead to the perception of performance being the result of misaligned or underdeveloped governance mechanisms, and the inability of the project team to provide a flexible and robust response to unavoidable challenges in the project environments. And the third is cultural and behavioural (which is the focus of this research) where performance problems are perceived as unavoidable outcome of the complexity, ambiguity, and conflict faced by project team with diverse and competing project cultures and behaviours.

It is therefore critically important to shift the focus away from too rigid governance structure and stringent use of existing change control tools and processes of managing benefits. Refocusing the attention towards effective use of benefit management tools and strategic alignment of benefit realisation in management of project, necessitate an imperative utilisation of the interests of those who established the project i.e. the stakeholders and what they hoped to achieve through the project benefits. It is unavoidable that different individuals of the project team would have different perspectives of the constituent of benefit realisation and different approaches of benefit management. The understanding of these perspectives and the coordination of these relationships is very vital to management and realisation of benefits. Failure to monitor these social and human aspects of projects is believed to be a significant shortcoming in the body of knowledge and may at least help to explain the exceptionally high ‘failure’ rate of projects given that human and financial outcomes are closely interconnected (Badewi and Shehab 2016).

It is to these contexts, this paper reflected on the strength and weakness of formal and informal ties in project governance drawing on a selection of concept from Mangham’s dramaturgical analysis. According to Mangham (1978), we improvise our performance within the broad limits set by the scripts the society makes available for us. He explains that improvising is critical to the achievement of any performance as a script is a set of instructions for performing. It is the task of the performer to bring the text to full realisation by giving it the finishing and concrete form that can be felt by the audience. In order to fully appreciate how performances are achieved, structured and realised, we must take into account the types of script in use and the way the actors improvise within a broad set of script heading. In so doing, Mangham highlighted the active role of the audience in the creation and achievement of any social performance.

It is on this backdrop of human behaviour and social network on a single case study in the rail industry that this research is focused on. It is tentatively posited that for too long attempts to impose tidy financial measurements on benefit realisation have largely ignored social costs. The costs of such a narrow focus are already being witnessed in the
ongoing challenges of this case study, illustrating that there is a need to consider the problem of benefit management and control from an alternative perspective of human behaviour and social network.

**METHODOLOGY**

This research utilises a single case study research methodology adopted with Mangham’s (1978) three script types’ dramaturgical approach. A single case study research has been used to provide a holistic and in-depth explanation and analysis of the behavioural and social aspects of projects team in the management, controlling and realising benefit.

The main strength of the dramaturgical method used is that it emphasises the nature of client-consultant interaction which in this case refers to the project stakeholders i.e. the supplier - buyer or project team - sponsors’ interaction. It accentuates the fact and the ways in which, this interaction can be manipulated by the project team or supplier in order to convey an impression of quality and value to buyers or sponsors. The most purposive means of viewing the work of consultants (supplier / project team) is therefore one that centres on the supplier / project team’s attempts to create and manage meaning with the buyer / sponsors relationship which then captures how the supplier / project team explore the demonstration of their expertise, value and quality to buyers / sponsors.

The data collection was carried out in three chronological phases using Mangham’s three script model. The initial phase was observation of the actors (project team) using the situational script, followed by an unstructured interview using the personal script. The final phase comprised the monitoring of the actors’ behaviours from strategic script perspective. For this study to be valid and reliable, and since the study is specific to one single case study, ethical measure was taken into consideration. Participants were enlightened of the intended anonymity to be used in the sensitive nature of handling personal opinions on organisation structure and performance measurement.

**Phase 1: Situational Scripts**

This tends to occur when the situation is clearly specified, where several actors (project team) have interlocking roles to follow, and where each of them shares a understanding of what is supposed to happen. Thus, project team ‘assume and enact relatively clearly defined roles within the confines of the anticipated sequence of events’ (Mangham 1978). In this phase, different project team actors within a single rail industry were observed and seen as actors using the Roles, Accountabilities and Responsibilities RACI table below (adopted from PRINCE 2 book) to explain who is responsible for what, who is accountable, who needs to be consulted and who needs to be kept informed in realising benefits and managing change.

![Figure 1: RACI describing division of responsibility for benefit realisation](image)

This observation also led to the projects governance structure of this organisation’s project environments been seen as a driving factor on how projects benefits are managed.
and how individuals act and behave in the organisation. In Crawford and Cooke-Davis (2009) view of project governance, the driving purposes are to define, regulate roles, accountabilities, decision making and boundary management to achieve coordinated project planning and control function. The table above emphasise the importance of addressing individual roles and responsibilities in order to address any conflicts or misinterpretations.

**Phase 2: Personal Scripts**

According to Mangham 1978, this occurs when a performance is constructed to achieve some personal goal. In this phase, the personal script would generally exist solely in the mind of the initiator (in this case the author) and the actors (project team) may not share an understanding of what is supposed to happen. Several project managers, project engineers and the supporting functions such as, commercial managers and procurement managers were informally engaged at different times / intervals without prior warning or preparation. The engagement was to obtain data on their understanding of benefit management, the impact of governance structure and how they manage and ensure benefits are realised on their projects. This was carried out by unstructured interview over a period of time with table 1 revealing some of the open-ended questions asked from various actors categorised under their job titles. It should also be noted that the participants below are both from supplier / client environment.

From the questions asked, Mangham's argument on the criticality of improvisation to achieve any performance came into play. According to Mangham, it is the performer's task to bring text to realisation and in this situation; the open-ended questions represent the text. Performance in this instance is the appearance and general demeanour of the various project team members and their maintenance of impressions in answering the various questions.

**Phase 3 Strategic Scripts**

Mangham (1978) further reported that strategic script arises where the actor is striving to instil certain behaviours from those with whom they are interacting. In this phase, during observation, similar behaviour was noticed within a project team environment. These are particularly manipulative in that the project team are only too well aware of what they are trying to achieve i.e. the project deliverables. The project manager consciously attempts to influence the response of the rest of the project team by planning and then invoking a strategic script of how the deliverables are met within the specified timescale and cost with limited attention to the project benefits.
# FINDINGS AND ANALYSIS

## Table 1: Summary of the unstructured interviews

<table>
<thead>
<tr>
<th>Number of participants involved</th>
<th>Job Titles</th>
<th>Supplier or Client environment</th>
<th>Questions asked</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Project Sponsors</td>
<td>Client environment only</td>
<td>What do you think your role is with management and realisation of project benefits?</td>
</tr>
<tr>
<td></td>
<td>Programme Manager</td>
<td>4 from client environment</td>
<td>How do you ensure effective and efficient management of various project benefits?</td>
</tr>
<tr>
<td></td>
<td>Programme Manager</td>
<td>2 from supplier environment</td>
<td>How do you manage benefit pre-and post-contract award? How do you ensure benefits are realised post completion of your project?</td>
</tr>
<tr>
<td>20</td>
<td>Project Managers</td>
<td>14 from client environments</td>
<td>Do you think the governance structure have any impact on the way benefit are managed and realised?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 from supplier environments</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Project Engineers</td>
<td>12 from client environment</td>
<td>What is your involvement with management and realisation of benefit and how do you ensure these are achieved?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 from supplier environment</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Commercial Managers</td>
<td>6 from client environment</td>
<td>How do you ensure and monitor efficient management and realisation of project benefit?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 from supplier environment</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Procurement Manager</td>
<td>4 from client environment</td>
<td>How often do you realize benefit during project’s procurement stage and how do you manage this process?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 from supplier environment</td>
<td></td>
</tr>
</tbody>
</table>

## Table 2: Summary of responses

<table>
<thead>
<tr>
<th>Number of participants involved</th>
<th>Job Titles</th>
<th>Supplier or Client environment</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Project Sponsors</td>
<td>Client environment only</td>
<td>We define benefits properly and form the scope of projects at pre-start before passing the information to the project delivery team as part of the project brief. We get regular update from the project team and then review whether benefit has been realised at the end of the project with the end users.</td>
</tr>
<tr>
<td></td>
<td>Programme Manager</td>
<td>4 from client environment</td>
<td>As the executors of these projects, there is not enough time and attention to actually maximize or realise benefits pre-contract and during the execution work therefore most of the benefits are not realised or measured until post projects completion.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 from supplier environment</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Project Managers</td>
<td>14 from client environments</td>
<td>There is currently no process in place for this. The business justification is detailed in the project brief. The deliverable checklist is reviewed and monitored throughout the project cycle to ensure delivery. In most cases, however, we constantly respond to the overwhelming amount of changes during the project lifecycle and most often lose sight of expected benefit.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 from supplier environments</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Project Engineers</td>
<td>12 from client environment</td>
<td>75% of projects delivered within this industry are due to safety and compliance issues. Therefore, there is more focus on these aspects and any non-engineering matters are to be dealt with by Project Managers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 from supplier environment</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Commercial Manager</td>
<td>6 from client environment</td>
<td>The focus is more on the cost benefit and ensuring that project does not exceed allocated budget. Cost change management is carried out by the project management with input from all supporting functions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 from supplier environment</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Procurement Manager</td>
<td>4 from client environment</td>
<td>Project benefits are rarely realised during procurement phase as in most cases, there is always pressure from the project team to use the fastest procurement option / route which the predefined framework is therefore not giving any room for possible benefit from open tender.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 from supplier environment</td>
<td></td>
</tr>
</tbody>
</table>
From the results, majority of the participants do not share same understanding of their roles and involvement in the management and realisation of benefits. Most of the responses revealed that though benefit can be realised pre-contract award and during the life cycle of the project however, the organisation structure does not allow for this to happen. Majority of the time, the organisation is more reactive / adaptive to evolving issues and ongoing maintenance of the Railway industry than using a proactive approach to start up and manage project. Quick approaches to procuring suppliers are used with an already established framework and not allowing the opportunity for competitive tender and realising benefit pre-contract award.

It was also evident that a lot of the project benefits are not realised until after the completion of the project therefore the project team would have moved on to other projects long after the benefits are realised. This means that output has been passed on to the users and maintenance team. The maintenance team / users i.e. the audience though involved to some extent during the lifecycle of the project, but their involvement is usually limited and, in most cases, limited knowledge of the outlined performance objectives and measurement for the project. Therefore, the business case set at the beginning of the project no longer become a live document that project team review on a regular basis to ensure validity of the project but a set of documents that gets reviewed at the beginning of the project and post project closure by the sponsor.

**CONCLUSIONS**

The single case study conducted using the dramaturgical approach revealed some findings that there is notable lack of practices for implementation of benefit management at project level in this industry. Therefore, a less rigid governance structure is required to be in place in order to actuate this concept for effective management of benefits. It is evident from the study that changing the behaviours and culture of project team towards benefits realisation approach and gradually shifting their focus to simple application of benefit realisation strategy pre-contract award - to execution phase - to post completion is strategically important and crucial to any project delivery.

This study could be criticised that there is potential lack of objectivity from the author as participant observation and that results were generated from a single industry. However, this study lends itself to practical real-life ethnography study which is an ongoing development for the overall PhD study.

**REFERENCES**


MEDIATION AND PLANNING DISPUTES IN ENGLAND AND WALES: OPPORTUNITIES AND CHALLENGES

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There is no dearth of academic research into the apparent benefits of mediation as a tool for the resolution of planning disputes. Several eminent lawyers have proffered their support for the use of this alternative dispute resolution mechanism within the UK planning system. Further, formalised mediation regimes have been introduced into the respective planning systems of a number of international jurisdictions, with apparent success; for example, in Australia, 34% of all planning disputes are now resolved via a form of mediation. Notwithstanding this apparent evidence-base, in England and Wales a substantial number of property developers, local authorities and planning professionals continue to believe that mediation is not useful or appropriate as a mechanism for resolving planning disputes and, despite early indications that a formalised mediation regime would be developed and adopted in England and Wales, to date no such regime has been implemented. This present research paper seeks to determine the viability of mediation for planning disputes in the UK, and whether a framework can be developed and structured to ensure that maximum benefit is gained from using mediation for such disputes.

Keywords: planning, disputes, mediation, England, Wales

INTRODUCTION

Globally, mediation has proven to be extremely successful in enabling disputing parties to engage in a constructive rather than destructive manner (Goldberg, 2003). For example, in the context of construction disputes, which typically involve complex agreements and time-sensitive contracts, mediation enables a particular dispute to be solved quickly so that the contract itself does not become frustrated. This is just one reason why construction and commercial contracts often feature a mediation / arbitration clause, so as to avoid lengthy and costly litigation. It moreover provides for a cost-effective and swift method of solving disputes in a more informal manner than litigation. Such benefits produce the expectation that mediation of planning disputes will result in quicker decisions, reduced time in determining applications, greater efficiency and an overall cheaper system.

However, it is important to recognise that mediation is not automatically more beneficial than litigation, and its role and advantages depends on the type of dispute involved. It is also important to point out that mediation depends ultimately on the consent of the parties, and hence to impose it as a compulsory method of dispute resolution would undermine the very qualities and advantages that it claims to have over litigation. The purpose of this paper is therefore to consider mediation in the context of planning disputes in the UK, with a view to determining its potential role, opportunities and challenges.

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challenges. This will be applied to determine the viability of mediation for planning disputes in the UK, and whether a framework can be developed and structured to ensure that maximum benefit is gained from using mediation for such disputes.

RESEARCH CONTEXT

As has been briefly addressed above, mediation provides a more cost-effective, faster and generally more beneficial form of dispute resolution than litigation for certain types of disputes. It is for these reasons that mediation may be considered a potentially useful form of dispute resolution in the field of planning disputes in the UK. Mediation for such disputes promises to facilitate participation in planning disputes on a much broader level, thereby promoting inclusiveness, and allowing for a broader and thus more accurate range of interests to be taken into account. The flexible nature of mediation also enables the process to be tailored according to the particular features of the individual case (Bacow and Wheeler, 2013). It is within this context that the potential benefits of mediation planning disputes should be approached and considered, in order to determine whether such benefits are applicable to this type of dispute.

The potential for mediation in the field of planning disputes has certainly not gone unnoticed in the UK. In 1996, a public debate was commenced by Chief Planning Inspector Chris Shepley concerning the potential benefits that mediation could offer planning disputes (Shepley, 2013). It also addresses certain important features and qualities of mediation that would need to be maintained and protected in order for the benefits of mediation to become realised. This is an important issue, because it addresses the fact that the success or failure of mediation for planning disputes depends largely on how the mediation process is structured for such disputes. Shepley for example emphasises the need to maintain certain core standards in mediation for planning disputes, such as its voluntariness and confidentiality. He also stresses that mediation should “not affect the rights of applicants to go on to appeal, in the normal way; or the rights of local authorities to make democratic decisions”. (Shepley, 2013; 49). Academic attention has also been given to such issues, with prominent focus on the successes of mediation for planning disputes in other jurisdictions, such as the US (Stubbs, 1997).

Such interest did not however provoke any major reforms in the UK; it merely resulted in the publication of policy guidance and recognition of the potential benefits of mediation for such disputes (DCLG, 2006). Given the recognised advantages of mediation in the field of planning disputes, it is quite surprising that no major practical changes have been implemented in the UK. This forms the main context of the research, in that it recognises and acts upon the need to progress from theory to practice, and to develop an effective mediation framework for planning disputes. The UK government has however taken relatively few tentative steps towards promoting mediation for planning disputes. It has, for example, merely expressed that it “support[s] the voluntary use of mediation within the planning system”, and recognised the need to “work with relevant professional bodies to promote mediation services by local authorities” (HM Government, 2007). It appears that policies and plans have lost pace when they reach the implementation stage, giving rise to the need to determine how a mediation framework for planning disputes may be best implemented, and what such a framework would need to contain. Planning disputes do not typically involve disputes concerning rights; they rather feature a disagreement between a local authority and a landowner about what they consider to be appropriate (Watson, 2016). This becomes all the more complicated due to the fact that third parties are able to participate in and contribute to the debate. Planning disputes may therefore often be more accurately defined as debates.
This further supports the claim that mediation is better suited to such disputes/debates because it provides an arena for voicing opinions and arriving at a negotiated outcome (Kaufmann et al., 2014). It is therefore clear that there is convincing evidence to suggest that mediation may play an important and valuable role in solving planning disputes. It is further necessary to ensure that the mediation process is tailored to suit the particular features of land disputes, so that potential problems and challenges may be avoided or minimised. Examples from other countries in which a structured mediation regime for planning disputes has been implemented will provide guidance in this respect.

This research is of considerable importance for a number of reasons. First, if mediation is indeed a cost-effective tool for the expedient resolution of planning disputes, then the adoption of a formalised mediation regime the UK could accelerate investment into the respective property sectors of England and Wales. After all planning disputes delay developments and, consequently, a dispute resolution mechanism which can facilitate an earlier settlement of such disputes will ensure a faster realization of the benefits of development projects, including but not limited to higher levels of taxation revenue, employment, and housing stock (IRS, 1971). A study commissioned by the UK Government in 2002 estimated that the adoption of a formal mediation regime within the UK’s planning sector would result in the realization of £3 billion of investment into the UK economy 40 weeks earlier than would be the case if all planning disputes were resolved via formal litigation. The findings of this study suggest that there is indeed a strong evidence-base in support of the adoption of a formal mediation regime within the UK’s planning system.

Second, planning appeals in the UK cost the Exchequer around £25 million each year (Planning Inspectorate, 2010), and substantially more still for the developers and local authorities embroiled in these formal proceedings (Ratcliffe et al., 2009). If mediation is a cost-effective and viable alternative to formal litigation, then its widespread adoption would almost certainly result in a reduction in the number of appeals being lodged each year and a substantial cost saving for all parties involved and the Exchequer (Ratcliffe et al., 2009). Third, there is evidence that the UK government is seeking to promote the development of a less centralised and more community-oriented planning system (Pemberton et al., 2015); for example, the Planning and Compulsory Purchase Act 2004 and the Planning Act 2008, both emphasise - and give a statutory footing to - the importance of efficient pre-application procedures and community participation. While mediation is only required after a dispute has arisen, as opposed to at the pre-application stage, nevertheless there is a clear synergy between the objectives of mediation and this emerging public policy agenda.

Traditionally, mediation was developed as an informal and private mechanism for the confidential resolution of bilateral or bipartisan disputes; however, it will be argued in this paper that mediation is a highly flexible process and this form of Alternative Dispute Resolution (ADR) has no intrinsic qualities or characteristics that would preclude it from being modified to accommodate a wider number of community participants. So long as the expectations of the parties are managed appropriately, and a suitable form of mediation is adopted, this ADR mechanism can be an excellent way of allowing a wider range of stakeholders to participate in the negotiation process than would ordinarily be entitled to participate in the judicial appeal process (MacLaran et al., 2007).

**RESEARCH ISSUES, AIMS AND OBJECTIVES**

The primary research issue relates to the potential benefits that mediation provides in planning disputes, both in its own right, and in comparison, to litigation. This will
provide a basis for developing specific conclusions and reasoned arguments pertaining to
the benefits of mediation for planning disputes. This then gives rise to the research issue
pertaining to the potential disadvantages of mediation for planning disputes. This is a
critical issue, because it recognises that mediation is not automatically advantageous for
all mediation disputes. The objective of this research area is to balance the potential
advantages and disadvantages of mediation for planning disputes. The research paper
seeks to (i) evaluate the viability of mediation as a mechanism for the resolution of
planning disputes which occur between developers and public authorities, and (ii) identify
the barriers to the uptake of mediation within the planning system of England and Wales.
These aforementioned research issues, aims and objectives may be outlined as
encompassing the following research questions: Is mediation more cost-effective than
formal litigation and ADR in resolving planning disputes? How can this cost-
effectiveness be measured? What issues routinely characterise planning disputes and how
might mediation better be suited to the resolution of these kinds of dispute over formal
litigation and other forms of ADR? In any event, what recommendations for reform can
be proffered as a result of this findings of this present study?

METHODOLOGY

The methodology of this research takes the form of black-letter analysis. For each
research question identified above, a set of core database search terms were derived,
which were used to locate relevant textbooks, sections in edited textbooks, journal
articles, case reports, legislation, government consultation papers and newspaper articles.
Relevant facts, figures and arguments were then extracted from these sources and
categorised broadly into (i) data highlighting actual (empirical) or potential (theoretical /
academic) benefits of mediation in planning; (ii) data revealing actual or potential
challenges and barriers to the adoption of mediation in planning; and, (iii) data providing
insights into the legal and political reforms required to exploit those advantages and/or
overcome those barriers.

Definitional and methodological uncertainty; defining and evaluating the cost-
effectiveness of mediation, as opposed to formal litigation or other forms of ADR.
In this section, this author examines the difficulties in defining a working definition for
the term ‘mediation’ and explains the implications of this definitional and conceptual
uncertainty for reliable international comparative analysis and also for evaluating the
cost-effectiveness of mediation, as compared to formal litigation or, indeed to other forms
of ADR.

The problem of deriving a working definition for the term ‘mediation’
It is no straightforward task to derive a working definition for the term mediation
(Morasso, 2011). The term and the process of mediation are used in so many different
contexts (Nicholson, 2009)—legal and non-legal—that it is difficult to derive one
singular definition which encompasses all essential characteristics of this process
(Barsky, 2009). Definitions which do attempt to achieve generality are invariably too
simplistic to be useful to an academic researcher. For example, Schrumpf et al., define
mediation as, “... a communication process in which the people with the problem work
together, with the assistance of a neutral third party, cooperating to resolve their conflict
peaceably (Schrumpf et al., 1997)” This definition provides no real insight into the nature
of the mediation process, the role of the mediator—beyond the fact that mediators are
‘neutral’—or the nature of the outcome of the process.
It is also not entirely clear that this definition is capable of distinguishing mediation from other types of ADR, such as conciliation. Those definitions which are sufficiently specific to serve as a working definition for the term mediation, tend to be limited to a specific context or to a particular variant of mediation or to one or more author’s personal conceptions of the process or a variant thereof, and are therefore also of limited use. For example, even though it is generally agreed that there exist five main types of mediation—facilitative, evaluative, transformative, therapeutic and narrative mediation (Brooker, 2013) - there is no general consensus as to the meaning of these terms and different authors tend to adopt their own prescriptive or descriptive definitions for this nomenclature. Bush and Folger, for example, define ‘transformative mediation’ through reference to a process of human development which involves a transformation in the behaviour of the actors involved in the mediation process (Spencer and Brogan, 2007); whereas, Boulle and Nesic have an entirely different conception of ‘transformative mediation’, and use the terms ‘transformative mediation’ and ‘therapeutic mediation’ interchangeably (Brooker, 2013: 8).

In the introduction to this paper, this author stated that there is wide support in the academic literature for the adoption of a formal mediation regime within the UK’s planning system. One would have thought, by now—bearing in mind that this debate originates from the mid-1990s—that a single working definition for the term ‘mediation’ or at least for the preferred type of types of mediation would have emerged from the planning literature. Unhelpfully, this is not the case; in fact, it is not uncommon for academic articles dedicated to the promotion of this agenda to avoid altogether any attempt to define this term or to specify which type of mediation they are advocating. This could help to explain why, to date, this recurrent agenda has failed to be implemented in the UK; if there is no broad agreement on the form that the mediation process comprising this formal regime should take then how can the authorities be expected to know which type of mediation process and (accompanying) procedure to prescribe?

The lack of definitional certainty in this area is perhaps itself a result of the informal nature of mediation and the wide degree of autonomy which is given to mediators to decide how to bring the disputing parties towards consensus (Brooker, 2013; 1). As Chern argues, “There are as many different types of mediation as there are mediators (Chern, 2014).” In the UK, the focus of mediation training is on the ‘facilitative’ and ‘evaluative’ varieties (Chern, 2013); however, in practice, the professional experience and instinct of the mediator is more likely to guide the mediation process than his or her formal training. This view is supported empirically; various studies have found that one of the more reliable predictors of the success of mediation is the skill and experience of the mediator (Roberts, 2014). In practice, this means that there must be a high level of inconsistency in the success rates between different mediators (Bercovitch and Jackson, 2009). This inconsistency may help to explain why there seems to be such wide disparity between the success rates of mediation within different nation states. For example, in Canada and New Zealand, the success rates of mandatory mediation are 80% and 73% respectively; whereas, in England and France, the published success rate for mandatory

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mediation is 50% or lower (Hopt and Steffek, 2013). A wide variety of different forms of mediation are being practiced internationally, within entirely different legal and cultural environments, by mediators with different types and level of training and experience, and consequently there is a wide disparity between the success rates of mediation within different nation states.

**Mediation within the context of planning disputes**

The term ‘planning’ encompasses a wide spectrum of different activities and consequently, the term ‘planning dispute’ demands definition. For the purposes of this present paper, the term is used narrowly to refer to those disputes which arise between developers and local authorities, prior to, during or after the grant of ‘planning permission’, i.e. permission to develop or commercialise real estate in a certain way. Because of the intrinsic value of real estate, the outcome of a planning dispute can have substantial economic impacts on the parties. A successful application for planning permission can add considerable value to a developer’s land. Conversely, an unsuccessful application can reduce considerably the value of that land, by confirming that the land in question does not enjoy short- or medium-term development prospects. A successful planning application can also have profound positive and/or negative impacts upon the community at large, depending upon the nature of the proposed development and its likely impact on the aesthetics, economy, infrastructure and citizenship of the affected locality. Therefore, planning disputes are rarely frivolous or vexatious, and they are invariably contentious, as they navigate those difficult waters which exist at the interface of private rights and public interests (Levy, 2016): Private developers understandably wish to maximise the land value of their real estate holdings, and are therefore likely to pursue aggressive and ambitious development strategies (Barlow and Duncan, 2004). Local authorities welcome planning applications for such schemes, as privately-funded property development can bring considerable benefits to the local area, including new housing stock, infrastructure, local amenities and aesthetic enhancement. However, all large-scale developments will have both positive and negative impacts upon the local community, and local authorities must consider each planning application carefully on its own merits, to ensure that the overall impact of any approved scheme is likely to be positive (Crook et al., 2016). This utilitarian approach to planning decision-making enjoys a statutory footing. For example, section 106 of the Town and Country Planning Act 1990 (as amended) adopts a mechanism through which developers may offer local authorities incentives to offset the potential negative impacts of their proposed development schemes (Jansen et al., 2008), for example, by providing a sum of money for local authorities to invest in public amenities (Cullingworth et al., 2014). Planning disputes may arise for a number of different reasons. However, in practice, the vast majority of planning disputes arise where a developer believes that a local authority has failed to discharge its duties or powers properly or in a timely manner and commences formal litigation against the local authority to appeal that decision or compel a determination (Isaac et al., 2016). The substance of such a dispute usually hinges around the correct interpretation and contextual application of a particular law or policy. Consequently, planning disputes are atypical—as compared to traditional claimant-defendant litigation—because they arise when developers and planners have different views of what is appropriate, rather than as a result of the alleged infringement of a right, per se. This viewpoint is supported by Sir Henry Brooke who explains the nature of planning disputes, succinctly:

> A typical planning dispute does not involve a dispute between parties about a right. It is an argument between a landowner and a local authority about what is appropriate... It is wrong to assume that an applicant for planning permission, or an appellant who challenges a
refusal of planning permission, can be equated with a claimant in civil litigation, with the local authority in the role of a defendant [Brooke, 2015].

These kinds of dispute do lend themselves to settlement by mediation, as they are interest-based rather than positional (Berger, 2006); as noted previously a developer’s interest is in maximizing the value of their land asset and local authorities are (or ought to be) interested solely in protecting the public interest. This means that there is wide scope for the parties to move from their opening gambits to reach a consensus, so long as the local authority is able to reconcile a compromise with the public interest. In England and Wales there are three different ways that an appeal can be ‘heard’; by written representations, by hearing or by public inquiry (Isaac et al., 2016).

While there is no right, under English law, for third-parties to appeal an initial planning decision (Norton, 2017), once an appeal has been lodged by a developer, interested third parties, such as neighbouring local authorities, commercial rivals, neighbours, statutory bodies or local groups, are entitled to participate in the appeal process, should they so wish, by submitting written representations and giving oral testimony at any hearings or inquiries (Harwood, 2013). The entitlement of third parties to participate proactively in the appeal process is an added complication of English planning law (Brooke, 2015), and it follows that if the judicial appeal process is going to be replaced with a formalised first-instance mediation regime, then that regime will need to accommodate at least the same level of third-party participation as is accommodated by the judicial process. This presents both a challenge and a potential opportunity for the pro-mediation agenda; the challenge is to ensure that the rights of third parties to be represented within the planning appeal process are not compromised by the introduction of a formal mediation regime; the potential opportunity is to devise an alternative dispute resolution process which actually enhances third party participation.

It has been argued in the academic literature that mediation may also be a viable alternative to judicial enforcement action, i.e. where local authorities bring proceedings against land owners who have failed to comply with the conditions and limitations of their planning permission (Pugh-Smith, 2011). This type of planning dispute does not usually involve third parties, even though enforcement proceedings are often instigated as a result of third party referrals. In the opinion of this present author, there are some immediate and obvious concerns with the utilization of mediation as a first-instance enforcement mechanism; notwithstanding the definitional uncertainty surrounding the word ‘mediation’ and the huge variety of different processes which are subsumed by the umbrella of this term, it is unlikely that the threat of enforcement action would have the same deterrent effect if mediation replaced litigation as the dispute resolution mechanism of first instance. In fact, the adoption of a formal mediation regime for the resolution of such disputes could lead developers to believe that the conditions and limitations attached to planning permission grants are somehow negotiable post facto. Unfortunately, there is no empirical data available to test this thesis or to quantify the potential reduction in compliance with planning conditions which might result from the adoption of a formal mediation regime for planning enforcement action.

There is, however, in the context of the criminal justice system, evidence that mediation has less of a deterrent effect than more formal enforcement mechanisms (Roberts, 2002); it seems likely, to this author, that a similar effect would be observed within the context of the UK planning system. Legal precedent is also valuable in this arena, and the adoption of a formalised mediation regime could curb the development of planning law (Costello, 1996). As noted previously, the substance of a planning dispute usually hinges around the correct interpretation of a particular law or policy; if such disputes are
routinely mediated then future litigants may not be able to enjoy the precedential value of the outcome of that dispute (Arnavas, 2014).

While the adoption of a formalised mediation regime might - and the evidence is by no means compelling - cause a reduction in litigation costs for disputing parties, it would almost certainly cause more disputes to arise in the first place, as mediation outcomes are usually bespoke, confidential, idiosyncratic, party-controlled and not legally binding on anyone except for the signatories to the mediated settlement agreement (Hopt and Steffek, 2013). This unintended consequence of the adoption of such a regime could, ultimately, be more costly than the problem which the regime seeks to overcome. In addition, if the majority of planning disputes were settled through traditional mediation, which would presumably be the objective of a formalised mediation regime, then local and regional disparity in planning decisions would be exacerbated, because the settlement of those disputes would be controlled by the local authorities involved and not by an independent tribunal applying national laws, policies and principles. This would be at odds with the UK government’s focus on addressing these kinds of disparity in the application of planning law (Thomson and Maginn, 2012).

CONCLUSIONS

In the introduction of this paper, this author cited the findings of a study commissioned by the UK Government in 2002 which estimated that the adoption of a formal mediation regime within the UK’s planning sector would result in the realization of £3 billion of investment into the UK economy 40 weeks earlier than would be the case if all planning disputes were resolved via formal litigation. In light of the preceding analysis it seems quite clear that the findings of this government-funded study must be treated with a high level of scepticism; bearing in mind the uncertainties and inconsistencies identified within the paper, especially those pertaining to the challenges of relying upon international comparative analysis in this context, there is simply no methodology available which could produce reliable results with this level of quantitative specificity. The focus of the preceding analysis was limited to a comparison between the cost-effectiveness of mediation and court litigation. However, logically, the same conclusions and concerns derived above are equally applicable to a comparison between the cost-effectiveness of mediation and other forms of ADR. In conclusion, it must be argued that presently there does not exist an adequate evidence-base from which to justify the implementation of a formalised mediation regime within the UK’s planning system, on grounds of cost-effectiveness alone. Consequently, to justify the introduction of such a regime, it is necessary to take a step backwards, and examine empirically the nature of planning disputes to see if there exist other measurable barriers to efficiency, in this context, which might be overcome, measurably, through the adoption of a formalised mediation regime.

REFERENCES

Mediation and Planning Disputes


Agapiou


EXPLORING THE DRIVERS OF ADAPTATION AND RETROFITTING OF EXISTING BUILDINGS IN GHANA

Peter Amoah, Ernest Kissi and Daniel Oteng

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Many structures age and outgrow their original functions. Even though there has been a surge in technology prompting construction and design to be constantly updated to meet modern demands, many older structures have been left in the wake of change. The main aim of this research is to explore the drivers of adaptation and retrofitting of existing buildings in Ghana. Using mix research methods including literature review and survey (interview and close ended questionnaire) data were collected and analyzed using one-way analysis of variance (ANOVA). From the ANOVA, the study highlighted on increasing the stability of the existing building, implementation of sustainable building practices, increasing building aesthetics, reduce the adverse impact of building on the environment to change the function of the existing building and update existing building to modern standard are the significance drivers that has triggered the growing adaptation and retrofitting of existing buildings in Ghana. A further ANOVA test revealed that there were differences in the rating of the importance of the identified drivers. This study provides building owners, tenants, and construction professionals with the better insight of what drives adaptation and retrofitting of existing buildings in the Ghanaian environment.

Keywords: adaptation, drivers, Ghana, retrofitting

INTRODUCTION

The activities of the construction industry are pivotal to the achievement of the socio-economic development goals of providing shelter, infrastructure and employment. In Ghana, the construction industry is helping to achieve socio-economic development goals, providing shelter, infrastructure and employment, and most importantly contributing significantly to the economic growth of the country (Anaman and Osei-Amponsah, 2007). Adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change (Kane and Shogren, 2000). Adaptations vary according to the system in which they occur, who undertakes them, the climatic stimuli that prompts them, and their timing, functions, forms, and effects. In unmanaged natural systems, adaptation is autonomous and reactive; it is the process by which species and ecosystems respond to changed conditions (Rezessy et al., 2006). According to Koslow (2009), adaptation depends greatly on the adaptive capacity or adaptability of an affected system, region, or community to cope with the impacts and risks of climate change. The adaptive capacity of communities is determined by their socioeconomic characteristics. Enhancement of adaptive capacity represents a practical means of coping with changes and uncertainties in climate, including variability and

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extremes. In this way, enhancement of adaptive capacity reduces vulnerabilities and promotes sustainable development (Koslow, 2009).

There are three forces which ultimately create a building reuse project - they can be people-driven, building driven, or policy-driven. People-driven projects start either when an individual or group has a need or is searching for a building to fulfill it; or an owner of a building who is looking for a way to creatively adapt his or her building (Lippke et al., 2004). A building-driven project is started when the character of the building is so notable that redevelopment comes in the form of a silent cry. A policy-driven project is led by governmental incentives, either in general or within a specific district or area (Lippke et al., 2004; WBCSD, 2007). In developing countries, retrofitting existing buildings at the optimal level is also a priority. In this regard, there is tremendous scope for using this opportunity to update the heating and cooling technologies used in buildings, as well as implementing low cost but effective passive solutions to improve energy efficiencies such as thermal mass and sunshades. Developing countries, particularly those undergoing rapid construction growth, should set optimal energy performance standards to enhance efficiency (UNEP, 2007). Many structures age and outgrow their original functions. Even though there has been a surge in technology prompting construction and design to be constantly updated to meet modern demands, many older structures have been left in the wake of change (Koslow, 2009). Ghana is not an exception. Most buildings were designed to meet the building code in place at the time of construction. However, since codes only certify the minimum requirements for safety, when changing a building's use, a structural analysis of the strength of the existing materials must be completed (UNEP, 1998; UN, 2002). This research was therefore conducted to identify the drivers for the adaptation and retrofitting of existing buildings within the three major central business districts in Ghana.

Drivers of Adaptation and Retrofitting

During the half of the 20th century, the adaptation and retrofitting of existing buildings gained an increasing recognition as a viable and an increasingly acceptable alternative to new buildings. It caught the attention of some communities and replaced majority of the housing with poor qualities or inadequate design (Douglas, 2006). The extensive demolition and replacement of much of the defective but repairable existing buildings units in many urban areas, especially in the 1960s and 1970s, went too far in some cases (Latham, 2000). There are many stakeholders or decision agents in building adaptation with differences in perspectives, and these differences give each stakeholder a different set of priority when the adaptation of the building is being considered (Wilkinson et al., 2009). As identified by Kincaid (2002), these stakeholders could be investors, producers, developers, regulators, occupants/users and marketers. Based on their differences in perspectives, an investor for instance may want to ensure that the long-term future value of the building is considered as a priority whereas a marketer would want to see certain features provided in the adaptation that the market is currently demanding. Also, policy makers indirectly affect the decision to adapt. Their policies bring much influence as to the amount of sustainability to be incorporated into buildings and to greater extent aid in mitigating global warming and climate change (Dong and Wilkinson 2007 cited in Wilkinson et al., 2009). “Lower operating cost within sustainable buildings is a further driver and a potent reason for implementing sustainability, given increasing energy cost” (Wilkinson et al., 2011). Upgrading the performance of existing stock, to put it, adapting existing building is the most critical aspect in the event of improving the sustainability of the built environment (Cooper, 2001) and in the event of responding to this ever-pressing need of climate change challenges and stringent/ambitious sustainability standard has
Drivers of Adaptation and Retrofitting

actually led to a significant growth in the adaptation and retrofitting of existing building towards the process of achieving low carbon, energy efficient and environmentally friendly buildings to help cope with the increasing demand for sustainability in modern infrastructure projects (Ankrah and Ahadzie, 2014). Adaptive re-use (adaptation and retrofitting) mostly offers a more efficient and effective process of dealing with buildings than demolition, this is because it is usually deemed to be safer as it reduces the amount of disturbances due to hazardous materials, contaminated grounds and the risk of falling materials and dust (Bullen and Love 2011). Added on by Douglas (2006), as buildings age, they wear out and their components need to be repaired or replaced.

“Adaptation and retrofitting can be a cost-effective strategy in accordance with consumer preference within residential alternatives to more institutional care through the provision of space and accessibility needed to enhance access to and delivery of services through conversion of existing building facilities (Nishita and Pynoos, 2006 cited in Oppong and Masahudu, 2014). Adding to this argument of provision of more space through retrofitting, Oppong and Masahudu (2014) posit that developing countries like Ghana usually retrofit their building to gain more space for accommodation with no consideration for green agenda in terms of material and components of sustainable building design and construction. From the case study conducted by Oppong and Masahudu on selected rural banks in Ghana, it was identified that one of the driving motives of the people is to adapt their building into modern use. To solidify this argument, it was stated in the study that: “The first-floor slab which serves as roof had developed cracks and therefore leaks profusely when it rained. It had exposed and broken down the strip foundation which had to be underpinned. The level of deterioration revealed by the condition survey resulted in adaptation and retrofitting the entire building as a new building with “ultra-modern” bank building and facility” (Oppong and Masahudu, 2014). Table 1 presents a summary of the drivers of adaptation and retrofitting from literature review.

Table 1: Drivers of adaptation and retrofitting

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meeting tenants’ demands</td>
<td>Kincaid (2002)</td>
</tr>
<tr>
<td>For building sustainability</td>
<td>Wilkinson and James (2009)</td>
</tr>
<tr>
<td>Increasing the performance of existing building</td>
<td>Cooper (2001); Ankrah (2014)</td>
</tr>
<tr>
<td>To avoid building obsolescence</td>
<td>Douglas (2006); Bullen&amp; Love (2011).</td>
</tr>
<tr>
<td>Expansion for more space</td>
<td>Oppong and Masahudu (2014).</td>
</tr>
<tr>
<td>Lower operating cost</td>
<td>Wilkinson (2011).</td>
</tr>
<tr>
<td>To update existing building to modern standard</td>
<td>Oppong and Masahudu (2014).</td>
</tr>
<tr>
<td>To reduce the adverse impact on the environment</td>
<td>Wilkinson and James (2009); Douglass, (2006)</td>
</tr>
</tbody>
</table>

METHODOLOGY

The research adopted a mixed methodology approach thus, qualitative and quantitative paradigms were the underpinning philosophies considered. The qualitative approach involved the use of semi-structured questions among top industry players (experts with over ten years of experience in the industry) including contractors, consultants and
clients. The reason for the use of the semi-structured interview was to triangulate literature review findings to improve and expand the depth of the questionnaire. This was done by elaborating and exploring the experience of the practitioners in relation to the phenomena under consideration. This helped in achieving variables that were peculiar to conditions pertaining to the Ghanaian Environment. The second stage considered quantitative technique which involved the collection of primary data based on the twelve (13) identified variables in the previous stage. The sample for the data collection consisted of tenants, building owners and construction professionals thus, representing the population of people who were associated with such developments. The questionnaire utilized closed-ended questions to explore drivers for retrofitting and adaptation. This was done by measuring respondents’ perceptions on the level of significance using a Likert items, from 1 = not important to 5= most important. Thus, the numerical representation, statistical analysis and subjective were the underlying individuals’ perceptions.

Sample Size and Sampling Technique
The semi-structured interview was administered to ten (10) top industry players who have not less than five-year practical experience on adaptation and retrofitting projects and has been in the industry for over ten years. The second section involved the use of closed ended questions, which were also administered to three-hundred (300) respondents involving tenants, building owners and construction professionals who have been involved or were doing such projects. The respondents had enough working experiences as more than half of the total sample size were having more than five years' experience. Added to their experience is their level of education, as majority had a Bachelor of Science and Higher National Diploma degrees in building technology. These questionnaires were administered using purposive snowballing sampling technique, which helped in reaching professionals who have an in-depth understanding on retrofitting and adaption, and those who were far from being reached. Out of the 300 questionnaires administered, 166 were retrieved with a valid response rate of 55%.

DATA ANALYSIS
Validity and Reliability Test of the Data
Before advancing to the statistical evaluations, the internal consistency was checked, the dataset was subjected to reliability scrutiny employing the Cronbach’s alpha. The consistency examination was performed to check the reliability of the drivers and its measure, this aids to establish whether the thirteen (13) variables mirror the construct it was intended to statistically measure (Norusis, 1993; Ameyaw, 2014). From the data set, the overall alpha value was 0.855 which is greater than the 0.70 recommended (Eybpoosh et al., 2011; Oyedele, 2013). This suggests a good internal consistency and reliability of the data obtained from the field survey and thus the five-point scale system adopted for the design of the questionnaire was reliable.

One-Way ANOVA
Indeed, respondents’ perceptions about the factors that trigger the decision for adaptation and retrofitting of existing buildings influences the endurance of the concept in Ghana. In this study, there was an interest in comparing the mean scores of more than two groups (Pallant, 2010; Howell, 2007). Hence, it deemed fit to establish from the respondents the causality between their perceptions using the One-Way ANOVA. As part of the data collection, respondents were asked to rank their views about the drivers that trigger the decision for adaptation and retrofitting of existing buildings in Ghana. In the analysis of
the causal relationship between respondents and their views, analysis of variance (ANOVA) was used to compare the variance (variability in scores) between the different groups of respondents (independent variables) and their perceptions (dependent variables). The aim was to find the relationship among the three groups of personalities identified in the study scope. In this case, the test statistic has an F sampling distribution with df1 and df2 degrees of freedom at a significant level of 0.05 (5%). A large F ratio indicates that there is more variability between the groups (caused by the independent variable) than there is within each group (error term) whilst a significant F test indicates that we can reject the null hypothesis (Pallant, 2010). The analysis and results of the investigation are presented in Table 2.

**Hypothesis Testing**

**Null hypothesis (Ho)** - There is no difference among respondents’ views on the drivers that trigger the decision for adaptation and retrofitting of existing building.

**Alternative hypothesis (Ha)** - There is difference among respondents’ views on the factors.

From Table 2, 11 out of the 13 driving factors rejected the null hypothesis, meaning there is significant difference among agreements on the influence of the variables as factors that drives the decision for adaptation and retrofitting of existing building in Ghana for the three group respondents. However, 8 out of the 13 factors had their significance values less than 0.05 indicating its level of importance to the retrofitting and adaptation of existing buildings at the Central Business District, namely: To increase the stability of the existing building (0.001), for implementation of sustainable building practices (0.000), To change the function of the existing building (0.001), To avoid building obsolescence (0.000), Expansion for more space in the existing building (0.019), To increase building aesthetics (0.011), Update existing building to modern standard (0.023), To reduce the adverse impact of building on the environment (0.011). According to Wilkinson et al., (2009), there are many stakeholders or decision agents in building adaptation with differences in perspectives, and these differences give each stakeholder a different set of priority when the retrofitting and adaptation of the building is being considered. These stakeholders could be building owners, construction professionals, investors, producers, developers, regulators, occupants/users/tenants and marketers (cf. Kincaid, 2002). Based on their differences in perspectives, an investor for instance may want to ensure that, the long-term future value of the building is considered as a priority whereas a marketer would want to see certain features provided in the adaptation that the market is currently demanding.

However, this does not explain as to which specific group is different from which other group. For this we need to conduct post-hoc tests. According to Stevens (1996), the multiple comparisons table can only be emphasized if it was found that there is a significant difference in the overall ANOVA. That is, if the Sig. value was equal to or less than .05. The post-hoc tests explained exactly where the differences among the groups occur. Having received a statistically significant difference, the results of the post-hoc test was looked at. In the Mean Difference column, an asterisk meant that the two groups being compared are significantly different from one another at the p<.05 level (Cohen, 1988).
Table 2: Drivers of adaptation and retrofitting

<table>
<thead>
<tr>
<th>No</th>
<th>Drivers</th>
<th>Mean</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>To meet demand of tenants</td>
<td>3.223</td>
<td>1.544</td>
<td>.217</td>
</tr>
<tr>
<td>2</td>
<td>To meet building regulations</td>
<td>2.868</td>
<td>0.085</td>
<td>.919</td>
</tr>
<tr>
<td>3</td>
<td>To reduce the energy consumption of the existing building</td>
<td>2.968</td>
<td>1.294</td>
<td>.277</td>
</tr>
<tr>
<td>4</td>
<td>To increase the stability of the existing building</td>
<td>3.608</td>
<td>7.082</td>
<td>.001</td>
</tr>
<tr>
<td>5</td>
<td>For implementation of sustainable building practices</td>
<td>3.946</td>
<td>22.768</td>
<td>.001</td>
</tr>
<tr>
<td>6</td>
<td>To change the function of the existing building</td>
<td>3.753</td>
<td>10.312</td>
<td>.001</td>
</tr>
<tr>
<td>7</td>
<td>To avoid building obsolescence</td>
<td>3.807</td>
<td>22.927</td>
<td>.001</td>
</tr>
<tr>
<td>8</td>
<td>Expansion for more space in the existing building</td>
<td>3.494</td>
<td>4.058</td>
<td>.019</td>
</tr>
<tr>
<td>9</td>
<td>To increase building aesthetics</td>
<td>3.500</td>
<td>4.629</td>
<td>.011</td>
</tr>
<tr>
<td>10</td>
<td>Update existing building to modern standard</td>
<td>3.223</td>
<td>3.848</td>
<td>.023</td>
</tr>
<tr>
<td>11</td>
<td>To reduce the adverse impact of the existing building on the environment</td>
<td>3.560</td>
<td>4.627</td>
<td>.011</td>
</tr>
<tr>
<td>12</td>
<td>Alteration for the elderly disabled</td>
<td>3.343</td>
<td>.448</td>
<td>.640</td>
</tr>
<tr>
<td>13</td>
<td>To increase the internal comfortability of the existing building</td>
<td>3.175</td>
<td>1.107</td>
<td>.333</td>
</tr>
</tbody>
</table>

Inferring from the post-hoc tests for dependent variable ‘To increase the stability of the existing building’ scores for respondent groups tenant and building owner differ significantly (.007), Tenant and construction professionals also differ significantly (.003), whilst building owner and construction professional does not differ significantly (.960). Similarly, for ‘For building sustainability’, tenant with the other two groups differ significantly (.000) whilst building owner and construction professional does not differ significantly (.102). Notably, for dependent variable ‘To increase building aesthetics’, only construction professionals are statistically significantly different from one another. Similar inferences for ‘To reduce the adverse impact of building on the environment’, only group tenant and construction professional differ significantly in terms of their scores.

DISCUSSION

In recent years, the idea of “retrofitting” has garnered more attention within policy agendas and research in the existing urban environments (Dixon and Eames, 2013). As the availability of land becomes scarce, there is an occasional demand to produce new and improved sustainable buildings which requires the demolition of existing buildings. Nonetheless, retrofitting and adaptation plays a major role in regenerating the built environment (Bullen and Love, 2009). Some global cities such as New York and London are making a lot of progress on adaptation. It is therefore necessary to build the capacity of organization and research institutes to create the support for retrofitting and adaptation of existing buildings (Carter et al., 2015). Discussed below are the drivers that pushes the move for retrofitting and adaptation of existing buildings in Ghana.

Increasing the Stability of the Existing Building

According to Wilkinson and Remoy (2011), in the adaptation of a building the physical attribute has an impact and should be considered in decision making. The stability of an existing building becomes imperative when a rehabilitation or renovation works are to be done. Many buildings collapse when being worked on, therefore, it becomes important to stabilise buildings when the thought of retrofitting and adaptation comes to play.
Buildings need to be repaired and replaced if worn out. They can accommodate new technologies when issues with the stability of the building are resolved (Bullen and Love, 2009). Stability therefore becomes an important factor when any adoption or retrofitting is to be done.

**Implementation of Sustainable Building Practices**

Retrofitting and adaptation supports the concept of sustainability as it extends the useful life of existing buildings bringing down pollution, energy consumption, transport, and materials. To improve the sustainability of buildings, adaptation is becoming a recognised strategy which is effective for improving existing buildings with sustainability (Bullen, 2007; Bullen and Love, 2009; Yung and Chan, 2012). According to Remøy and van der Voort (2014), the main drive in Australia that pushes a buildings adaptation is sustainability as its implementation contributes significantly to sustainability (Conejos et al., 2016). Many existing buildings lack sustainable components and as the world moves to a sustainable era, it becomes needed to implement these practices into the existing buildings in Ghana.

**Increasing Building Aesthetics**

The need to improve the aesthetics of existing buildings are driven by a building user’s changing preference to adaptive re-use which gives life to poor quality buildings visually (Bullen and Love, 2009). According to Bruce et al., (2015), architects are encouraged in their design of low grade structures to introduce architectural appeal in the recycling of existing buildings.

**Reduce the Adverse Impact of Building on the Environment**

According to the Australian Government, a strategy must be implemented to retrofit buildings in the wake of reducing environmental impact. Adaptive re-use reduces environmental loading addressing the environment gap by improving a buildings performance over its lifespan and greenhouse emissions (Bullen and Love, 2009; Yung and Chan, 2012). Low et al., (2014) suggest that there is a positive impact on the environment when existing buildings are retrofitted. The environment needs to be protected and reducing environmental impact has become a necessity because of the need to protect the earth. Many buildings being designed are incorporating amenities that has a low impact on the environment and as such existing buildings are being retrofitted to reduce the negative impact it has on the environment.

**Changing the Function of the Existing Building**

Buildings fall below expectations as it appreciates in years, their commercial performance and operations also decreases which constantly affects changing market demands (Bullen and Love, 2010). There has been a change of the function of buildings for several reasons in many cities (Kincaid, 2000). The function of many existing buildings is changing in the wake to make room or space to accommodate the increasing number of people in the urban cities of Ghana.

**Update Existing Building to Modern Standard**

For existing or old buildings to accommodate new technologies there is the need to adapt or retrofit the buildings to modern edifices (Bullen and Love, 2009). Retrofitting buildings to modern ones contributes to greenhouse gas emissions reducing the risk of climate change (Bruce et al., 2015). New technology in these modern times has driven many existing buildings nonfunctional and redundant. Retrofitting these buildings an avenue to inculcate new technologies and improve the function of the building.
CONCLUSION

Adaptation and retrofitting has gained a lot of recognition because of its constant drive to support sustainability and the environment. The study explores the drivers that push for adaptation and retrofitting in Ghana. The Analysis of Variance was used to examine the causal relationship between respondents and their perceptions about the drivers of adaptation and retrofitting of existing buildings. Six variables were extracted: Increasing the stability of the existing building; Implementation of sustainable building practices; Increasing building aesthetics; Reduce the adverse impact of building on the environment; Changing the function of the existing building and Update existing building are discussed as the drivers that drive the adaptation and retrofitting of existing buildings in Ghana. These findings are also recommended for developing countries who share similar conditions with Ghana. Further studies are recommended to assess the challenges and process of adaptation and retrofitting of existing buildings in Ghana.

REFERENCES


Drivers of Adaptation and Retrofitting


Amoah, Kissi and Oteng


FAKE NEWS: A FURTHER INVESTIGATION OF THE VALIDITY OF DATA AND METHODS USED TO COMPARE INDUSTRY PERFORMANCE BETWEEN COUNTRIES

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In June 2012 the Business Council of Australia (BCA) claimed that it cost considerably more to build a variety of types of infrastructure in Australia than in the USA. A preliminary investigation of the methods used to arrive at this conclusion showed that the results could be reversed by using a different method and/or different published cost data from other sources. The analysis presented here repeats that investigation using data from more sources and from two years (2014 and 2017) following the release of that report. The results show that not only is it necessary for people who make such comparisons to have a much better understanding of the underlying theory of international cost and price comparisons, specifically of the role of purchasing power parity, but also that greater care is needed in relation to the data used. It is possible that the 2012 BCA report was driven by vested interests for whom showing the Australian industry in a poor light was advantageous, and it was concerning that data published by a leading international construction consultancy may have been improperly used to produce a desired result rather than an evidence-based result. The author argues for more rigour in these comparisons and for wider recognition of the need for more education in purchasing power parity and cost comparisons in the built environment disciplines.

Keywords: purchasing power parity, international comparisons, industry performance

INTRODUCTION

In 2012 the Business Council of Australia (BCA) published a report (BCA 2012) claiming that, compared with the US, airports in Australia were 90% more expensive to build, with hospitals 62%, shopping centres 43% and schools 26% more expensive. The claims were reported in the national press (Hepworth 2012; Forrestal and Dodson 2012) and publicly referred to by at least one minister in the Australian government. The report appeared at a time when there was considerable conflict between building trade unions and government at both state and national level. Such conflict is ongoing (see, for example, Marin-Guzman 2018) and responsibility for apparent cost and productivity issues in the construction industry in Australia is often attributed to the building unions and any evidence that can be used to attach blame to the unions is welcomed by their opponents. It must be emphasised that there is no evidence to suggest that the BCA report was deliberately manipulated to provide support to any group it did give the anti-union bloc some useful ammunition. This could have been no more than coincidence but, as is shown in the following analysis and discussion, had the BCA analysis been done

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with more rigour and/or a greater understanding of the complexity of such comparisons, the results would not have favoured one side or other.

Best (2012) analysed the BCA report; he considered both the validity of the method used and the reliability of the data. While the data came from a reputable source (Turner and Townsend 2012), Best showed that using data from other equally reputable sources produced different results and he concluded that there were two basic flaws in the method. The first related to comparing what were treated as identical buildings in the two countries when in fact the data used was for functionally similar buildings rather than identical buildings (the building types referred to may vary considerably not only between the two countries but within each country - while the report talked of infrastructure, the examples used: hospitals, and schools and so on, are social infrastructure and as such are basically buildings). The second related to the use of money market exchange rates to convert construction costs to a common currency rather than using purchasing power parities (PPPs); the substantial impact of changes in exchange rates on comparisons of this type has been demonstrated many times (e.g. Best 2008:21; Best 2012:84).

THE BCA REPORT

The method used for the BCA report was straightforward and appropriate and the same method was used to produce the results presented in this paper. In general terms it is not the method that is the problem; the problems lie in the implementation of the method and the data used. The basic approach takes the average cost to build certain types of buildings in two countries, converts the cost in one country to the currency of the other to enable direct cost comparisons, and then differences in cost are computed.

Best (2012) used the same method but made two important changes in implementation: one was to use purchasing power parities (PPPs) to convert costs from AUD to USD, the second was to feed data from other sources into the same numerical method. The following tables are reproduced from Best (2012). Table 1 shows the data used and the results quoted in the original BCA report; Table 2 shows the results produced using the same cost data but with AUD costs converted to USD using PPPs.

Table 1: 2011: Turner and Townsend data (T&T 2012), annual average exchange rate (0.97AUD=1USD) (x-rates.com 2012)

<table>
<thead>
<tr>
<th></th>
<th>US cost/m2 (USD)</th>
<th>Aust cost/m2 (AUD)</th>
<th>Aust cost/m2 (USD)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airport terminal</td>
<td>3550</td>
<td>6565</td>
<td>6757</td>
<td>+90%</td>
</tr>
<tr>
<td>Shopping centre</td>
<td>1560</td>
<td>2172</td>
<td>2235</td>
<td>+43%</td>
</tr>
<tr>
<td>Hospital</td>
<td>3300</td>
<td>5185</td>
<td>5337</td>
<td>+62%</td>
</tr>
<tr>
<td>School</td>
<td>1570</td>
<td>1919</td>
<td>1975</td>
<td>+26%</td>
</tr>
</tbody>
</table>

Table 2: 2011: Turner and Townsend data (T&T 2012), GDP PPP (1.56AUD=1USD) (OECD 2012)

<table>
<thead>
<tr>
<th></th>
<th>US cost/m2 (USD)</th>
<th>Aust cost/m2 (AUD)</th>
<th>Aust cost/m2 (USD)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airport terminal</td>
<td>3550</td>
<td>6565</td>
<td>4208</td>
<td>+19%</td>
</tr>
<tr>
<td>Shopping centre</td>
<td>1560</td>
<td>2172</td>
<td>1392</td>
<td>-11%</td>
</tr>
<tr>
<td>Hospital</td>
<td>3300</td>
<td>5185</td>
<td>3323</td>
<td>negligible</td>
</tr>
<tr>
<td>School</td>
<td>1570</td>
<td>1919</td>
<td>1230</td>
<td>-22%</td>
</tr>
</tbody>
</table>

Using PPP produced very different results with only the airport terminal appearing to be more costly in Australia. As airport terminal size and design varies considerably from
project to project it is arguable that the airport example is not appropriate in any case; even it were, the cost difference is a far cry from the 90% quoted by the BCA. It is also worth noting the BCA report talks of ‘airports’ while the Turner and Townsend data is for ‘airport terminals’.

Best (2012) compared outcomes using cost data for a number of building types from three different sources (Davis Langdon, Rawlinsons and Turner and Townsend) and from two years (2008 and 2011). Currency conversions were made using annual average exchange rates (i.e. in the same way that the BCA report converted costs) and PPPs. In all cases results varied, with comparative costs showing differences between US and Australian costs ranging from +89% to -69%, but with an average result being that building in Australia appeared to be generally less costly. Table 3 shows the results for five building types using Davis Langdon data and PPPs for currency conversion; in all cases Australian costs appear to be lower than the US costs and in four out of five cases the difference is 50% or more.

Table 3: 2011: Davis Langdon (2012) data, GDP PPP (1.56AUD=1USD) (OECD 2012)

<table>
<thead>
<tr>
<th>Building Type</th>
<th>US cost/m2 (USD)</th>
<th>Aus cost/m2 (AUD)</th>
<th>Aus cost/m2 (USD)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shopping centre</td>
<td>3033</td>
<td>2353</td>
<td>1508</td>
<td>-50%</td>
</tr>
<tr>
<td>Hotel (three star)</td>
<td>2183</td>
<td>3036</td>
<td>1946</td>
<td>-11%</td>
</tr>
<tr>
<td>School</td>
<td>3267</td>
<td>1600</td>
<td>1026</td>
<td>-69%</td>
</tr>
<tr>
<td>Hospital</td>
<td>7033</td>
<td>3771</td>
<td>2417</td>
<td>-66%</td>
</tr>
<tr>
<td>Light duty factory</td>
<td>1267</td>
<td>637</td>
<td>408</td>
<td>-68%</td>
</tr>
</tbody>
</table>

General Observations

The variation is published costs is immediately apparent, e.g. Davis Langdon's US costs for schools, hospitals and shopping centres are around double those suggested by T&T. While this appears to be a major problem it probably is not, as long as the basis for the cost data from any one source is consistent between countries, i.e. as long as (say) T&T data is compared to T&T data and what is included/excluded in the costs from different locations is the same.

Whether it is even valid to talk of 'US' and 'Australian' construction costs at all is questionable. Both countries are large and there are significant differences in construction costs in different cities. AECOM (2014:100) shows cost indices ranging from 77 (Atlanta) to 136 (New York) with Los Angeles as a base with an index of 100. The same publication (at 75) shows a smaller range for Australian cities with a low of 92 for Brisbane, a high of 115 for Darwin with Sydney (100) as the base. These differences are significant so any attempt to identify any sort of national cost requires averages of averages.

In 2012 GDP level PPPs were used in lieu of construction-specific PPPs and historically there had been little difference between the two for Australia; in the 2014 PPPs, however, the GDP figure was 1.45 while for construction it was only 1.36. In the following tables the PPP used is the construction-specific index published by the OECD (2015). Exchange rates have not been used for the reasons noted earlier.
Best

Some Comparisons
In this section some examples of different comparisons from 2014 and 2017 are presented. As published cost data varies in many ways from source to source only pairwise comparisons are presented so that comparisons in each example are based on data from only one source. Costs have been restricted to three reasonably generic building types: Grade A offices, three-star tourist hotels and medium standard multi-unit residential, and where costs are published as ranges (e.g. RLB 2014) the median has been used. To avoid the problems of questionable national average costs the comparisons are between the cities typically chosen as the base in each country, i.e. Los Angeles and Sydney; T&T publish costs for three other US cities, including Seattle, but not for Los Angeles; Seattle costs, however, are shown by AECOM (2014:100) to be close to parity with Los Angeles.

Table 4: 2014: RLB (2014), Construction PPP (1.36AUD=1USD)

<table>
<thead>
<tr>
<th>Sydney/Los Angeles</th>
<th>LA cost/m² (USD)</th>
<th>Sydney cost/m² (AUD)</th>
<th>Sydney cost/m² (USD)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotel - three star</td>
<td>2558</td>
<td>4450</td>
<td>3272</td>
<td>+28%</td>
</tr>
<tr>
<td>Grade A office - high rise</td>
<td>1882</td>
<td>2775</td>
<td>2040</td>
<td>-9%</td>
</tr>
<tr>
<td>Residential - multi-storey</td>
<td>2475</td>
<td>3175</td>
<td>2335</td>
<td>-6%</td>
</tr>
</tbody>
</table>

Table 5: 2014: Rawlinsons (2015), Construction PPP (1.36AUD=1USD)

<table>
<thead>
<tr>
<th>Sydney/Los Angeles</th>
<th>LA cost/m² (USD)</th>
<th>Sydney cost/m² (AUD)</th>
<th>Sydney cost/m² (USD)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotel - three star</td>
<td>2105</td>
<td>3855</td>
<td>2835</td>
<td>+35%</td>
</tr>
<tr>
<td>Grade A office - high rise</td>
<td>1948</td>
<td>3345</td>
<td>2460</td>
<td>+26%</td>
</tr>
<tr>
<td>Multi-unit residential - medium standard</td>
<td>1718</td>
<td>2208</td>
<td>1624</td>
<td>+38%</td>
</tr>
</tbody>
</table>

Table 6: 2014: AECOM (2014), Construction PPP (1.36AUD=1USD)

<table>
<thead>
<tr>
<th>Sydney/Los Angeles</th>
<th>LA cost/m² (USD)</th>
<th>Sydney cost/m² (AUD)</th>
<th>Sydney cost/m² (USD)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotel - three star</td>
<td>2433</td>
<td>3230</td>
<td>2375</td>
<td>-2%</td>
</tr>
<tr>
<td>Grade A office - high rise</td>
<td>3552</td>
<td>3120</td>
<td>2294</td>
<td>-35%</td>
</tr>
<tr>
<td>High rise residential - medium quality</td>
<td>4101</td>
<td>2810</td>
<td>2066</td>
<td>-50%</td>
</tr>
</tbody>
</table>

Table 7: 2014: T&T* (2013; 2015), Construction PPP (1.36AUD=1USD)

<table>
<thead>
<tr>
<th>Sydney/Seattle</th>
<th>Seattle cost/m² (USD)</th>
<th>Sydney cost/m² (AUD)</th>
<th>Sydney cost/m² (USD)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotel - three star</td>
<td>2015</td>
<td>2375</td>
<td>1747</td>
<td>-13%</td>
</tr>
<tr>
<td>Grade A office - high rise</td>
<td>2220</td>
<td>3070</td>
<td>2257</td>
<td>+2%</td>
</tr>
<tr>
<td>High rise residential</td>
<td>1955</td>
<td>2570</td>
<td>1890</td>
<td>-3%</td>
</tr>
</tbody>
</table>

*2014 costs are averages from T&T 2013 and 2015.
Tables 4-7 illustrate the complexity of the problem. Using cost data from four sources, three of them being large international organisations, and the one conversion method, a PPP index specific to construction, has produced a broad spread of results. One example is sufficient to highlight the difficulties: using the four sets of data shows the relative cost of Grade A high rise offices ranging from Sydney being 35% less expensive to 26% more expensive compared to Los Angeles, with little consistency in results generally. While the range for residential is larger, there is less certainty of consistency of building type across the sources as some cost sources note 'high-rise' while others only note 'multi-unit'.

If the differences are averaged for each building type the average cost differences for Sydney compared to LA/Seattle are offices +0.5%, residential -5.25% and hotels +12%. These results suggest that rather than Australian costs being much higher than US costs, they are about the same on average. Again, this is very different to the results presented in the original BCA report (Table 1) but not too different to the results shown in Table 2, where the average cost difference across the different building types was -3.5%.

Similar comparisons were made using 2017 data (see Appendix) and the average differences were +8% for offices, +11% for high-rise residential and -53% for light industrial (factory/warehouse); the latter building type was used in lieu of three-star hotel due to the questionable data published by AECOM for hotels (see Table 8 and subsequent discussion).

DISCUSSION

Best (2012) suggested that the two major problems in the BCA methodology were the use of exchange rates and the direct comparison of functionally similar but not identical buildings; subsequently the same author looked further at the question of the data used in some comparative studies and identified additional problems (Best 2013). These three points are explored further below. It has been recognised for some years that the volatility of money market (nominal) exchange rates makes them an inappropriate basis for cost conversions when cost information is collected in different currencies and the goal is to explore the question: 'is construction more or less expensive in A or B?' Some form of purchasing power parity is generally considered to be more appropriate, however, the choice of conversion method will make little difference if the data is unreliable. As the comparisons presented here show, the data on international construction costs, even between two large cities in two industrialised countries, can vary considerably. Some recent comparative data published by AECOM (2017a; 2017b) contains some significant anomalies as Table 8 shows.

Table 8: Selected construction cost data: Sydney and Los Angeles (AECOM2017a:52)

<table>
<thead>
<tr>
<th>Sydney/Los Angeles</th>
<th>LA cost/m2 (USD)</th>
<th>Sydney cost/m2 (USD)*</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average standard offices - high rise</td>
<td>4000</td>
<td>4258</td>
<td>+7%</td>
</tr>
<tr>
<td>Light duty factory</td>
<td>1400</td>
<td>760</td>
<td>-46%</td>
</tr>
<tr>
<td>Average multi-unit high rise residential</td>
<td>3600</td>
<td>3420</td>
<td>-5%</td>
</tr>
<tr>
<td>3 Star budget hotel (USD per key)</td>
<td>75000</td>
<td>347199</td>
<td>+363%</td>
</tr>
</tbody>
</table>

*Costs for Sydney were converted to USD by AECOM using the current exchange rate

This small selection shows high rise office and residential costs to be similar while the cost of an industrial building in Sydney is nearly twice that in Los Angeles, and a three-
Best

star hotel in Sydney apparently costs several times as much as one in LA. By comparison, AECOM's 2014 Blue Book suggests USD2432/m² for LA and AUD3230/m² for Sydney for three-star hotels and USD1345/m² and AUD675/m² for light industrial; regardless of how the AUD to USD conversion is made the large difference in cost variance for hotels between 2014 and 2017 makes little sense and suggests that the data is simply wrong. The variance for the industrial building is, however, similar for all four sources used here with the cost of light industrial buildings being considerably lower in Sydney than in the US cities (LA and Seattle). This suggests that further examination of the data may reveal differences in inclusions, regulations, and/or structural systems, or perhaps other locational differences, that could account for the difference as it is not readily apparent why a relatively simple building type should show such a large cost differential when other building types appear to cost about the same in the two locations. This illustrates a basic problem that characterises international comparisons, where some balance has to be found between costing identical buildings, which may not be typical of buildings in all places, and functionally similar buildings, which may serve the same purpose but are clearly not truly comparable. In fact, it highlights the reasoning behind the adoption of a basket of construction resources/inputs as the basis of international comparisons rather than the standard projects approach that has often been used in the past (see, for example, various chapters in Best and Meikle 2015 for discussion of a range of comparison methods).

It is arguable that a large part of the problem that is explored here is that there is little education of professionals, such as quantity surveyors, in the complexities of international cost comparisons, although they are operating in an increasingly globalised marketplace. Even where the aim is to compare costs in two places at a point in time for a client paying for construction in another country, when exchange rates may be the appropriate currency conversion method (see T&T 2017:94-96), the considerable differences in cost data published by different firms demonstrate that cost consultants should be cautious when providing clients with indicative costs outside their own country. It is difficult, if not impossible, to validate cost data provided by contributors in different countries even where those contributors are part of a single organisation (Emmett and Langston 2018).

One final point should be made about the BCA report. In that report it was suggested that, in comparison to the US, it was not only more expensive to build in Australia, but that Australia's construction productivity was lower. This claim was based on the cost differences alone; apart from the questionable conclusion that Australian costs are in fact higher, this is fundamentally wrong. Higher project cost does not automatically equate to lower productivity as the higher cost could be a result of nothing more than higher material costs, and there are other things such as higher labour costs due to (for example) Australia's compulsory employer-paid superannuation scheme, skills shortages in remote locations and any number of other factors that could result in higher costs that have little or no impact on productivity (see also Best 2013 for a three-way method for comparing construction productivity in different locations). This claim about lower productivity is another example of the lack of real understanding of the complexities of international construction cost and performance comparisons.

CONCLUSIONS

This analysis has highlighted a number of problems that have to be addressed if industry comparisons, particularly those that cross national boundaries, are to have any validity. Given that we have no way of knowing if any method or result is 'correct' it is suggested that multiple approaches be used to produce composite results, in a similar fashion to the
four-way comparisons presented here. Construction cost data should be treated with caution as it varies considerably, and in some cases appears to be wrong. The problems and variances in cost data can be the result of a number of factors, not the least of which is that collecting, and publishing such data is an expensive process. A few large firms such as Turner and Townsend and Rider Levett Bucknall have done this for some years and continue to do so but others do not; AECOM, for example, no longer produces its Blue Book. Such publications are produced for marketing purposes as much as anything and while the aim is to gather consistent and reliable data the truth is that the cost of such exercises may outweigh the benefit to the firms and the additional cost associated with greater rigour and better data validation is a deterrent. In general terms, however, more education in the complexities of these issues could at least lead to a deeper understanding of the problem and thus to better advice being given to clients. Importantly, it could foster more robust examination of claims such as those made in the BCA report.

APPENDIX

Due to the unexplained anomaly in the cost for three-star hotel published by AECOM (discussed in the body of this paper) that building type has been replaced by 'light industrial' in the following comparisons. As construction-specific PPPs are not published on a regular basis there is no index available for 2017; however, the GDP-level PPP for Australia varied only slightly (from 1.45 to 1.49) between 2014 and 2017 so the 2014 construction PPP has been used here.

Table A1: 2017: RLB (2017), Construction PPP (1.36AUD=1USD)

<table>
<thead>
<tr>
<th>Sydney/Los Angeles</th>
<th>LA cost/m² (USD)</th>
<th>Sydney cost/m² (AUD)</th>
<th>Sydney cost/m² (USD)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse/factory</td>
<td>1508</td>
<td>945</td>
<td>591</td>
<td>-61%</td>
</tr>
<tr>
<td>Grade A office - high rise</td>
<td>2178</td>
<td>3250</td>
<td>2390</td>
<td>+8%</td>
</tr>
<tr>
<td>Residential - multi-storey</td>
<td>2530</td>
<td>4000</td>
<td>2941</td>
<td>+16%</td>
</tr>
</tbody>
</table>

Table A2: 2017: Rawlinsons (2018), Construction PPP (1.36AUD=1USD)

<table>
<thead>
<tr>
<th>Sydney/Los Angeles</th>
<th>LA cost/m² (USD)</th>
<th>Sydney cost/m² (AUD)</th>
<th>Sydney cost/m² (USD)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse/factory</td>
<td>920</td>
<td>630</td>
<td>463</td>
<td>-50%</td>
</tr>
<tr>
<td>Grade A office - high rise</td>
<td>2045</td>
<td>3378</td>
<td>2484</td>
<td>+22%</td>
</tr>
<tr>
<td>Multi-unit residential - medium standard</td>
<td>1235</td>
<td>2250</td>
<td>1655</td>
<td>+34%</td>
</tr>
</tbody>
</table>

Table A3: 2017: AECOM (2017a), Construction PPP (1.36AUD=1USD)

<table>
<thead>
<tr>
<th>Sydney/Los Angeles</th>
<th>LA cost/m² (USD)</th>
<th>Sydney cost/m² (AUD)</th>
<th>Sydney cost/m² (USD)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse/factory</td>
<td>1400</td>
<td>996</td>
<td>623</td>
<td>-56%</td>
</tr>
<tr>
<td>Grade A office - high rise</td>
<td>4000</td>
<td>5578</td>
<td>4101</td>
<td>+3%</td>
</tr>
<tr>
<td>High rise residential - medium quality</td>
<td>3600</td>
<td>4480</td>
<td>3294</td>
<td>-9%</td>
</tr>
</tbody>
</table>
**Table A4: 2017: T&T (2017), Construction PPP (1.36AUD=1USD)**

<table>
<thead>
<tr>
<th>Sydney/Seattle</th>
<th>Seattle cost/m² (USD)</th>
<th>Sydney cost/m² (AUD)</th>
<th>Sydney cost/m² (USD)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse/factory</td>
<td>1076</td>
<td>820</td>
<td>603</td>
<td>-44%</td>
</tr>
<tr>
<td>Grade A office - high rise</td>
<td>2476</td>
<td>3350</td>
<td>2463</td>
<td>negligible</td>
</tr>
<tr>
<td>High rise residential</td>
<td>2099</td>
<td>2950</td>
<td>2169</td>
<td>+3%</td>
</tr>
</tbody>
</table>

**REFERENCES**


Best, R (2013) The productivity puzzle: Is it just about the data? *38th AUBEA Conference, 20-22nd November*, University of Auckland, Auckland, New Zealand


THE INFLUENCE OF SAFETY LEADERSHIP, SOCIAL SUPPORT, AND PSYCHOLOGICAL CAPITAL ON CONSTRUCTION SAFETY CLIMATE

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Safety climate refers to employees’ perceptions of their work environment in relation to safety. Over the past 30 years, much research focuses on validating safety climate as a leading indicator of safety outcomes. Relatively little attention has been paid to the antecedents of safety climate and studying safety climate as a multi-level construct. This missing piece of knowledge could hinder the development of effective interventions to improve safety climate. This longitudinal study addresses this issue by examining how safety leadership, social support, and psychological capital, and organizational-level safety climate could affect group-level safety climate. The study sample consisted of 281 construction professionals from a large U.S construction firm using online survey responses. The results of the structural equational modelling analysis showed that safety leadership, social support and organizational-level safety climate significantly contribute to group-level safety climate. In addition, psychological capital moderates the relationship between social support and group-level safety climate. The findings imply that supervisory safety leadership is particularly important to cultivate group-level safety climate, and organisations are recommended to enhance employees’ levels of psychological capital in order to strengthen the effect of social support on group-level safety climate.

Keywords: safety climate, psychological capital, structural equation modelling

INTRODUCTION

Safety climate refers to employees’ perceptions of their work environment in relation to safety. It has been recognised as a leading indicator of various safety-related outcomes (Glendon and Clarke, 2015, 256). For example, a positive safety climate could support employees in making safety suggestions, and prevent them from engaging in unsafe acts and subsequent injuries (Beus et al., 2010; Clarke, 2010; Johnson, 2007). In addition, Cheyne et al., (1998) found that positive safety climate strengthened safety-related organisational citizenship behaviours including involvement in safety activities.

Ever since the publication of the original study by Zohar (1980) that defined, measured and tested safety climate, many studies have validated safety climate as a predictor of safety outcomes (Zohar, 2010). Little has been done on investigating its relationships with antecedents, moderators and mediators. In addition, although Zohar and Luria

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(2005) proposed a multi-level model that measures group-level and organisational-level of safety climate to depict the interdependence between individuals, team and management in creating safety climate, limited safety climate research has been conducted using the model (Glendon and Clarke, 2015, 257). Without narrowing these knowledge gaps, it can hinder the development of effective interventions for enhancing safety climate and thus safety performance. Against this backdrop, this study examines how safety leadership, social support, and psychological capital, and organizational-level safety climate affect construction professionals' perceptions of group-level safety climate.

**Literature Review and Hypotheses**

**Safety Climate**

Safety climate has been defined as “individual perceptions of policies, procedures, and practices relating to safety in the workplace” (Neal and Griffin, 2006, 947). It reflects employee’s perceptions of the priority placed on safety relative to other goals (e.g. production) in their work environments (Zohar, 1980).

According to Zhang et al., (2015), many safety climate studies in the construction industry used “organisation” as the unit of analysis. The underlying assumption is that employees share homogenous perceptions of all safety issues within an organisation. However, this assumption has been challenged. There is growing recognition that safety climate can be linked to different levels of managerial response and therefore should be interpreted as a multilevel concept (Zohar, 2000; Zohar and Luria, 2005). Zohar (2000) claimed that the top management of an organisation establishes formal policies and procedures, while supervisors at lower organisational levels implement the procedures using context-specific action directives. Due to supervisors’ discrepant interpretations and implementations of formal procedures, employees of different groups are likely to perceive supervisory practices differently. Therefore, employees’ perceptions of safety climate can be formed at two levels, i.e. organisational-level safety climate relating to formal policies and procedures, and group-level safety climate relating to supervisory practices. Zohar (2000) tested this proposition in a manufacturing context and confirmed that workgroup members differentiate between perceptions of the organisation’s safety climate and the workgroup’s safety climate.

Zohar and Luria (2005) maintained that although supervisory discretions lead to between-group variations, the variations are limited to certain extent. This is because the policies and procedures developed at the organisational level have set the limit or scope for permissible group-level interpretations. In this sense, organisational-level and group-level safety climate should be aligned, suggesting that the organisational-level safety climate predicts group-level safety climate (Zohar and Luria, 2005). The positive relationship between organisational-level safety climate and group-level safety climate has been supported by empirical research evidence (e.g. Melia et al., (2008), Lingard et al., (2012)).

**Hypothesis 1**: Organisational-level safety climate is positively related to group-level safety climate

**Supervisory Safety Leadership**

Recently, there has been an increasing interest in the impact of supervisory leadership styles and behaviours on safety-related performance and outcomes. Barling et al., (2002) claimed that supervisory leadership provides an opportunity for enhancing workplace safety that goes beyond ergonomic design of facilities or regulatory approaches. The two
most studied leadership styles in the safety leadership literature are transactional and transformational leadership. According to Bass (1985), transformational leaders engage subordinates by making them more aware of the value of task outcomes, by activating their higher-order needs, and by inducing them to transcend self-interest for the sake of the organisation; while transactional leaders identify actions to be taken to achieve desired goals, clarify role and task requirements, and develop monitoring and rewarding systems relating to those goals.

Most studies have focused on the role of transformational leadership, however, research evidence shows that transformational and transactional leadership styles can impact safety in different ways (Clarke, 2013). Hoffmeister et al., (2014) reported that although the transformational leadership aspects of idealised attributes and idealised behaviours consistently emerged as the most important predictors of multiple safety outcomes, the transactional leadership aspect of contingent reward also had some influence on safety climate and safety behaviours. Zohar (2002a) also found that contingent reward has demonstrated positive effects on safety outcomes, leading to reduced injury. Consistent with this, Barling et al., (2002) proposed the construct of safety-specific transformational leadership (SSTL), which consists of four components of transformational leadership (i.e. idealised influence, inspirational motivation, intellectual stimulation, individualised consideration) and contingent reward. Leaders who demonstrate SSTL are expected to "take an active and inspirational approach to safety issues, serving as good models of safety behaviour and encouraging others to work in a safe manner" (Kelloway et al., 2006, p78).

Zohar (2002b) argued that a supervisor’s leadership behaviours provide the source for group members to ascertain the supervisor’s concern for members’ welfare and the priority that the supervisor places on safety. This ascertainment then informs members’ perceptions of group-level safety climate. It is expected that supervisors who demonstrate SSTL will have a positive impact on the formation of group-level safety climate through demonstrating their high commitment to safety (i.e. idealized influence); motivating group member to achieve high levels of safety standards (i.e. inspirational motivation); encouraging group members to think out of box to improve safety performance (i.e. intellectual stimulation); showing real concern about members’ safety and wellbeing (individualised consideration); and recognizing and rewarding good safety behaviours (contingent reward). Many studies have empirically revealed a positive relationship between supervisor's safety-specific transformational leadership and employees' perceptions of safety climate (e.g. Barling et al., 2002; Clarke, 2013; Kelloway et al., 2006; Mullen and Kelloway, 2009). Consistent with the research evidence, it is hypothesised that:

H2: Supervisor’s safety-specific transformational leadership (SSTL) is positively related to group-level safety climate.

Social Support

Social support has long been examined as a psychological factor that affects personal wellbeing or workplace health and safety (Karasek and Theorell, 1990). Social support concerns the perceptions of "overall levels of helpful social interaction available on the job" (Karasek and Theorell, 1990, p69). Social support can be provided by top management, supervisors or co-workers.

Hofmann and Morgeson (1999) suggest that social support can be interpreted from the perspective of social exchange. Social exchange engenders individuals’ feelings of
personal obligation, gratitude and trust, and is characterized by norm of reciprocity (Blau, 1984). In light of social exchange principle, one party’s favour would lead to another party’s positive action in return. In the context of safety, if employees perceive that management and co-workers emphasize the importance of safety, and care their safety and well-being, employees would reciprocate with more positive safety perceptions, more safety compliance as well as safety citizenship behaviours. For example, Kath et al., (2010) reported that when railway workers perceive top management’s positive attitudes toward safety and supervisory support, they feel more motivation to raise safety issues with their supervisors. DeJoy et al., (2010) discovered that the exchange relationship between organisation and employees (i.e. perceived organisational support (POS)) exerts direct impact on employees' perceptions of safety climate, which in turn affect perceived safety at work and self-reported accidents. DeJoy et al., (2004) also identified that perceived organisational support and co-workers support positively predict workers’ perceptions of safety climate in work environment. On the basis of the existing research evidence, it is hypothesised that:

**H3: Social support is positively related to group-level safety climate**

**Psychological Capital (PsyCap) as a Moderator**

PsyCap has emerged as a set of important personal resources studied in positive psychology (Donaldson and Ko, 2010) because it has strong positive impact on various desired work outcomes such as job satisfaction, organizational commitment, and work engagement (e.g., Simons and Buitendach, 2013). It is defined as an individual’s positive psychological state of development that can be cultivated and improved through training. PsyCap consists of four psychological resources: self-efficacy, optimism, hope and resilience (Luthans et al., 2004). A person high in PsyCap is characterized as: (1) having the confidence (self-efficacy) to put in necessary effort to complete challenging tasks; (2) making positive attributions (optimism) about succeeding now and in the future; (3) persevering toward goals, and redirecting paths to goals (hope) to succeed whenever necessary; and (4) bouncing back and even beyond original states (resilience) to achieve success when encountering adversity.

In the context of safety, Eid et al., (2012) suggested that PsyCap as a positive motivational state that facilitate safety focused behaviours and outcomes in organisations. Empirical research evidence shows that PsyCap is positively associated with perceptions of safety climate among air traffic controllers (Bergheim et al., 2013). Eid et al., (2012) further argued that the social context of workplace is constructed through individual behaviours (e.g. supervisory leadership behaviours) and social interactions between individuals (e.g. social support), positive worker motivation in the form of PsyCap may present a significant personal resource in further promoting safety outcomes (e.g. safety climate). In other words, PsyCap may reinforce the influence of supervisory leadership and social support on safety climate. Therefore, it is hypothesised that:

H4: PsyCap moderates the relationship between SSTL and group-level safety climate;

H5: PsyCap moderates the relationship between social support and group-level safety climate.
RESEARCH METHODS

Measures

As all the factors in the research model are latent variables that cannot be measured directly. Previous literature developed survey questions to measure them indirectly. This study incorporated the established survey questions as shown in table 1 to validate the research model.

Table 1: Measurement scales

<table>
<thead>
<tr>
<th>Variable</th>
<th>Name of construct</th>
<th>No. of questions</th>
<th>Point of Scales</th>
<th>Sample questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Safety Climate: Organisational level</td>
<td>Organisational-level Safety Climate Questionnaire, Zohar and Lucie (2005)</td>
<td>16</td>
<td>5-point scale (completely disagree to completely agree)</td>
<td>“Top management in this company reacts quickly to solve the problem when told about safety hazards.”</td>
</tr>
<tr>
<td>2. Safety-Specific Transformational Leadership</td>
<td>Safety-specific transformational leadership scale, Droring (2002)</td>
<td>10</td>
<td>5-point scale (not at all to always)</td>
<td>“I show determination to maintain a safe work environment.”</td>
</tr>
<tr>
<td>3. Psychological Capital</td>
<td>Psychological Capital Questionnaire, Luthans et al. (2007)</td>
<td>24</td>
<td>6-point scale (strongly disagree to strongly agree)</td>
<td>“At the present time, I am energetically pursuing my work goals.”</td>
</tr>
</tbody>
</table>

Sample and Procedure

The data was collected in two phases from a large USA-based construction contractor. The first phase was completed in October 2016 collecting data of safety-specific transformational leadership, social support and psychological capital; the second phase was completed in March 2017 collecting data of safety climate both in organisational and group level. This longitudinal data collect method enables the study to draw causal inference between the dependent and independent variables after the completion of the
data analysis. By eliminating missing values and unengaged responses, and matching respondents in both phases, the total usable samples are 281, of which 90.7% (N=255) were male. Regarding job status, all participants are in managerial level positions with job titles distributed as follows: construction executive (3.6%, N=10), director (0.4%, N=1), executive (2.1%, N=6), manager (1.8%, N=5), project executive (11.0%, N=31), project manager (18.9%, N=53), safety director (1.4%, N=4), safety manager (4.6%, N=13), senior project manager (15.7%, N=44), senior safety manager (3.9%, N=11), senior superintendent (6.8%, N=19), senior vice president (2.1%, N=6), superintendent (18.1%, N=51), and vice president (9.6%, N=27).

Data analysis
To test our hypotheses, we employed structural equation modelling techniques. The first step involved validating the reflective measurement model using an exploratory factor analysis in SPSS 24 and then a confirmatory factor analysis in AMOS 24. The final step involves creating composite variables from latent variable scores in AMOS to test the structural model.

RESULTS
1. Measurement Model
We conducted exploratory (EFA) and confirmatory (CFA) factor analysis (using Maximum Likelihood) in order to establish the reliability and validity of our construct measurements. All loadings in the pattern matrix were above the 0.350 threshold recommended by Hair et al. (2013) with sample size greater than 250. All Cronbach’s alphas were above the recommended threshold of 0.700 for factor reliability (Fornell and Larcker, 1981). The total variance explained was 62.57% for the 12-factor model.

The CFA confirmed the factor structure established during the EFA and provided additional measures for validity and reliability. To establish convergent validity, the AVEs should be greater than 0.500 (Kline et al., 2012). We meet this threshold for all factors. To establish discriminant validity, the square root of the AVE should be less than any correlation with another factor. All of our factors achieve this criterion. Table 2 presents the correlations between factors, the AVE (average variance extracted) and CR (composite reliability). The square root of the AVEs are bold in the table.

<table>
<thead>
<tr>
<th></th>
<th>AVE</th>
<th>CR</th>
<th>SS</th>
<th>PsyCap</th>
<th>SSTL</th>
<th>SCG</th>
<th>SCO</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS</td>
<td>0.6579</td>
<td>0.8572</td>
<td>0.817</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PsyCap</td>
<td>0.5752</td>
<td>0.8428</td>
<td>0.498</td>
<td>0.758</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSTL</td>
<td>0.6815</td>
<td>0.9505</td>
<td>0.534</td>
<td>0.327</td>
<td>0.826</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCG</td>
<td>0.6569</td>
<td>0.9662</td>
<td>0.569</td>
<td>0.312</td>
<td>0.691</td>
<td>0.810</td>
<td></td>
</tr>
<tr>
<td>SCO</td>
<td>0.5051</td>
<td>0.9242</td>
<td>0.484</td>
<td>0.370</td>
<td>0.455</td>
<td>0.561</td>
<td>0.711</td>
</tr>
</tbody>
</table>

In addition, the measurement model achieve adequate goodness of fit, CMIN/DF = 1.675; CFI = 0.901; RMSEA=0.049; PCLOSE= 0.687; and SRMR = 0.052.

2. Structural Model
To test the hypotheses of the structural model, the structural model was evaluated by a set of fit statistics, and then the hypothesized dependence relationships in the model was evaluated using p-values and R squares. The structural models achieved adequate
goodness of fit, CMIN/DF = 1.573; CFI = 0.901; RMSEA = 0.045; PCLOSE = 0.997; SRMR = 0.052. The total variance explained is satisfactory for the endogenous variables: R^2 is 69% for group-level safety climate.

We found support for four of the five hypotheses. The positive effect of organisational-level safety climate (H1), safety-specific transformational leadership (H2) and social support (H3) on group-level safety climate was statistically significant. The interaction effect of PsyCap (H5) on the relationship between social support and group-level safety climate was also statistically significant. However, the interaction effect of PsyCap (H4) on the relationship between safety-specific transformational leadership and group-level safety climate was not statistically significant. Table 3 summarises these findings.

Table 3: Summary of hypothesis testing

<table>
<thead>
<tr>
<th>Factor</th>
<th>Standardised Beta</th>
<th>p-value</th>
<th>Hypothesis Testing Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCG ---- SCO</td>
<td>0.227</td>
<td>***</td>
<td>H1: Positive relationship (accepted)</td>
</tr>
<tr>
<td>SCG ---- SSTL</td>
<td>0.468</td>
<td>***</td>
<td>H2: Positive relationship (accepted)</td>
</tr>
<tr>
<td>SCG ---- S5</td>
<td>0.276</td>
<td>***</td>
<td>H3: Positive relationship (accepted)</td>
</tr>
<tr>
<td>SCG ---- SSTL X PsyCap</td>
<td>0.017</td>
<td>0.726</td>
<td>H4: Interaction effect (rejected)</td>
</tr>
<tr>
<td>SCG ---- S5 X PsyCap</td>
<td>0.133</td>
<td>0.013</td>
<td>H5: Interaction effect (accepted)</td>
</tr>
</tbody>
</table>

DISCUSSION

The present study revealed a significant positive relationship between organisational-level safety climate and group-level safety climate, suggesting the cascading influence of top management safety attitude and behaviours on lower level safety climate. This result is consistent with previous research evidence that organisational safety response is strongly related to supervisor safety response (Melia et al., 2008). The result suggests that it is important for top management to demonstrate a strong commitment to safety as their commitment to safety will be translated into safety values and practices by supervisors within workgroups, producing an impact on safety at the operational level (Lingard et al., 2012).

Consistent with previous research (e.g. Barling et al., 2002; Kelloway, et al., 2006), supervisor's safety specific transformational leadership (SSTL) is found to have a significant positive influence on group-level safety climate. This result highlights the importance of developing effective safety leadership behaviours of supervisors. Previous research has indicated that supervisory safety leadership can be enhanced through leadership interventions or training programs. For example, Mullen and Kelloway (2009) demonstrated that a safety specific transformational leadership training program improved managers' self-efficacy, intention to promote safety and safety attitude, as well as enhanced employees' perceptions of managers' safety leadership and safety climate. Zohar (2002b) and Zohar and Luria (2003) conducted intervention-based studies, and illustrated that the interventions designed to develop supervisors' safety leadership behaviours significantly improved employees' safety climate perceptions and behaviours. Meanwhile, Conchie et al., (2013) suggest that it is important to provide supervisors with a supportive environment to enable them to better engage in safety leadership. For example, a supportive manager is critical in supervisors' efforts to engage in good safety leadership, as the support from managers enhances supervisors' confidence that their leadership behaviors will be 'backed-up' (Conchie et al., 2013).

The study also found a significant positive relationship between social support and group-level safety climate. The finding aligns with what Lowe et al., (2003) concluded that
having positive social support in a work environment leads employees to feel they work in a safer workplace. For instance, with strong social support, when co-workers are exposed to work hazards, an employee can be more aware of them and are more willing to put forth steps to prevent them (Roy, 2003). Gradually, this could foster preventative behaviour and thus cultivate safety culture in a workplace.

Finally, there were two interaction effects tested in the study with the intention to examine how the personal factor, psychological capital, could affect the impact of safety leadership and social support on group-level safety climate. First, no significant interaction effect between psychological capital and safety leadership was identified on group-level safety climate. As safety leadership by itself has a large standard beta 0.468 towards group-level safety climate, this implies that safety leadership is a dominant factor influencing group-level safety climate. Under the circumstances, employees who experience positive safety leadership, even if they have low levels of PsyCap, it will not affect their perception on how their groups care about safety matters. Second, there is a significant positive interaction effect between psychological capital and social support on group-level safety climate. This is a novel finding which means that higher levels of personal resource in the form of PsyCap strengthen the relationship between social support and group-level safety climate. Positive organisational psychology believes that human resource strengths and psychological capitals can be developed and managed for organisational performance improvement. Therefore, organisations should develop intervention or training programs to enhance employees' PsyCap to achieve best possible safety functionality.

CONCLUSIONS AND FUTURE DIRECTIONS

The majority of safety climate studies have focused on how safety climate affects safety outcomes and looked at safety climate as a single-level factor. The current study adopted a different focus and concentrated on studying what factors affect safety climate using a multi-level approach. The results showed that organisational-level safety climate, safety-specific transformational leadership and social support affect group-level safety climate. In addition, high levels of PsyCap could strengthen the effect of social support on group-level safety climate, and vice versa.

This study used quantitative research method to seek for an overall understanding on safety climate as a phenomenon, future study could employ qualitative method to investigate why such a phenomenon occur in the industry. In addition, Future studies could look into how PsyCap could affect the relationships of other organisational factors on safety climate, and how the research model used in the study could be applied to other high-risk industries such oil and gas, and mining.

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Safety Leadership, Social Support, and Psychological Capital


CAN NICHES PROVIDE 'PROTECTED SPACES' FOR INNOVATIVE ENERGY PROJECTS?

Beck Collins

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The construction industry is tasked with undertaking retrofit projects to reduce energy consumption and carbon emissions from existing homes and buildings. The national scale of the task and the complexity of addressing the technical, funding and processual problems makes it difficult to have mass solutions. Socio-technical systems theory has been used to describe the situation at the large scale, and introduces the idea of niches to connect this to the local scale. Niches are protected spaces where innovations can be developed and experimented with, so that fruitful ways forward for a mass transition can be found. This research explores whether this concept is useful for describing real projects. It uses interview data and documentary evidence from two UK municipality-led case studies projects that used the Green Deal to initiate mass energy retrofit in Birmingham and the North East region. In particular the idea of how far such projects can indeed be ‘protected’ was explored. The findings from both projects showed efforts were made to protect the innovations of the projects locally. However those efforts were undermined by central government changes to the legislation. Neither project realised their goals as originally envisaged. Consequently, one project was terminated early. Thus, the research argues that the concept of niches, as protected spaces, is untenable for local energy projects, as questions of energy and the role of the state in this are political issues. Therefore more sophisticated and practical theories are required for dynamic and contested energy retrofit projects.

Keywords: energy retrofit, innovation, niches, project failure

INTRODUCTION

Carbon emissions from energy use in buildings make a significant contribution to anthropogenic climate change, and must be reduced if the worst climate change predictions are to be avoided. The construction industry has a great role to play in reducing these emissions through the retrofit of existing homes and buildings, and yet such retrofit has hitherto been slow and piecemeal. The sustainability transitions literature can provide useful insights into why this might be. It describes ‘systems of provision’ (of housing, energy, transport etc.) as interdependent ‘systems of systems’, which because of their interlocking nature, and co-evolution with social practices, are difficult and slow to change (Geels, 2004). However, such transitions have happened in the past, and transition scholars point to the importance of ‘niches’ or ‘protected spaces’ for innovations which can eventually threaten the prevailing ‘regime’. Often, successful niches are localised niches, either because learning about innovations benefits from proximity (Neij et al., 2017), or because municipalities are taking a lead in setting up such niches in order to speed up change and direct it towards low carbon ends (Bulkeley and Castán Broto, 2013). Energy retrofit in the UK is bound up within wider systems of

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housing and energy. It is necessary because UK housing stock is often thermally inefficient (Palmer and Cooper, 2013), and yet difficult to change as the required technologies can be expensive and not prioritised by householders in a predominantly owner-occupied housing sector.

However, in 2013, the UK government sought to address this problem by introducing a piece of legislation which has been described as innovative (Pettifor et al., 2015); the Green Deal (GOV.UK, 2018). This introduced a pay-as-you-save mechanism to overcome the barrier of upfront costs of energy efficiency measures. The cost of measures would also be supported by the Energy Companies Obligation (ECO - an obligation on energy companies to improve household energy efficiency). In response to this legislation, some municipalities sought to use it to run their own area based programmes of energy retrofit, to drive investment towards householders most in need, and towards buildings that are ‘hard to treat’ - a key area of need of energy retrofit in the UK.

The aim of this paper is to explore the ability of local area niches to protect innovative energy retrofit projects, such as those that made use of the Green Deal. It explores this through two such programmes; Birmingham Energy Savers (BES), in Birmingham, UK, and Warm Up North (WUN) in the North East region of England, chosen because they were both ‘Green Deal pathfinders'. Given their focus on a particular geographical area, and the support and promotion of these projects by municipalities, these two programmes provided a ‘niche’ or ‘protected area’ for Green Deal assisted mass energy retrofit. However, both projects were perceived to have 'failed', raising questions as to the strength of protection provided by these local area niches.

This paper first explains the concept of sustainability transitions, the role of niches in protecting innovations to drive these forward and the role of localities or municipalities in creating these niches. The two cases of BES and WUN are then explored to understand how the relevant municipalities set up a niche for energy retrofit in their areas, and how far the projects met their aims. The discussion then draws on the findings to tentatively demonstrate how far local area niches can really provide protected spaces for innovative energy retrofit projects.

**The Role of Niches within Sustainability Transitions**

The sustainability transitions literature argues that ‘societal functions’, of housing, energy, transport, food or communications, are provided by ‘socio-technical systems’. These are interconnected systems of technology, institutions, regulations, user practices, and symbolic meaning (Geels, 2004). Since these systems are interconnected and interdependent, they become stabilised and difficult to change. Change tends to be incremental and innovation improves the prevailing solution or ‘regime’. However, radical change can and does happen in such systems. The most commonly cited explanation of such change is the Multi-Level Perspective (Geels, 2002, 2004). This describes three levels; micro, meso and macro. The sociotechnical regime sites at the meso level, and is where incremental change happens. The landscape sits at the macro level, and is a stabilised backdrop to the regime which can exert influence. Niches sit at the micro level, and are argued to be the site of radical innovations with the potential to change the regime completely (Kemp et al., 1998). These innovations are varied; they could be new products or services, new processes, new social practices, or new configurations of existing processes, products, practices and markets. However it is this ability to radically change systems of provision which is key (Freeman and Perez 1998), and is how innovation is understood in this paper. Historical case studies have given
examples of such niche innovations going on to replace the incumbent regime, such as the transition from sailing ships to steamships (Geels, 2002).

A defining feature of niches is that they afford temporary ‘protective space’ for the development of new innovations. New innovations may not align with the prevailing regime of industrial and technological structures, user practices, policies and ideas of cultural significance, and as such are unable to compete in mainstream selection environments (Kemp et al., 1998). Protective spaces shield them from these pressures with which they are unable to compete. With this protection new innovations can be nurtured; learning about the innovation is assisted, a supportive social network can be built behind it, and expectations about it can be articulated (Schot and Geels, 2008). Niches can also empower new innovations, either to be competitive with the current regime, or to destabilise the regime itself to the benefit of the innovation (Geels, 2004).

Although much discussion on niches foregrounds the idea of a ‘global’ niche, there is an increasing awareness among scholars of the potential of geographical localities in niche formation. For example the role of cities has gained interest; Bulkeley and Castán Broto (2013) show how a number of cities are taking it upon themselves to set up and drive ‘experiments’ (or niches, see Sengers et al., 2016). Going further, some cities are seeing themselves as governing through experimentation and setting up urban laboratories (Karvonen and van Heur, 2014). In local areas (be they cities or even regions whose constituent areas share similar characteristics and concerns), experiments can be tailored to those local issues and contexts (Raven et al., 2008), and gain from proximity in local learning (Neij et al., 2017). Place dependent factors, such as formal and informal institutional configurations, face-to-face interactions, inter-organisational relations and the clustering of organisations provide ‘protection’ for a niche (Sengers and Raven, 2015).

However, can geographical niches always provide protection in this way? Governance is multi-level; municipalities may have a say over land-use and the changes permitted to buildings, but the legislative and funding arrangements of energy retrofit are often matters for national governments. Localities may have objectives which are not in conjunction with national goals, (Busch and McCormick, 2014) or simply different priorities to national governments (Seyfang et al., 2014) which may later cause difficulties for providing protection for innovation locally. This is a particular problem within the UK which by European standards is hyper centralised (Wilson and Game 2006), with a high level of central government intervention and little financial autonomy. This raises questions as to the ability of local areas to protect innovation locally.

Energy retrofit is a complex example to fit within a discussion of transitions. Energy retrofit often involves some technologies which are common, such as loft and cavity insulation and condensing boilers. However many technologies, such as solid wall systems, are innovative, or at least not commonly deployed. Additionally, energy retrofit involves two ‘systems of provision’; that of housing and energy. This is an important and viable area for transitions. Eighty per cent of homes that will be standing in 2050 are already built (UKGBC 2008); therefore energy retrofit must happen if we are to reduce carbon emissions. This requires innovations in technologies, but also in funding mechanisms, and in mechanisms of delivering energy retrofit at scale. Learning needs to take place about what works and what does not. Local protected spaces could provide the opportunity for this to take place.
METHODS

In order to gain insight into whether local area niches can provide protected spaces for innovations, two exploratory case studies of innovative energy retrofit projects were studied. Qualitative data were gathered from ten interviews conducted in 2017, and documentary evidence. The cases selected were Birmingham Energy Savers, which took place in Birmingham UK, and Warm Up North, which took place in the North East region of England.

Both projects began in 2013 in the context of newly introduced “Green Deal” legislation. This made available a ‘pay as you save’ finance mechanism. After an independent assessment of their home’s energy efficiency needs, householders could take out a loan to pay for energy efficiency measures to be installed. Repayments were then made through a fixed charge on the electricity meter over a period of up to 20 years. Repayments had to be less than or equal to the savings on energy; this was the Golden Rule. For more expensive measures unlikely to meet the Golden Rule such as solid wall insulation (SWI), or for those people on social security payments, ECO could be used as well. Although the Green Deal was to be a private arrangement for individuals, Birmingham City Council (BCC) and the Association of North East Councils (ANEC) wanted to harness the legislation to bring greater benefits to their local areas.

BCC began procurement for a lead delivery partner for Birmingham Energy Savers through a process of competitive dialogue in 2012. They awarded the contract to a multinational construction company (hereafter the BES Delivery Partner) who began delivery in 2013. There were a number of very ambitious Key Performance Indicators as part of the contract: to improve the thermal efficiency of 29,000 homes, create 360 jobs, and provide 16,000 training weeks to jobseekers. The contract made use of a break clause to terminate after only three years, in April 2016.

Nine local authorities within ANEC began procurement for a delivery partner for Warm Up North six months later, also through competitive dialogue, and awarded the contract to a major utility company (hereafter the WUN Delivery Partner) in July 2013. Newcastle City Council acted as the lead partner and project manager. Again there were ambitious targets for the project - delivering improvements to 10,000 - 15,000 houses within the first five years, delivering local economic and social benefits, creating jobs and cutting carbon emissions. However the KPIs that were eventually negotiated were more focused on quality and targets to reach householders. The contract run to completion as planned.

BES and WUN were chosen as cases for this research because they were innovative; they were the first two projects to have made use of the Green Deal, itself described as a policy innovation (Pettifor et al., 2015), which was certainly unfamiliar to householders and the delivery partners. The projects were also innovative in that they set up area-based initiatives for energy retrofit across different tenures and different types of buildings, while increasing the capacity of the local supply chain, addressing fuel poverty and providing jobs for local people (as shall be shown below). These were not simply energy retrofit projects, but complex and large-scale projects aiming to provide social value, thereby driving a transition in local housing and energy systems. They were therefore examples of radical innovations at the system level (Freeman and Perez 1988).

The cases were also chosen because they were 'protected' in various ways, and therefore can be argued to be examples of local area niches. BCC and ANEC deliberately set up each of these projects and sought to guide their design through the tender process. This is...
reflective of the literature on cities setting up local experiments or urban laboratories (Bulkeley and Castán Broto, 2013; Karvonen and van Heur, 2014). Both projects were tailored to local issues and contexts (Raven et al., 2008; for example fuel poverty and hard to treat homes (Victorian terraces in Birmingham, and 'Tyneside flats' in the North-east). Both cases also provided protection by being actively supported and signposted by BCC and ANEC; for example, despite being run by private delivery partners, both projects were allowed to use municipal branding. Furthermore local authority staff signposted people to the projects, provided contact details of eligible customers, and provided buildings from their own social housing stock as major streams of work. Finally, being locality-based, it was hoped that interest in energy retrofit would grow as households saw retrofit projects going on around them, and as the local supply chain became increasingly involved, something that was supported through business engagement events run by BCC (Neij et al., 2017; Sengers and Raven 2015).

In total ten interviews were carried out; the below table lists the interviewees.

**Table 1: Interviewees from BES and WUN**

<table>
<thead>
<tr>
<th>BES</th>
<th>WUN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Staff</td>
<td>Programme Manager (BES PM)</td>
</tr>
<tr>
<td></td>
<td>Former BES Officer (BES LA)</td>
</tr>
<tr>
<td>Delivery Partner</td>
<td>Programme Manager (WUN PM)</td>
</tr>
<tr>
<td>Staff</td>
<td>Council Officer South Tyneside (WUN LA1)</td>
</tr>
<tr>
<td></td>
<td>Council Officer Newcastle (WUN LA2)</td>
</tr>
<tr>
<td></td>
<td>Council Officer Darlington (WUN LA3)</td>
</tr>
<tr>
<td></td>
<td>Account Manager (BES DP1)</td>
</tr>
<tr>
<td></td>
<td>Former Energy Assessment Manager (BES DP2)</td>
</tr>
<tr>
<td></td>
<td>Project Director (WUN DP1)</td>
</tr>
<tr>
<td></td>
<td>Former Account Manager (WUN DP2)</td>
</tr>
</tbody>
</table>

Further interviews (to these ten) with other individuals involved in the project were not considered necessary; repetition in responses occurred reasonably quickly (theoretical saturation - Eisenhardt, 1989). Interviewees were asked about original expectations of the projects, whether they had met them and why; inviting them to talk about their lived experiences of project delivery. Project documentation and government documents were also studied to 'fill in the gaps' of the stories of both projects that was not provided by interviews (Glaser and Strauss 1967) and also to triangulate key issues. The interview data were coded according to the themes of the literature review and those that emerged from the data. All other data were used to support the story that emerged from the interviews. Through this it can be shown how these programmes were perceived by the practitioners delivering them, and it can be suggested how far they were able to provide protection for innovation.

**FINDINGS**

**The Difficulties of Practice and Protecting Local Innovation**

The findings are laid out according to the themes that emerged from the data as important within the projects, and pertinent to the research question. These are: creating large scale area based projects, perceptions of the effect of government changes to funding and legislation, and perceptions of the effect this had on the projects; i.e. of failure.

**Creating Large Scale Place-Based Energy Retrofit Projects**

Both projects were locality-based in that they sought to address the particular challenges of their local areas. Both Birmingham and its surrounding region and the North East suffer from some of the highest fuel poverty levels in the country (DECC, 2016). They are also economically disadvantaged; Birmingham is one of the most deprived local
authorities in England (BCC, 2015). Finally, both Birmingham and the North East have a high proportion of energy inefficient housing stock; solid wall terraces in Birmingham and solid wall Tyneside flats in the North East, as well as non-traditional construction and high rise towers in both areas.

The concerns for staff of both projects were that the opportunity of energy retrofit would not be taken up; or that energy retrofits might be done badly and generate a negative reputation. As such they wanted to control the energy retrofit that happened in their area by choosing and then being seen to endorse, a trusted delivery partner; “if Green Deal was gonna launch we were really concerned about you know, the fly-by cowboys knocking on our doors, loads of complaints getting poor service, we wanted something that we can control and, […] all the leaflets that would be in our customer services centres, our libraries, the letters that we would send out would all have the local authority name endorsing that” (WUN DP). Similarly in Birmingham; “Birmingham wanted to be a bit more proactive, […] we want to give citizens the option of using a procured provider that we have selected that we think is really good value for money, provides high quality delivery projects, provides a guarantee, and is backed by the City Council, […] if they choose our provider, […] then they’ve got certain levels of I suppose security, they can come to us” (BES DP).

Birmingham in particular also wanted to use BES to generate wider economic growth in the city. They saw energy retrofit as an opportunity to provide the sorts of jobs and business opportunities that had been lost as a result of the reduction in manufacturing: “…it’s the wider benefits we’re developing the supply chain, increasing the skills of the local environment, retaining funding within the city, […] there were definitely economic, primary economic drivers around skills and employment” (BES DP). The BES contract also had Key Performance Indicators on the number of small and medium sized enterprises forming part of the supply chain receiving assistance, on the value of works delivered by supply chain members that pay Birmingham business rates for operational business premises, and on the number of jobs created and safeguarded per million pounds spent on the delivery of the project.

A key characteristic of both BES and WUN was that they were hoping to address these issues by projects that were at scale, as explained by the BES DP1: “we typically deal with scale projects, that’s what we do. […] we weren’t looking at it sort of, we’ll do a few properties here, we were looking at schemes, city wide programmes” (BES DP1). Similarly, WUN awarded their contract to the WUN Delivery Partner partly based on the understanding that they would “ring-fence” their entire ECO budget for the North East, which given the size of this budget would mean a massive scale project; “So we ended up choosing [the WUN Delivery Partner] and one of the main reasons was their ability, their commitment to ring-fence ECO funding to the Warm Up North partnership” (WUN PM).

Perceptions of Central Government Changes to Funding and Legislation

Both projects were soon heavily disadvantaged by problems with the national level Green Deal and ECO legislation that emerged by 2013. Nationally, despite initial targets, only circa 1,500 people signed up to the Green Deal in the first year against a target of 10,000 (DECC, 2013). It emerged that privately renting tenants could not participate, further reducing the market. The cost of the finance (7%) was much higher than that of personal loans available at the time (3-4%). The process as a whole was extensive and complex. Crucially, in December 2013, the UK Government made a number of changes to ECO, reducing energy efficiency targets, extending the deadlines to meet them, and allowing those targets to be met through ‘easy’ measures such as loft and cavity insulation and
boiler replacements. The WUN PM described this: “It all changed overnight. Ed Miliband, er, who was the leader of the Labour Opposition at the time, announced that if they came to power, […] They would freeze all energy bills […] for two years or whatever. So all of a sudden, the incumbent government had to come up with a response to that. […] So they came to a deal with the energy companies and overnight they knocked £50 off everybody's bills. [But] that the £50 saving off the bill was actually a reduction, £50 contribution towards the ECO element. […] So that, those pipelines of schemes that were lined up which was gonna get 40% contribution all of a sudden it was you know, it was 10, 12%.” (WUN PM).

For both Birmingham and the North East who had a number of difficult to treat properties, a major avenue to address those under these projects was thereby removed. Both projects cited this change in ECO and the low take up of Green Deal as key points when their own local projects began to unravel. Additionally, the Government announced the end of the Green Deal Finance Company in July 2015, effectively ending the Green Deal.

Interviewees from both projects also cited other funding difficulties as a result of central government priorities, which impact upon their ability to drive forward energy retrofit. “I think the big problem we’ve got is also […] the drive towards austerity, and cuts and cuts meant that it was never a priority for the government” (BES LA). In the North East: “Funding’s just, it’s never been so dire” (WUN LA1). This impacted on the ANEC local authorities’ ability to help their Delivery Partner to drive interest in the Green Deal, and the energy efficiency measures on offer: “there just wasn’t any money to do anything. And like we used to have people who used to go out and do events, we don’t have that any more. […] Um, so we weren’t doing that kind of outreach stuff” (WUN LA2).

The Perceived Effect of Funding/Legislative Changes: Perceptions of Failure

Ultimately, that BES was perceived to be a failure is primarily signified by the fact that the contract was terminated early. The contract was initially signed for 8 years, but included a break clause at the end of March 2016 (after three years). The reason given for resolving to exercise this break clause was that The BES Delivery Partner had not achieved at least 15,000 Green Deal plans in Birmingham, including 40 public non domestic buildings by the break clause date. Instead only 3,100 properties had been improved and only 16 properties had used the Green Deal to pay for the works. As the Public Cabinet Report on BES demonstrates, BCC felt it had to take action; “BCC recognises CES has not achieved the date break criteria specified in the PA [Project Agreement] and takes appropriate action” (BCC 2015, p10). The BES Delivery Partner also described the project as a failure (although less directly); “It wasn’t a big success … I think we as a company have made decisions internally that mean that we won’t do this type of work again” (BES DP1).

Like BES, WUN was also perceived to be a failure, when compared to its original ambitions. The changes to ECO meant that a lot of planned schemes could not go ahead; “So the local authorities couldn’t afford the 78%, they were back to more or less where they were in the past, so all those pipelines of schemes just disappeared” (WUN PM). WUN essentially became a boiler replacement scheme, which did not address the most important energy retrofit issues of the area, and was no different to the WUN Delivery Partner’s offer around the country: “We did a hell of a lot of boilers, it’s got to be said. But that wasn’t really what Warm Up North was set up to do. And you could argue that, that boiler proposition was no different to what they [the WUN Delivery Partner] were offering nationally. So what was the benefit of having got a partnership?” (WUN PM).
For projects that were about energy efficiency at scale, both projects were recognised by all parties as failures.

DISCUSSION

This paper explores the ability of local area niches to provide ‘protected spaces’ where complex innovations for the process of energy retrofit can be tried and improved, to increase their potential to drive a transition. This paper argues that BCC and ANEC did indeed both try to set up niches (although they did not use those terms), analogous to the urban laboratories or niche experiments described in the literature (Karvonen and van Heur, 2014, Bulkeley and Castán Broto, 2013). Their projects were targeted towards particular local concerns (Raven et al., 2008) of hard to treat homes, fuel poverty and the need for more economic opportunities locally. They drove much activity in their respective areas, and sought to actively protect that activity with trusted municipal branding. It was hoped that this clustering of activity would provide protection for energy retrofit innovations and opportunities to learn about what works and what does not (Sengers and Raven 2015, Neij, et al., 2017).

However, both projects were perceived by their organisers to have failed, or certainly to have not met original ambitions. The data presented here suggest that this was not entirely due to a failure of energy retrofit innovation. Certainly, the innovation that was the Green Deal mechanism was overly complex, poor value for money, and did not reach those parts of the housing sector where perhaps it was most needed. Failure of innovations itself need not be a bad thing - there is useful learning to be gained (Sengers et al., 2016). However, as well as the Green Deal, both projects had wanted to make use of ECO to do large schemes of energy retrofit across whole neighbourhoods of hard to treat homes. This would have provided an excellent opportunity to learn about the most appropriate technology systems and the best way of marketing such schemes to a range of tenures. It would have provided local supply chain companies and contractors with an opportunity to change their usual practices, and increase the range of products and services offered. It could have influenced householder expectations in these local areas as to how warm homes should be and perceptions as to the inconvenience of retrofitting. And yet those opportunities did not materialise.

The data presented tentatively suggest that these local niches could not provide the necessary protection for energy retrofit innovation because their projects relied heavily on legislative and funding decisions that were taken by central government, and were therefore beyond the control of local municipalities. Central governments can provide a helpful context for the setting up of niches through national legislation and financial support (Busch and McCormick, 2014), but the data here suggest that if that support is removed, it can undermine local efforts to protect innovations. The UK in particular has a centralised system of governance (Wilson and Game, 2006) -municipal areas simply do not have the ability to set up some forms of (arguably more powerful) protection through local legislation and funding. As well as this, energy is also a very political issue. The WUN Programme Manager described the situation of ECO funding and energy prices as if it were a ‘political football’, used to score points against the opposition. Any transition of the energy system is an inherently political issue; and yet Mitchell and colleagues (2016) argue that the UK political system does not deliberate well to manage this.

CONCLUSIONS

Energy retrofit of the built environment is essential if the worst predictions of climate change are to be avoided. The sustainability transitions literature provides the concept of
‘niches’, which provide protected spaces for innovation; a theory which is useful in understanding how localities or municipalities can protect innovations around energy retrofit. The cases of BES and WUN demonstrate how two municipalities attempted to set up and protect mass energy retrofit projects. These projects were unsuccessful as the protection they provided was undermined by central government changes to the legislation and funding mechanisms upon which the projects were based. The stability of these localised niches was therefore too sensitive to the energy policy backdrop. The research therefore finds that the concept of niches, as protected spaces, does not work well for dynamic and contested local energy retrofit projects, and would benefit from more nuanced, practical theory.

REFERENCES


THE FRENCH CONNECTION

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This paper analyses the educational collaboration model between a UK university and an educational partner in Paris that provides a joint educational programme to employees of French construction companies. The literature review evaluates 3 collaboration evaluation tools. Critical reflection on the assumptions informing the different assessment tools identified the McLean and Behringer, Give-Get model informs drivers for success but lacks detail requiring further criteria for evaluation. The Baird and Gordon QA Framework confirms the robustness of the quality assurance when compared with results of quality review but does not provide evaluation of criteria outside the quality framework. Bhougzalla and De Vreede’s Collaboration Maturity Model (Col-MM) is devised for general application to all collaborations but has not previously been tested and reported in the context of HE collaborations with industry. The application of the model identified the adaptability of the Col-MM collaboration model for detailed analysis, insight and understanding of the collaboration as it incorporated data readily available from quality review and could measure collaboration maturity. Analysis found interagency team dynamics, leadership and communications proved to be critical success factors for the collaboration. The collaboration presents a successful new model for Higher Education post-graduate education that can be applied to other disciplines.

Keywords: collaboration, international, Higher Education, construction

INTRODUCTION

A number of authors have explored issues around employer based skills development in construction (Moehler, Chan and Greenwood, 2008) and related areas of the employers’ role in skills development including evaluating the effectiveness of project management courses (McArdle \textit{et al.}, 2012; Mills \textit{et al.}, 2010). Education providers are expected to design and deliver postgraduate courses that are founded upon industry relevant knowledge that students can apply in the workplace to make a positive difference to the success of a company (Jackson, 2010). This study intends to contribute to the theme on the relationship between academia and industry through analysing the factors determining the success of an educational collaboration to deliver a joint MSc Construction Management Programme between a UK University and a French educational provider in which all the students are employees of French construction companies.

LITERATURE REVIEW

Collaboration amongst cross sectional alliances e.g. business, governments, NGO, education organisations is increasingly necessary to respond to problem domains (Gray, 2000). Archer \textit{et al.}, (2014) identified that an increasing number of higher education institutions are establishing collaborations with organisations that have commercial

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interests in fulfilling their mandate. However, a lack of understanding of collaboration structure and dynamics is the major cause of failure of collaborative initiatives (Busi and Bititci, 2006). These collaborations require evaluation as once collaborations are established they will not last unless it can be shown that they are successful (Kidder, 1997; Maclean and Behringer, 2008). The existing formalised mechanisms of quality assurance provide limited data on approaches to evaluate the success of collaborations. Organisational performance indicators are the typical method of evaluation for success and in the context of education form the basis for quality review (Cullen et al., 2003). Quality review can provide some understanding of the nature of a collaboration in order to make a judgement but the factors involved in a typical quality review are not analysed using any specific model to assess the impact of their contribution.

Baird and Gordon (2009) provide a model for evaluating HE quality enhancement and their framework identifies areas of good practice where various issues can be considered critical. However, the framework does not provide suitable mapping on to collaborative arrangements. Other quality based models provide potential application to the evaluation of education collaborations.

The Teacher Collaboration Improvement Framework (TCIF) (Gajda and Koliba, 2008) possesses some relevant factors within the Community of Practice Collaboration Assessment Rubric (CopCAR) (Gajda and Koliba, 2007). The model identifies 6 critical factors in collaboration dynamics and team relationships: (a) shared purpose, (b) cycle of inquiry, (c) dialogue, (d) decision making, (e) action, and (f) evaluation. There is an overlap between these factors and the seven factors identified by Johnson et al., (2003) as important to inter-agency collaborations: commitment, communication, strong leadership from key decision-makers, understanding the culture of collaborating agencies, engaging in serious pre-planning, providing adequate resources for collaboration, and minimizing “turf” issues; summed up in three area as commitment, communication, and strong leadership.

Twitchell et al., (2007) identified 17 criteria that had similarities to other collaboration models covering: management and program administration, interagency team dynamics and communications, and program design. It is recognised that evaluators are uniquely positioned to empirically examine the development and effects of inter-agency collaboration (Woodland, 2012). The Collaboration Evaluation and Improvement Framework (CEIF) by Woodland et al., (2012), develops collaboration theory and identifies five points of entry to evaluating collaborations. Woodland et al., (2012) suggest actions that evaluators can take to (a) define and describe the value of collaboration, (b) measure the attributes of organizational collaboration over time, and (c) increase stakeholder capacity to engage in efficient and effective collaborative practices. The CEIF framework entry points include: (1) operationalizing the construct of collaboration; (2) identifying and mapping communities of practice; (3) monitoring stage/stages of development; (4) assessing levels of integration; and (5) assessing cycles of inquiry. The quality frameworks provided some indicators of success through quantitative and qualitative data for developing an understanding of the influential factors for collaboration success but do not readily identify the priorities for the collaboration that could help inform strategy development and provide reassurance that industry needs are being achieved. The complexity in evaluating collaboration outcomes using appropriate metrics should not be underestimated (Wilkinson et al., 2014).

The European Foundation of Quality Management (EFQM) uses a set of criteria in response to the growth in university-industry collaborations increasing demand for
methods to evaluate them (Kauppila et al., 2015). The EFQM identifies success factors covering leadership, strategy, people, resources and processes to create an environment of trust and commitment, in which collaboration can take place in an organized manner while aiming towards mutually agreed goals. These factors are similar to those identified by Marek et al., (2015) for their Collaboration Assessment Tool (CAT); environment, membership characteristics, process/structure, communication, purpose and resources. The CAT model provides extensive detail for evaluation to obtain the maturity measure of the collaboration and requires a longitudinal study commencing from the start of the collaboration to establish the trends and identify development areas. Whilst the CAT model is an extensive evaluation framework, a method is required that could evaluate the collaboration at its current stage of maturity without further years of ongoing study to provide indicators for strategic development based on an existing longer-term relationship (Hauschildt, 1991).

**Collaboration Development**

The collaboration between the Abertay University and Ecole Supérieure de Conduite de Travaux (ESCT) formed in 2011 to deliver a joint MSc Construction Management Programme to employees of French construction companies. ESCT is a private educational institution in Paris that works directly with industry to provide relevant educational qualifications specifically for employees of French construction companies, many of which are large, international organisations such as Vinci and Bouygues Construction. The programme is an integration of technical, managerial and entrepreneurial concepts in the context of the management of construction projects. Students are thus equipped with the knowledge and experience of ensuring construction project delivery that uses resources efficiently and effectively whilst considering social and environmental impacts. The programme covers subject areas such as business strategy, environmental regulations, construction logistics, entrepreneurship, project management, health and safety and the Legislative framework and processes which control these in construction.

To start the preparation for the course a student must have gained a Brevet de Technicien Supérieur (BTS) or a Diplôme Universitaire de Technologie (DUT), (See Figure 1). The students enrol for a further two-year period of study at undergraduate level with ESCT and must have employment as Construction Managers. The construction employers sponsor the two-year post BTS/DUT education at ESCT. During these two years of study the students are prepared thoroughly for the transition to MSc (Lowe and Cook, 2003). Those students meeting MSc entry requirements continue to be supported by their employer including providing industry based MSc project supervision. The MSc programme is delivered in Paris and Dundee in French and English under Abertay procedures and academic regulations.

In examining the programme, it is clear that it is complex in terms of delivery and it has taken several years to enable the entire delivery team to fully internalise the operational issues. The results of two separate quality reviews confirm the collaboration was effective in relation to those metrics. The results of the quality reviews were successful and this framework confirms why, but it does not analyse the less visible and less easily measured factors outside a quality assurance framework, factors that may be, arguably, equally as important in ensuring on-going development of the collaboration.
The team thus commenced an in-depth investigation of the collaboration to understand its impact and performance in more detail after the first quality review. McLean and Behringer (2008) provide a useful starting point. Their use of the ‘Give-Get’ model (Table 1) has aided reflection for the team and formalised what had been tacit knowledge between all those involved in the collaboration.

### Table 1: Give-Get model analysis of collaboration

<table>
<thead>
<tr>
<th>Partner Gives</th>
<th>Partner Gets</th>
</tr>
</thead>
<tbody>
<tr>
<td>University</td>
<td>Viable post-graduate course</td>
</tr>
<tr>
<td></td>
<td>International student engagement</td>
</tr>
<tr>
<td></td>
<td>New long-term links with industry in France</td>
</tr>
<tr>
<td>ESCT</td>
<td>Lecturing skills in HE</td>
</tr>
<tr>
<td></td>
<td>Increased reputation and recruitment</td>
</tr>
<tr>
<td>Expert knowledge in French CM practice</td>
<td></td>
</tr>
<tr>
<td>Exceptional industry focus and links</td>
<td></td>
</tr>
</tbody>
</table>

Using this model for analysis of the collaboration it has been possible to identify where the motivational drivers for each organisation exist and the role of industry in driving the focus for the educational collaboration. Whilst the Give-Get model identifies indicators that explain why the collaboration has continued to develop an appropriate model for a more detailed and rigorous analysis needs to be identified.

### METHODOLOGY AND DATA COLLECTION

Whilst quality metrics provide a benchmark to compare across MSc courses internally and externally, what is important to the employers is somewhat different (Nicholson, 2011). The metrics for quality have to be achieved but the long-term viability of the course depends upon a knowledge of more than the measurable data for quality assurance (Westhuizen, 2005). Quinn et al., (2016) adapted and applied Himmelman’s (2002) strategies to quantify the various levels of collaboration. A comparison between Himmelman’s strategies and the Boughzala and De Vreede (2012) Collaboration Maturity Model (Col-MM) indicated that there were similarities between them that aligned with the team’s needs and both used similar scales. Himmelmann’s strategies used a broad framework that could be adapted for the context of the MSc Construction Management but it was considered that the Boughzala and De Vreede model was more transparent in methodology for evaluating collaborations and the detailed analytical framework aligned more closely with the existing collaboration.

Boughzala and De Vreede (2012) identify limitations of various collaboration maturity models; they are limited in the type of collaboration covered; may only apply to certain project life-cycle phases, that the descriptive models identify collaboration problems without proposing solutions and there appears to be little evidence assessing whether the use of these models leads to meaningful performance improvements. Boughzala and De Vreede (2012) and Himmelman (2002) reduce some of the limitations in that their models are suitable for more generic applications as well as assisting in identifying the areas for
development and producing relevant recommendations to prioritise improvement measures. From the team’s perspective the more detailed framework of Boughzala and De Vreede was more transparent and readily applied to obtaining data for analysis and therefore more suitable. Whilst a comparison of the results from applying both models was considered, in assessing the duplication it was considered that no operational advantage could be gained by using both methods. Applying the Boughzala and De Vreede model to the Higher Education teaching collaboration required the application of the following formulae to ascertain the maturity of the collaboration:

**Formula 1: Criterion Maturity (average of respondents’ ratings)**

\[ m_{\text{criterion}} = \frac{\sum m_{\text{respt}}}{n_{\text{respt}}} \]

Where \( n_{\text{respt}} \) is the number of respondents interviewed

**Formula 2: Collaboration Maturity (average of collaboration maturity values for each criterion)**

\[ M = \frac{\sum k_i \cdot m_{\text{criterion}}}{\sum k_i} \]

Where \( k_i \) is the coefficient corresponding to the criterion \( i \) used for the average calculation. The maturity level is then categorised as follows: ad hoc (<20%), exploring (20-50%), managing (51%-80%), and optimising (81-100%); see Table 4.

The team adopted the 7 stage methodology:

- **Scoping** - Define the purpose and boundaries of the Col-MM process
- **Data collection** - Collect quantitative and qualitative data related to the quality of team collaboration
- **Quantitative data analysis** - Identify individual perceptions about the collaboration maturity of the team; highlight critical perception differences
- **Qualitative data analysis** - Identify deeper individual perceptions about the collaboration maturity of the team; facilitate a more in-depth understanding of these perception differences
- **Cross-data analysis** - Combine Col-MM criteria for additional interpretations for specific measurements of capabilities
- **Presentation of results** - Present in various formats using the Col-MM tool; visualise results (spider diagrams)
- **Setting up of an action plan** - Define an action plan to enhance the collaboration; frame recommendations in terms of actions and prioritise improvement measures

An extract of the types of question is shown in Table 2. The interviewee assigned a level rating for each question that was then used to define Collaboration Maturity Model Scores.
Table 2: Sample of questions

<table>
<thead>
<tr>
<th>Area for analysis</th>
<th>Criteria</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration characteristics</td>
<td>Collaboration objectives</td>
<td>How clear is the future vision and strategy?</td>
</tr>
<tr>
<td></td>
<td>Collaboration depth</td>
<td>How well does the team work together?</td>
</tr>
<tr>
<td></td>
<td>Working mode</td>
<td>What are the characteristics of the environment?</td>
</tr>
<tr>
<td></td>
<td>Interaction intensity</td>
<td>What is the intensity of the interactions participants?</td>
</tr>
<tr>
<td></td>
<td>Collaboration forms</td>
<td>What are the forms of collaboration?</td>
</tr>
<tr>
<td></td>
<td>Relationships</td>
<td>What is the level of formalisation?</td>
</tr>
<tr>
<td></td>
<td>Commitment</td>
<td>What is the degree of commitment of individuals?</td>
</tr>
<tr>
<td>Collaboration management</td>
<td>Collaboration boundaries</td>
<td>What is the scope of the collaboration?</td>
</tr>
<tr>
<td></td>
<td>Collaboration goal</td>
<td>What is the purpose of the collaboration?</td>
</tr>
<tr>
<td></td>
<td>Management style</td>
<td>How is the collaboration managed?</td>
</tr>
<tr>
<td></td>
<td>Decision making</td>
<td>How are decision made in the group?</td>
</tr>
<tr>
<td></td>
<td>Leadership endorsement</td>
<td>To what extent are managers involved?</td>
</tr>
<tr>
<td></td>
<td>Rewarding</td>
<td>Are collaborative skills recognised and rewarded?</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION

6 key personnel from the two institutions who are responsible for the partnership collaboration were surveyed to complete assessment methods. The scoring of the criteria provides a deeper understanding of why this construction education collaboration is working and identifies the priority areas for future development (Table 3 and Figure 2). Barnes and Fisher (2006) identified that where the organizations tend to be smaller and the parties are passionate about their work, issues surrounding governance, integration and implementation can become personal and success is often determined by the personalities involved. They also found that it took time to work toward communication and mutual respect; something that the team had done through initial engagement prior to developing the MSc Construction Management. Successful collaboration is difficult to achieve and failure is prevalent as establishing effective collaborations requires time and compromise (Marek, 2015). Barnes and Fisher (2006) identified shared vision as an essential element of collaboration success, particularly where there are challenges with different organisational and national cultures.

Burnside (2008) acknowledges that the cultural divide between universities and industry, whilst considerable, can be overcome where the strategic issues are the focus and overt attention to contractual language and detail is subservient to consensus building. It could be argued that the time taken to develop the shared vision and the strategic focus reinforced the trust being developed between the collaborating parties. Trust has been found to provide competitive advantage in collaboration (Darabi, 2012) because the commitment and trust encourage both parties to resist attractive short-term alternatives in favour of the expected long-term benefits of staying with existing partners.

Darabi also found that trust facilitates a more open approach to discussing and resolving problems resulting in each partner gaining a better understanding of each other leading to more ambitious collaboration. These variables reflect the priorities for the collaborating partners to the education and training of construction professionals.
### Table 3: Collaboration Maturity Model Scores

<table>
<thead>
<tr>
<th>Areas for analysis</th>
<th>Criteria</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration characteristics</td>
<td>Collaboration objectives</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Collaboration depth</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>Working mode</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>Interaction intensity</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Collaboration forms</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>Formalisation of relationships</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>Commitment and availability of individuals</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>Collaboration boundaries</td>
<td>97</td>
</tr>
<tr>
<td>Collaboration management</td>
<td>Collaboration goal</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Management style</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>Decision making</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>Leadership endorsement</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>Rewarding</td>
<td>72</td>
</tr>
<tr>
<td>Collaboration process</td>
<td>Collaboration framework</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Resource sharing</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>Context awareness</td>
<td>91</td>
</tr>
<tr>
<td></td>
<td>Conflict management</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Collaboration techniques and technologies</td>
<td>63</td>
</tr>
<tr>
<td>Information and knowledge integration</td>
<td>Information collection</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>Information structuring</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>Information access</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>Knowledge validation</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>Knowledge reuse</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Knowledge creation</td>
<td>72</td>
</tr>
</tbody>
</table>

### Figure 2: Criteria Maturity Model Results
Table 4: Results of maturity survey

<table>
<thead>
<tr>
<th>Collaboration Maturity</th>
<th>86% Optimising</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration characteristics maturity</td>
<td>90% Optimising</td>
</tr>
<tr>
<td>Lowest criterion = Working mode</td>
<td>72% Managing</td>
</tr>
<tr>
<td>Highest criterion – Collaboration objectives</td>
<td>100% Optimising</td>
</tr>
<tr>
<td>Collaboration management maturity</td>
<td>86% Optimising</td>
</tr>
<tr>
<td>Lowest criterion = Rewarding</td>
<td>72% Managing</td>
</tr>
<tr>
<td>Highest criterion – Collaboration goal</td>
<td>100% Optimising</td>
</tr>
<tr>
<td>Collaboration process maturity</td>
<td>87% Optimising</td>
</tr>
<tr>
<td>Lowest criterion = Collaboration techniques and technologies</td>
<td>63% Managing</td>
</tr>
<tr>
<td>Highest criterion = Conflict management</td>
<td>100% Optimising</td>
</tr>
<tr>
<td>Information and knowledge integration maturity</td>
<td>81% Optimising</td>
</tr>
<tr>
<td>Lowest criterion = Knowledge reuse</td>
<td>69% Managing</td>
</tr>
<tr>
<td>Highest criterion – Knowledge validation</td>
<td>97% Optimising</td>
</tr>
</tbody>
</table>

The main factors that have been identified as leading to the success of this collaborative delivery are:

- Strong partnership working developed over several years prior to formalising the course that enabled trust to be established and knowledge of the capabilities and strengths of each institution to be shared.
- Long-term commitment from the collaboration partners involved, support from the External Examiner and from employers.
- Willingness and flexibility from all involved to share experience and develop staff in support of the student experience in such a way that a single team ethos and culture are embedded within the course that is not affected by the geographic distance between the two institutions. Regular cross institutional visits as well as video conferencing and teaching observations are an integral part of the course.
- Former students are sharing and cascading their knowledge and experience to those students at undergraduate level providing informal support and guidance in preparing for the course through, for example, accommodation information, what the student experience is like, etc.

CONCLUSION

The McLean and Behringer (2008) model assists in identifying areas for success through the Give-Get model. A number of framework models provide more detail are based on quality criteria (Baird and Gordon, 2009; Gajda and Koliba 2008; Woodland, 2012) although they have limitations. The European Foundation of Quality Management framework provides greater breadth of criteria than other quality-based frameworks and mapping indicated that the collaboration was successful, but the degrees of success were unclear and the model could not assess maturity. Marke’s Collaborative Assessment Tool provides a relevant method but the Col-MM collaboration model was more suitable for providing detailed analysis, insight and understanding in measuring collaboration maturity. Inter-agency team dynamics, leadership and communications proved to be critical success factors. The main issue as a priority for the next strategic planning period relates to integrating the teams in the separate locations even more. The action plan that has been developed from this analysis has prioritised criteria for measurable improvements after implementation.
The educational collaboration has been successful for both educational institutions and industry. Metrics evaluating the collaboration show success for educational organisations based on the strong industry informed focus of the course content and operational delivery resulting in increasing recruitment. For industry, the impact of students implementing knowledge from the course that improves their own companies encourages further engagement and support for the course. The collaboration presents a successful new model for Higher Education post-graduate education that can be applied to other disciplines.

REFERENCES


BECOMING COLLABORATIVE: ENHANCING THE UNDERSTANDING OF INTRA-ORGANISATIONAL DYNAMICS

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The multifaceted nature of highway maintenance provision requires the coordination of a complex web of intra-organisational inputs. Collaborative approaches for the management of such complexity frequently feature in construction management research. Research however orientates toward antecedents and processes for the application of a collaborative approach and in doing so conceptualises collaboration as an exceptional and applicable event. Through a longitudinal case study consisting of 4 years of participant observation, this study adopts a micro-practices approach to reconceptualise collaboration as an ongoing accomplishment. This study takes a novel look toward institutional theory to understand how micro-practices of collaborative behaviour are shaped by macro-institutional logics, particularly as institutional theory tends not to consider such intra-organisational processes. It follows the implementation of three improvement initiatives designed to enhance collaborative working for the purposes of service improvement. Findings revealed tensions between regulatory and cognitive institutional logics; tensions that were observed to impact negatively on service delivery, particularly given the non-relation contractual arrangements employed to procure and govern service provision. This paper proposes an alternative approach to service improvement that addresses the failure to recognise conflicting logics, understand why conflict arises and effectively manage the consequences, particularly in adversarial environments. This paper contributes to our understanding of collaboration within construction management literature whilst attending to its oversight of institutional theory.

Keywords: collaboration, institutional theory, highway maintenance, micro-practice

INTRODUCTION

The UK has an aging transport infrastructure asset with many areas suffering from historic under-investment, a problematic situation compounded by long-term trends of growing road traffic (HM Treasury 2014). Cash strapped local authorities unable to meet financial demands for the development and maintenance of its infrastructure assets (Odoemena and Horita 2017) has seen the rise of partnerships between the public and private sector (PPPs and PFIs) as alternate ways are sought to finance the work needed to keep the UK’s roads operational. PFI contracts have received much media attention with disputes over performance common, which does little to address the adversarial reputation of the industry. Lengthy contract terms, often stretching in decades bring an inevitability of uncertainty and highlight many of the limitations of such contracts (Garvin 2009). Other procurement arrangements of around 5 years in length (typical of strategic road network maintenance contracts) bring alternative challenges in the guise of frequently changing service providers and the TUPE of contract staff. Nationally (with

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very few exceptions) these works are procured under contracts that do not make provisions for collaborative working practices with no signs of partnering becoming a dominate choice (Phua 2006).

The construction industry as a whole is characterised by litigation and adversary with a raft of reports such as Construction the Team (Latham 1994) and Rethinking Construction (Egan 1998), Accelerating Change (Egan 2002) and more recently Modernise or Die (Farmer 2016) which talks of the industry’s collaboration problem. The answer they all have in common - to collaborate more. More and better collaboration would allow us to deal with the complexity faced (Walker et al., 2017). Working collaboratively has been linked to better performance in a construction context (Greenwood and Wu 2012) and whilst the benefits of a collaborative approach are widely accepted and there is a willingness within the industry to implement collaborative approaches to working, the application is not profound. Solutions to major problems are often ad hoc ‘bolt-on’ elements (Anvuur and Kumaraswamy 2008). Firms often show willing to experiment with a suite of tools and techniques but are either unwilling or unable to instil a culture of collaboration (Boyce et al., 2012) with the potential impact of team building hindered by the ‘formalisation’ of collaborative practices (Suprapto et al., 2015, 1357). This research arises from an interest in collaboration within a highways maintenance setting for the following reasons: (1) fragmentation of the multifaceted service arrangement and the siloed approach to deliver, (2) adversarial client/service provider relationships and the effects on internal project teams, (3) hypothetical value attributed to collaboration as a key strategy element, (4) a lack of empirical research into the detailed practices through which collaboration is mobilised by organisational members and (5) failure of Construction Management Research (CMR) to effectively consider connections between macro institutional factors and micro-practices (M-P) of collaboration. The fundamental question this research seeks to answer is how can collaborative relationships be managed to better support service delivery?

LITERATURE

Applicability of Collaboration

Collaboration is defined here as the coming together of resources to jointly develop solutions. A review of the research that deals with collaboration reveals a commonality; prescriptive recommendations based largely on the experience of isolated success stories are dominated by accounts of the application of tools and techniques (Green 2006). The prevalent neo-institutional, macro views of collaboration are concerned with meta-analyses that document antecedents and provide normative explanations (Suddaby et al., 2013) and treats collaboration as an exogenously created phenomena. In this sense, collaboration is conceptualised narrowly as something that can be externally created and applied to situations under specific condition by certain people, for example consultants, or collaboration conveners (London and Pablo 2017). Far from being externally created and applied we argue that collaborative working is a phenomenon socially constructed from within organisations by the actors involved. Collaboration is often depicted as a set of specific behavioural and contractual actions and obligations, each of which can be codified and evidenced through as outcomes achieved (Suprapto et al., 2015; Kovacic and Filzmoser 2014). Practically, firms often show willing to experiment with a suite of tools and techniques but are either unwilling or unable to build a sense of joint belonging or to instil a culture of collaboration (Hietajarvi and Aaltonen 2017) with the potential impact of team building hindered by the ‘formalisation’ of collaborative practices (Suprapto et al., 2015, 1357). The relationship between collaboration and organisational processes
tends only to be discussed to the extent to which the processes render it operable. Collaborative planning methodologies, such as The Last Planner (Ballard 1994), and BS11000 and ISO44001 are prime examples of this where people are mere users of the systems and occupants of space whose activities were never described (Ahrens and Chapman 2007). Ahrens and Chapman (2007) describe the rhetoric of collaboration and the practice of collaborative behaviour and conclude that doing and saying are fundamentally different, or put another way, formal narratives of organisation change are different to the lived reality (Löwstedt and Räisänen 2012). Just as an application of technology cannot increase or decrease productivity or performance (Orlikowski 2000), collaboration will not simply occur through the colocation of people (Kokkonen 2017), particularly when the unique characteristics of the case receiving the transplant are not considered. Difficulties in realising collaborative change arise when new action is inconsistent with the latent understanding of how the organisation operates (Feldman 2003).

**Micro-Practices of Collaboration**

Treating collaboration as applicable and taking a prescriptive approach assumes that collaboration can applied to a situation whilst all other factors remain constant. Despite their mundane nature, routines and conversations are elementary forms of daily life and richer picture are provided when routines are not separated from the people applying them (Feldman 2000). As a microscope aids an understanding of the whole through its tiny parts, routines and conversations offer an interesting insight to examine strategic change (Rouleau 2005). The benefit of refocusing on M-P to reveal otherwise hidden knowledge is explained via Tsoukas and Chia’s analogy of a tightrope walker (Tsoukas and Chia 2002) but applied to a car travelling along a motorway. If the focus of analysis is upon the car, it may be viewed as stable as it travels within the lane markings at a constant speed. But if the level of analysis is reduced to the driver it becomes possible to observe the constant adjustments made to the steering wheel, the rise and fall of the foot on the accelerator pedal and the eyes that make regular glances to the mirrors to check for other road users. At certain levels of analysis stability can be seen and yet at another levels high degrees of dynamism are apparent, highlighting the importance of both the macro and micro view and a need to include the occupants of the space in any analysis of the collaborative application and failure to achieve this carries the potential for distorted view of stability. As such, methods designed to support collaborative working do not account for the intricate networks people build to collaborate around more complex issues. Understanding how this happens is crucial for understanding how actors organise themselves and the consequences this has for the organisation centrally (Tello-Rozas et al., 2015).

**An Institutional Perspective**

The study of institutional processes and institutionalisation arose as researchers sought to explain and predict commonality across organised systems (Osborn and Hagedoorn 1997). Institutional theorists shift levels of analysis to enquire how institutional features shape organisational structures and to examine the determinants of institutional systems themselves (Scott 1987, 508). It is impossible to understand an institution adequately without understanding the historical process in which it was produced (Scott 1987). A facet of institutionalisation is the process of instilling value: ‘to institutionalise is to infuse with value beyond the technical requirements of the task in hand’ (Selznick 1957, 17). As such, institutionalised organisations have become more than just the producers of things, they are the product of interactions, receptacles of group idealism (Scott 1987).
Institutional features of organisational environments shape both the goals and means of actors (Scott 1987) therefore it is important to understand what these features are and how they shape what actors do and why they do it. In the context of this study institutional theory is used to explain why collaborative working remains elusive despite a common rhetoric to be collaborative. The concept of M-P observation to understand how change can be realised at the macro-level exists (Tello-Rozas et al., 2015), as does a rich body of literature regarding institutional forces forming and shaping organisational structures which in turn affects the M-P but it mostly resides in Business Management Research and is largely absent in CMR (Bresnen 2017). Linking the two together in a single study offers novelty whilst practically unravelling the mismatch between collaboration rhetoric and practice.

There are two distinct theoretical approaches to institutionalisation; the environment as the institution and the organisation as the institution. The former approach sets the wider ‘state-project’ environment as the creator of the institution. This ‘statist’ view asserts that organisations merely reproduce the institutions created within the environment (Zucker 1987). As such, organisations conform to the collective normative order in a sector wide reproduction of basic processes. The statist view which asserts that only external elements can be institutional creates theoretical obstacles, not least because the creation of new social order is problematic (Zucker 1987). The opposing theoretical approach is that institutional elements arise from within the organisation or from imitation of other similar organisations but not from the state or elsewhere (Zucker 1987). This concept of institution reproduction can help to explain the disconnect between rhetoric to be collaborative and the actuality of adversary. ‘People draw on a variety of structures to inform how they perform a specific routine and the same performances can give meaning to a variety of routines or processes for accomplishing work’ (Feldman 2003, 747).

Simultaneously drawing on the organisational level values to be collaborative (which align with personal values to do a good job) whilst performing activities in accordance with a non-relational, zero-sum contractual environment (where your loss is my gain) creates tension at the micro-level of project delivery. But tension does not have to be unmanageable. In a specifically collaborative context, London and Pablo’s (2017) review of meta-analyses suggests effective collaboration should lead participants toward coherence (rather than conformity) to exploit the potential for innovation as a result of contradictory ideas. One-sided responses that seek consistency in response to organizational tensions may spur vicious cycles whereby negative effects are reinforced. Conversely, an acceptance of tensions that embraces both sides may create virtuous cycles leading to sustainable development (Szentes 2017). In line with Phua’s (2006) discussion of partnering, when firms rationalise that benefits are to be gained by following an industry norm, in this case to act collaboratively, the presence of such practice will likely increase. We argue here that firms do rationalise the benefits of collaborative behaviour but while the industrial institution to be adversarial dominates, any institutional force to be collaborate, will continue to compete/be in tension with it/be less dominant. ‘Institutional elements are easily transmitted to newcomers, are maintained over long periods of time without further justification or elaboration, and are highly resistant to change’ (Zucker 1987, 446). Here the approach ought to be about managing the tension between conflicting institutions rather than an attempt to overpower or eliminate the force perceived as problematic. In this vein, (Uhl-Bien et al., 2007) in their conceptual framework of the three entangled leadership roles (i.e., adaptive leadership, administrative leadership, and enabling leadership) reflect a dynamic relationship between the bureaucratic, administrative functions of the organization (or
regulatory) and the emergent, informal dynamics of complex adaptive systems (CAS) (or cognitive). To manage a dynamic relationship between the potential conflict first requires a recognition of the tension.

**METHOD**

Over a four-year period of participant observation, this study followed the implementation of three improvement initiatives designed to enhance collaborative working for the purposes of service improvement. All cases were within the same organisation, a private sector provider of highway maintenance and management services to the public sector in the UK. The researcher assumed the role of a participatory observer with intention of observing existing practice and affecting change. To achieve this, the researcher assumed a variety of roles within a fieldwork situation and participated in many of the actions studied (Yin, 2014). Throughout this period the researcher had extensive and intensive contact with members of the contracts under investigation as well as considerable contact with others across the organisation. In general, the researcher spent around 40 hours per week as an embedded researcher within the organisation. The researcher had a desk within the company, access to archival documents the same as any other employee and was granted an organisational email account and could communicate with others as an employee. Benefits of this approach included access to groups and events that would otherwise have been inaccessible to study and an ability to perceive reality as someone on the “inside” described as ‘invaluable in producing an accurate portrayal of a case phenomenon’ (Yin, 2014).

Focus groups, an infrequently mentioned data collection technique but an effective tool particularly for those studying work environments and associated behaviours (Frey and Fontana 1991), were held to further investigate the themes that emerged. A root cause analysis approach was adopted in the third case to unearth the underlying issues of the topics identified. The researcher facilitated 26 sessions of between one and three hours in duration and engaged with 66 individuals. Focus group participants consisted of office and site-based operatives, engineers, project managers and commercial managers and benefit was drawn from the stimulation and opinion elaboration that the group dynamics permitted (Frey and Fontana, 1991). Listening to what people say was important; how people talk has profound implications for how they think and act (Orlikowski 2000). All sessions were facilitated by the same researcher which allowed for internal consistency and equivalence (Kidd and Parshall 2000).

To support the continuous real time data collection retrospective interviews and expert verification was undertaken. Unstructured, conversational style interviews that gave a sense of openness were employed; sometimes exploratory and at other times, confirmatory. When conducting and analysing interview data consideration was paid to the notion that actors’ accounts of their own activities are categorically unlike the complex cognitive processes they go through to accomplish them (Ahrens and Chapman 2007). As such, multiple methods were used to triangulate the data (Lee 1999, 94). The researcher was privy to many discussions of a strategic and confidential nature. In addition, the embedded nature of the researcher exposed the researcher to many unsolicited conversations in the form of company gossip and “off the record” accounts of participants’ observations and reactions to daily life told directly to the researcher and overheard.
FINDINGS AND DISCUSSION

Case one involved participant observation of an initiative to improve the performance of highway engineers designing strategic highway renewal schemes in the Midlands. The works were procured via a contract which combined lump-sum fees with cost reimbursable elements. It was felt that the teams had a wide range of capabilities but was failing to effectively structure them through the project delivery phase which prompted the intervention described here. Collaborative planning was the solution adopted by senior managers to address this problem and an external consultant was appointed to manage the process. Weekly meetings lasting around three hours followed The Last Planner (Ballard 1994) methodology whereby task lists were generated and planned works versus actual work was analysed. The representatives from the design teams rotated in and out of the meetings to report on the progress of the schemes they were working on. Collaborative planning revealed process deviation and prompted efforts to ensure designers adhered to the documented process (regulatory institutions at play). Observations revealed that the collaboration planning process failed to account for the cognitive institutions whereby design teams would collaborate “behind the scenes” to devise locally optimal solutions and work-arounds in order to appear to be adhering to official processes whilst continuing to operate as they saw fit. A preoccupation with the application of such a method failed to fully understand the factors that led to the organisational conditions that prompted the collaborative planning intervention. Those who had defined the problems and agreed on the solution did so in the absence of a systematic investigation to analyse the root causes of the problem they were attempting to resolve.

The tools explored in Case one provided a useful account of the merits and demerits such techniques have on management practices but they were found to be unhelpful for contingent circumstances thereby conceptualising collaborative practice as externally created an applicable. While such techniques provide social networking opportunities the findings show that bringing people together is not the end but is the means for further necessary changes which vitally requires an understanding of the knowledge possessed and embedded. In line with other studies softer issues tended not to be appreciated, or were actively ignored (Newell et al., 2006) and off the shelf collaborative tools did little to understand the embedded business as usual attitudes. A micro-practices approach that draws on institutional theory to help unravel the multiple and complex behaviours that impact project performance was called for.

Case two adopted a micro-practices approach to observe the operational delivery of highway maintenance and renewal of the strategic road network in the East of England, procured under a transaction lump-sum contractual arrangement. In this case the client-supplier relationship was reported to have quickly become adversarial as contractual compliance was employed as the preferred method to govern the delivery of services. Interviews revealed regulatory institutions to dominate and suppress cognitive desires to collaborate. Participant observation of the micro-practice of daily interactions was conducted during a collaborative ‘transformation project’ initiated to address the rising level of dissatisfaction in the perceived quality of the services provided. The transformation project was designed and facilitated by an external consultant as a ‘bolt-on’ solution to business as usual activities. Despite initial improvements in service delivery and an increase in satisfaction, when the consultant withdrew, the transformation project failed to be sustained and ultimately the mutual decision to terminate the contract early was taken.
Highway maintenance involving reactionary work in response to defects arising on the network was seen to create tensions for project participants that must manage the conflict between cognitive forces encouraging the development of innovative solutions and the regulatory pressures that confines them to prescribed design fees and contractual obligations. Case two observed the consequences of these tensions and the failed attempt to restore collaborative working practices. Interviews and observations carried out suggested that the transformation project was too little too late. The implication for this study was to investigate further how collaborative working practices can be operationalised to avoid reactionary applications as a response to rising adversary. Doing so called for a reconceptualization of collaboration as an ongoing accomplishment and not as an end goal (Marshall 2014).

Case three involved the operational delivery of highway maintenance services on behalf of a local authority in the Midlands, governed by a PFI contracting arrangement with hundreds of contractual obligations linked directly to service payments. Interviews revealed historically, interactions between project participants occurred at a time when actions by managers promoted organisational competition between teams through a fear of sever financial deductions in connection with any underperformance/failure to meet the obligations set out in the contract. For example, previous management style was to highlight areas of underperformance in meetings that became known as “white board beatings” and were described by staff as follows:

You wouldn’t believe that people would do those things to people’ and ‘it was the humiliation. And the language was beyond belief...and loud and aggressive and ‘I never got the wrath of him but I was scared of him. [We] would hide problems because we couldn’t risk the humiliation of raising them.

Case three observed the design and implementation of a Service Improvement Plan (SIP) initiated in response to high levels of financial deductions levied by the client for failures to meet contractual obligation. The focus group approach permitted the design of the SIP to delve into the underlying circumstances by going beyond an examination of the symptoms (that manifested as non-compliance deductions) to an understanding, guided by institutionalisation, of how micro-practice at the operational level is affected by macro-institutional forces. A micro-practice investigation confirmed collaborative practice not as an exceptional event but as a normal part of everyday life. People were observed to collaborate informally to develop solutions to the problems they faced in everyday delivery of their responsibilities. Case three uncovered teams driven by a fear of financial deductions to compete against one another to not be the worst performer. A siloed approach resulted, reinforced by regulatory institutions to meet project targets, which made the flow of knowledge across teams problematic. As such, localised solutions that unwittingly created problems elsewhere were rift. Again, triggered by collective social recognition of the problem, which manifested as significant financial deduction, led to the initiation of a contract wide collaboratively designed SIP. As depicted in figure 1, the difference in this case was the time invested upfront to deeply understand the underlying circumstances. As such, support was reformed to provide bespoke solutions for collaborative working to take hold in a sustainable way.

**CONCLUSION**

Lounsbury and Crumley (2007) set out a process model for new practice creation which identifies the point at which new fields of practice begin to be developed. In their model, they identify a trigger point as the social recognition that existing practice is problematic. Observations of the three initiatives described above suggest their model does not account
for what happens when irregularities in practice are socially recognised and the boundaries of practice are redrawn but attempts made to alter practice are then resisted and existing practice is not substantively changed. In response, an adapted model is presented in figure 1 with an additional trigger point. For the alternative practice to be sustained and for revisions to extant practice to occur requires a deep understanding of the problem that the alternative practice is attempting to alter.

Figure 1: New Practice Creation

Case one observed the implementation of a collaborative planning solution, triggered by a recognition that documented processes were not adhered to and a failure to structure capabilities of the team through the design process created inappropriate variations to accepted practice. The approach was to reinforce the extant practice, as shown in figure 1. Case two also experienced inappropriate variations to accepted practice and in response initiated a collaborative transformation project to alter rather than reinforce extant practice. For the reasons discussed above this approach resulted in improvements but were unsustainable and the alternative practice was ultimately rejected. Cases 1 and 2 showed reactionary tendencies toward improvement initiatives; at the point where a problem was socially recognised a solution was selected and rolled out before a thorough assessment of the problem had been achieved. These findings introduced the notion that an understanding of macro institutional factors can be the mechanism through which collaboration can be viewed as an ongoing accomplishment. Building on this learning, Case 3 saw the design and implementation of an initiative to collaboratively develop improvement solutions that would alter business as usual and accepted practice through a consideration of the wider institutionalised factors that shape micro-practices of collaboration. This paper moves beyond an assertion that, through institutional theory, values are instilled (Scott 1987) to an understanding of how this occurs. By placing greater emphasis on the character of the institutional structures that constrain the choices individuals make (Zucker 1987, 459) it is possible that leadership can work to minimise and mitigate the institutions effects.

REFERENCES


DEVELOPING SAFETY COOPERATION IN CONSTRUCTION: BETWEEN FACILITATING INDEPENDENCE AND TIGHTENING THE GRIP

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Attempts at implementing and maintaining rules to avoid risks and prevent injuries prove difficult in construction. Cooperation about safety between managers and workers in construction runs the risk of focusing on formalities rather than on engaged collaboration in establishing safe working practices. Drawing on an understanding of safety as practice, built from interwoven patterns of different forms of knowledges, this study attempts to empirically unpack the difference between fragmentation (disciplining unsafe behaviour) and integration (engaging with local knowledges) regarding safety. The research involved an ethnographic study at two large construction sites in Denmark. The study follows empirical examples of how safety breaches are identified, catalogued and then revealed later on at safety meetings. Managers saw this as an attempt to 'learn from mistakes' and engage the workers in collaborative practices. However, from the workers perspective it was effectively a punitive way of criticising their work at a distance, and they, in turn, felt this practice and the safety meetings ran counter to establishing collaborative safety practices on site. Efforts to engage workers in safer ways of working should therefore acknowledge the integrated nature of safety practice and the value placed on independence when engaging in collaborative practices regarding workplace safety.

Keywords: collaboration, cooperation, ethnography, health and safety, risk

INTRODUCTION

Background

Construction is one of the industries in Europe that still has high numbers of occupational accidents (Eurostat 2010) and Danish construction is no exception (Tómasson et al., 2011). In addition to fatal accidents, addressing less severe injuries represent a moral as well as economic challenge with regard to health and wellbeing at work. Over the years the Working Environment Regulations have become an essential tool for attempts to reduce workplace accidents and improve health and safety at work (i.e. Treaty on the Functioning of the European Union article 153; Work environment Act 2010; Zwetsloot et al., 2017).

Efforts to introduce safer working environments in construction have included not only statutory injunctions, but also safety management and safety culture programs. Yet these have proved difficult to put into practice due to the fact that construction industry organization and working conditions differ from other industries (e.g. Wilson 1989), with...
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regards to environmental, organizational and individual factors (Shipton et al., 2014; Andersen et al., 2015; Törner and Pousette 2009). Formal safety rules stand in contrast to the ways in which work environment and safety are practiced (Thiel 2007; Oz mec et al., 2015), as these often do not match the craftsmen's experience of what establishes a sense of security, influence and freedom in their work (Grytnes 2018; Pedersen 2012; Bourrier and Bieder 2013). Safety in the construction industry becomes a topic of conflict; craftsmen, for example, find that management's talk of safety equals control and monitoring of their work (Sherratt et al., 2013; Andersen et al., 2015).

The statutory intention to foster a common responsibility for a healthy and safe working environment through involvement of all labour market parties parallels an increased focus on behaviour based safety management and an increased professionalization of health and safety work which has led to standardization and measuring of safety through audits and risk evaluations (i.e. Daudigeos et al., 2017). It is actively debated whether the application of rules and procedures to ensure safety has any positive effect in construction (Hasle et al., 2014; Grote et al., 2009; Bourrier 2013; Kines et al., 20013; Zalk et al., 2011; Dekker 2014; Jeschke et al., 2017). As construction work is characterized with high levels of insecurity, where it is difficult to predict how the work processes will unfold, Grote et al., (2009) point to the need for high levels of flexibility, and contrast this to organizations with greater predictability who benefit greatly from standardization.

However, while flexibility allows for discretion on behalf of individual workers, at the same time it also opens up the potential for individual misjudgement and unwanted incidents. In many high risk industries, standardized risk management systems are established (off shore, aviation) but high standardization also runs the risk of hindering the workers in establishing ownership to strongly regulated work procedures and risk regimes (ibid). Especially in construction, registration of misses and near-misses, or tight safety regulation aimed at 'learning from mistakes' seems to have the opposite effect and instead demotivates workers (Andersen et al., 2015; Bourrier 2013; Grytnes 2018; Sherratt et al., 2013). The reason seems to be that safety rules and regulations become decoupled from the daily meaningful handling of tasks and challenges (Gherardi et al., 1998; Gherardi et al., 2002; Oz mec 2015). At the same time involvement of workers is generally acknowledged as a central factor when it comes to improving safety (DeJoy 2005; Lund and Aarø 2004; Grill et al., 2017).

However difficult, the importance of applying an inclusive understanding of what safety is and how it is achieved seems pertinent, as social relations, work practices and local meanings are at stake. Sherratt et al., (2013) point to the two discursive practices of 'enforcement' and 'engagement' in the management of safety and, as will be argued, this seems to mirror findings in this study.

Theoretical Perspective

In the analysis we draw on an understanding of safety as an integrative and essentially collective practice (Gherardi et al., 1998) and as such safety is not something in itself (i.e. privileged or standalone knowledge); it is rather a doing, an integrated part of how things are done. Pink et al., (2010) draw attention to the importance of an understanding of safety as 'local knowledge'. Therefore, to understand what construction workers 'know' requires attention to the detail of their everyday practical activities, common beliefs, values and discourses in which this knowledge is manifested, as contextualised in specific institutional practices (Pink et al., 2010: 651). This perspective considers safety knowledge as something dynamic, diverse and sometimes contested (Pottier 2003), which at the same time challenges the organizational practice of standardizing safety.
Empirically however, 'local knowledge' can be difficult to pinpoint given that the concept of a locality is itself difficult to apply to the realities of construction sites. Studying safety practice in construction, suggests an understanding of knowing as a practice constituted through regular interactions with specific other people (other workers, managers), materialities (tools, equipment, materials), institutions (companies, agencies) and discourses (Nicolini and Monteiro 2017). It thus involves interacting in a recognizable environment that might be reconstituted in rather different configurations for different jobs, rather than in a determined locality. There is therefore a situated body of construction knowing, experienced and mobilized in practice.

To understand the contested and essentially powered nature of the management of safety, we draw on Foucault's (1977) theory of disciplinary power. Building out of a description of Bentham’s eighteenth-century prison design called the Panopticon, it helps explain how surveillance can lead to self-surveillance and self-monitoring. The practice of observation (the gaze) can, through the anticipation of the authoritative gaze, introduce self-regulating behaviour and self-surveillance of subjects (interiorization). Foucault writes of the institutional gaze, “the meticulousness of the regulations, the fussiness of the inspections, the supervision of the smallest fragment of life and of the body” (Foucault, 1977: 140). For the workers, it is understandable that such systems are seen to represent “a meticulous observation of detail, and at the same time a political awareness of these small things, for the control and use of men” (141), as opposed to the improvement of their safety.

Yet, as we will discuss, this inspecting gaze does not necessarily end by “interiorization to the point that he is his own overseer” with each worker exercising this surveillance over, and against, him/herself and other workers (154). In other words, rather than incorporation into an individual’s self, workers can still voice a resistance to internalise this practice as a norm.

Drawing on an understanding of safety as practice, built from interwoven patterns of different forms of knowledges this study attempts to empirically unpack the difference between fragmentation (disciplining unsafe behaviour) and integration (engaging with local knowledges) regarding safety.

Methods

The analysis is based on ethnographic fieldwork, drawing on a qualitative multi case study of two large construction sites in Denmark. Site 1 was part of a larger hospital construction organised as a turnkey contract, with several sub-contractors. At the time of our study approximately 40 workers and 4-5 subcontractors were on site. Site 2 was organized as a turnkey contract as well, but was also a so called public-private cooperation, where the contractor had responsibility for the maintenance of the building 15 years after completion of the project. Around 30 workers from 4 different sub-contractors were at the site at the time of our study, but it was in the early phases of the project and the majority of the workers were in-house employees doing concrete work. Site 1 was recruited through a meeting initiated by the builder after which the main contractor of one of the projects volunteered to participate. Site 2 was recruited through direct contact with the site manager who agreed to participate after a meeting where the project was presented. The study was conducted first at site 1 and next at site 2, and first and last author spent one or two days a week at each site during 4 months. Ethnographic methods were used. We attended safety meetings and production meetings, and took part in site walks with the safety managers (both in house and consulting advisors). Aside from these forms of participation we walked around the site by ourselves, talking to
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different construction personnel at work. Semi-structured interviews were conducted with gangers, foremen, site managers and site safety managers and sub-contractors, with advisory engineers, builders and health and safety directors; in all 40 interviews.

Data (field notes and transcriptions of the interviews) were analysed with the aim of gaining knowledge about the context in which differences in safety perceptions and cooperation about safety unfold. After reading all the written data material, the software program NVivo 11 was used for initial coding and categorization of the material. Coding was performed deductively as well as inductively and themes and relations between them were discussed and developed by the authors in collaboration. The main categories that related to the informants' perception of safety cooperation were: prevention of accidents, notions of risk, the difference between cooperation and collaboration. In order to focus on the details and structures of everyday interactions and cooperation in which these notions were acted out, we coded and analysed these as 'situations'. The analysis involved coding as well as discussion of categories and application of theoretical framework in order to illuminate how local knowledge of risk and safety were at stake in a relation to the powered nature of safety management. The coding and analysis pointed to differences as to what safety pertains to and how it is achieved. In the analysis citations and descriptions are used as illustrations of themes and patterns across the data material.

In an effort to juxtapose and connect different forms of data, the analysis draws on data from both interviews and field notes across the two sites.

ANALYSIS

Safety Meetings: Procedure or Engagement?

Safety meetings held every fortnight function as a structuring principle for safety cooperation between representatives from management and workers and are intended to involve the partners in safety at the site. At the two sites the safety manager of the main contractor runs the meetings following a relatively formalised schedule for the meetings. They always start with the minutes from the last meeting, and move on to issues like: staffing, start-up of new workers, status and progress of the work from each contractor, measures taken since last meeting, accidents and near-misses, any reactions or issues from the Labour Inspectorate and so forth. Meetings were mostly retrospective, passing on information and agreements that had already been taken. Yet attempts to involve workers in decisions, drawing on their knowledge and experience, was also present in places as the following extract from the field notes illustrate:

Towards the end of the meeting the safety manager turns to the site walks: 'It still looks very nice', he says, 'there is a staircase that is missing cover, but it has been arranged'. He praises one of the sub-contractors for purchasing an electric-powered truck to drive inside the building. 'We have water on the floor' - what do we do?' he says. He seems to try to engage the participants in dialogue, and they reach a solution together: they agree to lay out sand, to absorb the water. (Notes from Site 1)

As the example illustrates the manager attempted to engage in dialogue about safety by consulting with the workers about solutions to on-site situations that might cause risk and therefore accidents. The intent was to engage with, but also educate, people about risk prevention, by praising their efforts and guiding their vision.

During these meetings the participants were mostly silent, only saying something when asked to. Safety knowledge in these meetings are communicated as 'risks'; of not using the designated access roads, of falling due to cables lying around, but also of practical
problem-solving and getting ideas from the workers about how to deal with water on the concrete floor during the freezing winter period.

At Site 1, the main contractor ran weekly 'canteen meetings' in addition to the safety meetings. These meetings took place during the morning break when all workers were present. According to the safety manager, the aim of these meetings was to involve the workers from different sub-contractors more directly and to facilitate dialogue between the workers. Ahead of the meetings, the safety manager walked the worksite and rated different target points related to health and safety at the site using an online rating system available on an iPad. At times during the walk, he approached the workers directly if something 'risky' caught his attention, but at other times he just registered the issue for the next meeting, where he used pictures to illustrate safety breaches or areas for improvement. He also complimented the workers if safety standards were kept, e.g. in relation to clearing the access roads on the site.

The canteen meetings provoked different reactions from the sub-contractors. Some felt the meetings strengthened relations across different contractors, but the practice of showing pictures of situations, where some sort of breach of rules had taken place, was largely seen as counterproductive in relation to safety, and one of the workers asked us: "how can showing the pictures at meetings two days later, improve safety? Instead of embarrassing me at the meeting, he should get to me on the spot, so I could've corrected it". This illustrates that understandings of safety, as well as what it takes to cooperate about safety, are contested; is safety about correcting behaviour through a disciplinary power of surveillance or are other contextualized practices at stake?

This situation illustrates how the power of management (to punish), is dependent on the knowledge (safety knowledge which classifies poor behaviour), and this knowledge takes on its authority because of the uneven power relationships with the workers (Foucault 1980). Part of this disciplinary apparatus is the meeting through which the knowledge is legitimized by experts/authorities in the way the identified safety breaches have been withheld and then revealed to the workers.

Safety: Disciplining or Engaging with the Unsafe?

The questions of how to balance the different understandings of the best ways to manage safety risk, and how to promote safer working conditions, were often themes of our conversations with the workers during observations. For a period of two weeks we followed workers at Site 2 who mounted concrete decks and walls three storeys up the building. They described trust in colleagues and knowledge of their work tasks and whereabouts as essential for their sense of security in what they did. They followed a certain procedure for installing safety as they worked; edge protection was installed as part of finalizing the deck, since it would take some time before walls were in place. Earlier, when installing the edge protection they used safety lines, a so called "yo-yo", but at some point we noticed that one of the workers installed the edge protection without using the yo-yo. The safety manager happened to come by, and immediately called him over to ask where his protection was. The incident resulted in a disciplinary talk with the two colleagues, their foreman and the safety manager. The worker explained his behaviour by claiming that they had asked the foreman for additional yo-yo's and when these did not arrive, they reasoned that the company did not see this as imperative. The foreman on the other hand felt this was an unjust accusation as he felt that the workers should know his prioritization of safety. He claimed that he had heard nothing about the missing yo-yo's. In his mind, the safety line was not used because, he said, "they don't feel it is risky". Safety, in the sense of the security of being protected from harm, is not a
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standalone entity, but a relational practice of trust contingent on diverse aspects, including the availability of materials as well as power relations in companies.

Later, when discussing the incident with the workers, one of them sarcastically said that he would not talk to us because we had 'stabbed him' to the management. While he said it in a joking manner, he mentioned it again and again. We explained that we had not said anything to management, but this distrust highlighted how our own 'inspecting gaze' had (unwittingly) been linked with the system of safety surveillance (and discipline) onsite. His team claimed they had asked for the safety lines and, when it did not arrive, they reasoned it was because the company would save money. Therefore, they felt it was a joke when the foreman said that they had not asked for it and to "just ask if you needed something". They did not think there was much of a conversation to be had with the management, "it was more like being stopped by the police for speed driving" (Notes from Site 2).

This example illustrates how safety can become rarefied and distanced from the everyday concerns of the workers, and judgements of their way of handling the task were made from a position of disciplinary power; from the health and safety professional function. As such, risks were isolated, fragmented from the work practice. According to the workers, this judgement is devoid of the context of the work and becomes a dispute on words and credibility. The incident illustrates how safety can become a ground for debate and conflict, as safety knowledge can be used for positioning and blaming others in relation to safety onsite.

**Between Facilitating Independence or Tightening the Grip**

As illustrated safety is a practice related to and informed by different positions but is also a part of hierarchies and structuring processes at the construction site. Cooperation about safety is intended to involve all construction parties and is sanctioned by law, but in this is also a dilemma; some notions about safety and risk are considered to be safer than others, and the different perspectives of independence and control become evident. The following quote from a group interview with workers from one of the subcontractors helps illuminate this:

**Interviewer:** In your experience, what is essential for the construction site safety?

**Electrician:** It is if there is a sensible flow, a balance, between how safety is perceived and how it is performed. If you go for 110% safety, and do it 110% and crack down on all incidents, the site will never run. I do not say you have to compromise on safety, but there has to be a certain room for manoeuvre. You must find the middle ground. There is no use in everyone bashing each other's heads, and finding things you should not do. As an example, I have just been at a site, and the first thing we should do was to take a safety license to get in there. In order to redeem our license, we had to go to the site and find one of the other craftsmen who had made a mistake and take a photo of it. It isn't a very good thing to do. That's what I think. It doesn't provide a good environment, and it doesn't spark a good environment for cooperation if you start off like that. But, otherwise we couldn't get our license card. You have to inform on colleagues to be allowed to work there. I don't like that. (Interview with workers from sub-contractor)

This example reinforces the notion of the contra productiveness of 'picture showing' already seen in the example with the canteen meetings, and in this situation the workers feel that they are also drawn into this way of identifying faults and risks as a way of showing their understanding of safety. This points to how safety knowledge is wielded. Safety breaches are catalogued (identified, concealed and then revealed) not only by
management, but also by colleagues in order to demonstrate their understanding of company views and this represents a means of rarefying safety and becomes a management function; a (privileged) way of seeing and a knowledgebase used to admonish. From the safety management's perspective, pointing out mishaps and errors onsite is understood as a general practice, and not something directed at individuals. Yet from the view of the workers, this practice amounts to a punishment preventing their engagement or learning.

The interview extract also raises the question of whether finding faults and violations of rules is a way of achieving safety. There seems to be two different logics at stake; one is about learning as a generalized practice, the logic being that something happened - it does not matter who did what - the important issue is for the organisation to draw general conclusions, and to point out new directions for action on that basis. The other is an approach based on an understanding of incidents as situated in a local practice where actions are understood as part of practices embedded in professional power relations. The first logic is based on a theoretical and fragmented understanding of learning from mistakes, but the challenge in this setting is that workers from different sub-contractors draws on the second logic and do not have the organizational sense of belonging, that the first logic presupposes.

Again, in relation to Foucault, this can be seen as an attempt to engage individual workers in self-surveillance and self-discipline. Workers described these actions as “informing on colleagues” and “pointing out an error”. In this way, a culture of monitoring and reporting on unsafe actions, poor workmanship, corner-cutting and indiscretions, may represent a proactive safety culture. Even in articulating their displeasure and unease with this approach, the workers acknowledge that it is “finding faults”. Yet, it is also an example of power normalised through everyday practice which Foucault (1978), in relation to the managing a population, terms "biopower". These practices do not seem to represent ‘docile bodies’ enacting a change in safety culture. Rather, there is resistance to this being good safety practice, but a resignation that "it's how it is" to work construction here.

Such forms of ‘horizontal monitoring’ may be premised on enhancing worker engagement and empowerment, but Graham Sewell’s work (1998; 2012) shows how such disciplinary apparatus can operate to reward high performers and expose others and that workers are very conscious of conflicts in managerial discourse. Rather than a democratic practice, it can become a process “whereby pressure peer enforces management-inspired group norms on an individual basis” (Zureik 2003: 44).

CONCLUSIONS

This study taps into the discussion of whether safety in construction is achieved through engagement or enforcement, or rather how these two perspectives unfold empirically. Through a perspective of safety as a local practice it has been pointed out how safety tends to be legitimised as a privileged risk oriented vision, used to admonish workers. It has been shown how managers attempted to engage the workers through participating in meetings and taking photos of 'mistakes', and how workers saw this as a punitive way of criticising their work at a distance. They, in turn, felt this practice ran counter to establishing collaborative safety practices on site. Identifying mistakes and faults through an inspecting gaze is something that workers are resigned to accepting onsite, and yet they effectively reject it as meaningfully contributing to safe practice. Rather than an interiorizing this understanding of safety workers voice a resistance to internalise this practice as a norm.
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Based on ethnographic data the analysis has empirically unpacked the difference between disciplining unsafe behaviour where behaviour is judged on the basis of standardized norms of risk (fragmentation) and engaging with dynamic and local knowledges integrated in personal, material and organizational practices. Applying the Foucauldian notion of discipline allows for an understanding of the hierarchy of safety understandings in the context of a construction company, and at the same time it sheds light on the 'rule-breaking' practice, as workers do not always see the behaviour sanctioned by the management as producing better health and safety onsite. Even if facilitating independence and collaboration among workers was an aim for the main contractor, these efforts were countered by a sense of being watched or blamed. These judgements were made through a safety knowledge that is unreachable and unknowable to workers outside the confines of the safety meetings. This study shows how engaging workers in safer ways of working should acknowledge the integrated nature of safety practice and the value placed on independence when engaging in collaborative practices regarding workplace safety.

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Developing Safety Cooperation


IMPACT OF URBAN HEAT ISLAND ON ENERGY EFFICIENCY OF GLAZED MULTI STOREY OFFICE BUILDINGS IN ACCRA

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Urban heat island (UHI) has been proved to have significant impact on the local climate of a built up area. Previous studies on the phenomenon have identified: urban morphology, wind flow, ambient temperature, relative humidity and solar irradiance as major factors which affect the intensity of UHI. Although UHI is known to increase cooling loads of buildings in warm climates, in the case of Ghana, no quantification of such energy consumption has been done. Glazed multi storey office buildings in the CBD of Accra have been chosen for this study due to concerns about the extensive use of glass cladding, which is considered inappropriate for the prevailing climate. The purpose of the study is to assess the impact of UHI on energy performance of glazed multi storey office buildings, using at least one building in the CBD of Accra as a case study. The study also seeks to unearth the impact of traffic load on urban heat island and carbon footprint and thus, propose strategies for urban planners and built environment professionals to mitigate their impacts on the affected areas. This report covers the first stage of the study, and it focuses on the investigation of the existence of UHI in Accra. It investigates possible variations in UHI intensity within various local climate zones (LCZs). Weather data are gathered through stationary and mobile traverse measurements. To conform to research protocol, same data are gathered from a reference location on the outskirts of Accra. Measuring weather elements in the two different locations would allow for comparative analysis of the UHI intensity. The data from the study could be used as inputs for the simulation of the energy performance of buildings in the densely built parts of the CBD of Accra in the next stage of the research.

Keywords: UHI, LCZ, climate data, central business district

INTRODUCTION

The urban heat island (UHI) phenomenon has been an issue of concern to cities over the world. Numerous studies (Hirano and Fujita, 2012; US EPA, 2015) have attributed the main cause of UHI to the extensive use of manmade materials. Cities have become densely populated due to urbanization, hence the reduction in greenery and increase in hard surfaces (Jusuf et al., 2007; Rajagopalan et al., 2014). Due to the many negative impacts UHIs have on an urban environments, they have become a very important subject for urban planning and environmental control (Hirano and Fujita, 2012). Several studies have revealed that UHI has significant impact on the urban environment, particularly the micro-climate, and hence the associated impact on building energy consumption (Ichinose et al., 2008; Rizwan et al., 2008; Hirano and Fujita, 2012).

It is projected that by 2030, over 61% of the people in the world could be living in urban areas (Economic and Division, 2012; Rajagopalan et al., 2014). Berger et al., (2014)

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posit that due to the high level of occupancy, office buildings generally use substantial amount of energy. According to Straube (2006), more than one-third of the world’s energy consumption is attributed to the construction and building industry. For warm climatic areas, large buildings and buildings with high occupancy levels, typical of the cities, usually have high cooling loads.

“Ghana’s population is becoming increasingly urbanized. Urban centres in Ghana are characterized by settlements with population of at least 5,000 people (Osei et al., 2015). Accra has been expanding in the past few decades, and very little attention has been paid to UHI mitigation measures. This has been attributed to inadequacies in the existing planning control regime. Ahmed and Dinye (2011) assert that this situation has arisen because of poor development control regime. It is worthy of mention that, high land value in the Accra metropolis has resulted in the shift to the development of high density buildings. Simon et al., (2014) and Koranteng et al., (2016) posit that in Ghana, where air temperatures are generally high for most part of the year, users of most office spaces have had to rely on artificial comfort systems for cooling. For a country which has been grappling with erratic power supply over the last decade, it becomes very necessary to investigate the impact of UHI on building energy performance, since that would contribute positively towards the search for energy saving measures which would be appropriate for its urban areas. Against this backdrop, the overall goal of this research seeks to assess the impact of UHI on building energy performance of highly glazed multi-storey office buildings using Accra as case study.

The Study Area

With a population of 25 million (GSS, 2014), Ghana is located on the west coast of Africa. The country shares boundaries with: La Cote D’Ivoire to the west; The Republic of Togo to the east and Burkina Faso to the north. The location map of the study area is shown in figure 2. Administratively, the country is divided into 10 regions and 170 districts (Antwi-Agyei 2012). The main climatic seasons in Ghana are wet and dry. Generally, most parts of Ghana have annual temperatures above 24 °C (Ghana Environmental Protection Agency (GEPA), 2001). Figure 1 shows the study area.

![Figure 1: Location map of Accra and study area; Source: Adapted from Grant (2009)](image)

Mean monthly temperature figures for the city fall between 22°C and 32°C, with February usually being the warmest month (GMET, 2016). One of the most visible impacts of the liberalization program introduced in Ghana in the 1990s, is the dramatic rise in the number of new foreign companies that have established operations in Accra, which is currently headquarters for 655 foreign companies (Grant, 2001, 1005). This has contributed significantly to the high cost of land for infrastructural development in the...
CBD of the city. The heart of the CBD is characterized by mixed-use (mostly civic-commercial) developments with a considerable number of glazed multi-storey buildings defining its skyline.

LITERATURE REVIEW.

What is Urban Heat Island (UHI)?

According to Bagiorgas and Mihalakakou (2016), “the UHI phenomenon exists in cities which usually have much higher air temperatures than those of their surrounding areas.” Rajagopalan et al., (2014, 159) corroborate the assertion by Oke (1982) that, UHI is caused by the reduction in vegetation which causes heat build-up in the ground and on building surfaces, resulting in higher air temperatures in the urban areas than their surroundings. UHI has also been defined as the increased ambient temperature of urban areas as a result of warmer surfaces (Synnefa et al., 2007). It could be inferred from the foregoing that, UHI results from higher air temperatures caused by manmade changes to the natural environments with say hardscapes, that characterize heavily built up urban areas compared to those of the less built up surrounding areas.

UHI Occurrence and Intensity

Tan and Li (2015) have indicated that the intensity of UHI varies with the characteristics of a given urban area, which could include the effects of wind tunnel. Rajagopalan et al., (2014 160) have categorized the factors that affect UHI occurrence and intensity into meteorological factors as well as city design. Dhalluin and Bozonnet (2015) corroborate the aforementioned factors but further extend the discourse to indicate that the geographic characteristics of an area can also impact its urban heat island. As seen from various studies, there is a wide range of factors (geographical, meteorological, anthropogenic, differences in shapes, city design etc.) affecting the occurrence and intensity of UHI.

Quantification of UHI

Various studies (Nichol, 1994; Ao and Ngo, 2000; Wong and Cheng, 2003) have shown that remote sensing; mobile survey and thermal satellite image as well as GIS methods are appropriate for investigating UHI of areas with wide spatial coverage. Wong and Cheng (2003) recommend spot temperature measurements for smaller areas. Although spot temperature measurements are considered suitable for small locations, Aduah et al., (2012) point out the high cost associated with equipment acquisition and installation, and hence the limit to the number of point locations where land surface temperatures or air temperatures can be measured.

UHI Mitigation and Adaptation

As Kleerekoper (2012) points out, several tools and strategies to counteract the UHI effect are available and some of them have already been successfully implemented in several cities around the world, however, one of the biggest problems faced is the transfer of this knowledge to the urban planning process. Kleerekoper (2012) and Futcher (2008) have identified the following as significant tools/techniques for urban design which can help cities mitigate their UHI effects:

- Cooling the environment with vegetation by evaporation and transpiration
- Using water bodies or large water
- Using building density and geometry (built form) to influence the incidence of radiation on materials that can store heat
- Managing the permeability of building materials
METHODOLOGY

The study made use of both primary and secondary data. The primary data collection mainly involved direct observation (photographic recordings) and measuring of weather elements: Air temperature and relative humidity. The secondary data collection focussed on: 1. Meteorological data from the Ghana Meteorological Agency (GMA, 2017) over a thirty-year period (from 1987 to 2016) and 2. Landsat images (from google earth captured in 2016).

For UHI or urban climate studies, there is the need to understand urban morphology and its impact on the local climate (Ren et al., 2016). The LCZ classification for this study is based on the parameters for classifying the 10 built types identified by Stewart and Oke (2012): LCZ1 (Compact high-rise); LCZ2 (Compact mid-rise); LCZ3 (Compact low-rise); LCZ4 (Open high-rise); LCZ5 (Open mid-rise); LCZ6 (Open low-rise); LCZ7 (Lightweight low rise); LCZ8 (Large low-rise); LCZ9 (Sparse low-rise); LCZ10 (Heavy industry). The LCZ classification for the study area has also adopted Bechtel’s method which involves the use of multiple observation data (Bechtel, 2012). It has thus depended on Landsat images obtained in 2016 as well as photographic recordings through direct observation. Snapshots of LCZs identified from the reference location the study area are shown in table 1.

Table 1: Snapshots of LCZs of the survey area (in Accra); Source: Google Earth

![Snapshots of LCZs](image-url)
Table 2 provides a summary of the descriptions and locations of the identified LCZs in the survey area.

**Field measurements**

The mobile traverse and the stationary survey were conducted on 26th December, 2017 and 31st March, 2018 respectively. In both cases, measurements were taken at a reference location and other locations within the CBD. The collection of both the mobile traverse and stationary weather data was done around the same time on each day of the campaign, in order to enhance their validity.

**Table 2: Characteristics of identified LCZs between the reference station and the study area (using Stewart and Oke, 2012)**

<table>
<thead>
<tr>
<th>LCZ</th>
<th>Locations</th>
<th>Built types</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCZ1</td>
<td>Cedi House, National Theatre, Airport City</td>
<td>Compact high-rise</td>
</tr>
<tr>
<td>LCZ2</td>
<td>Shangri-la Hotel</td>
<td>Compact mid-rise</td>
</tr>
<tr>
<td>LCZ3</td>
<td>Awoshie, Baah-Yard, Kwashieman</td>
<td>Compact low-rise</td>
</tr>
<tr>
<td>LCZ4</td>
<td>Supreme Court-Public library, Attah Mills High Street, City Hotel, Novotel-Movenpick, Ministries-Ind. Square, Advantage Place</td>
<td>Open high-rise</td>
</tr>
<tr>
<td>LCZ5</td>
<td>37 Military Hospital, PWD-Barnes Rd., Adabraka Polyclinic, Accra Ridge Hospital, Electoral Commission</td>
<td>Open mid-rise</td>
</tr>
<tr>
<td>LCZ6</td>
<td>Arko Agyei Interchange</td>
<td>Open low-rise</td>
</tr>
<tr>
<td>LCZ9</td>
<td>Lands Commission, Anyaa NIC</td>
<td>Sparse low-rise</td>
</tr>
</tbody>
</table>

**Stationary Data**

Three EL-USB-2 data loggers (built-in temperature and relative humidity sensors) were positioned at three different locations within the CBD; meaning, for each LCZ, a station was selected for the stationary data survey. The stations: A - Airport City Park (LCZ1); B - Accra Regional Hospital, Ridge (in LCZ5) were selected based on variations in their
built types and surrounding vegetation. The sensors were placed at a height of within 1.8-2.0 metres from the ground, and in an area devoid of heavy traffic and artificial heat source such as exhaust fans and air conditioning (see Oke, 2004).

For station R - Anyaa NIC (in LCZ6), which was used as the reference location, the average temperature and relative humidity recorded during the entire campaign were 34.°C and 64%RH, whilst stations A - Airport City Park (in LCZ1) and B - Accra Regional Hospital, Ridge (in LCZ5) recorded 38.5°C, 48%RH and 37°C, 50.5% respectively.

**Mobile Traverse Data**

A digital weather sensor (Eltek data logger) was mounted on top of a vehicle to measure the weather elements across the length and breadth of the selected area in the CBD of Accra. In mounting the sensor, it was ensured there was no contact with the metallic roof (see figure 2). This precaution was taken so that air temperature measurements would not be compromised by the temperature of the roof of the car. Several important landmarks were selected for the routes used, and the routes were mapped (see figure 3). It was ensured that the traverse covered different local climate zones.

![Figure 2: Traverse survey setup - data logger mounted on roof PVC rack of car](image)

Figure 3 shows the LCZ map of the CBD of Accra - with the traverse routes and the station survey locations.

![Figure 3: Map showing traverse routes and station survey locations; Adapted from: Google Maps](image)

**ANALYSIS**

The data obtained were tabulated against respective LCZs and outlier analysis was performed. This was done to identify significant deviations from other observations in
the data. Some deviations were noticed whilst analyzing the measurements taken at the Accra Ridge area (LCZ5), where a heavy vehicular traffic was experienced occasionally during the survey. LCZs with outliers were not considered for measuring inter-LCZ temperature difference (see Bagade and Kotharkar, 2018).

Temperature and relative humidity measurements recorded at the selected locations during the traverse are presented in the graph shown in figure 4.

Figure 4: Graph depicting Mobile Traverse: Anyaa to CBD of Accra (Author generated)

Analysis of Data from mobile traverse

Air temperature and relative humidity measurements taken at the reference location (Anyaa) were 29.5 °C and 61% respectively. An eight-minute drive from the reference location into a more densely built up area saw a temperature rise of 0.5°C. There was a significant drop in the relative humidity value from 58% at Tetteh-Quarshie Interchange (LCZ2) to 47.5% at Shangri La Hotel (LCZ2), near the Kotoka International Airport. The change in temperature between the two locations was very significant, as it had increased by +3.5°C. Figure 4 illustrates the trend in the measurements taken. The last mobile traverse was undertaken as a round trip between the Electoral Commission Head Office (LCZ5) located in the periphery of the CBD) and the Pension House/National Theatre, located at the core of the CBD (LCZ1). The route used for this traverse was between the northern and southern sections of the selected area in the CBD. In terms of temperature recordings, there were slight variations (between +0.5°C and +1°C) at various locations.

Analysis of GMet. Data for Accra (1987 - 2016)

Available climate data from GMA’s Accra weather station for the 30 year period indicate that in November, latter part of December and then from January till May which constitute the warm periods, average maximum temperatures are generally above 30 degrees Celsius. Since UHI is directly related to high air temperatures, the research focuses on climate/meteorological data from November to May. Meteorological data (GMA, 2017) for the period January 1987 to December 1996 show that, temperatures over the city between November and May were generally high (between 27°C and 34.5°C). Maximum temperatures (between 30°C and 36.1°C) were recorded between November and May, whilst the relative humidity range observed in the same period was between 53.0% and 80%.
RESULTS AND DISCUSSION

Only a few (3) stations were set up for the stationary survey due to the availability of a limited number of sensors; consequently, the mobile traverse and stationary survey could not be conducted simultaneously and on the same day.

The line graph shown in figure 5 depicts a correlation between humidity and temperature. Temperature measurements taken at the Airport City (LCZ1) were high. This area is heavily built up, with little vegetation or soft landscape. The buildings are mostly high-rise commercial structures with typical ‘modern Ghanaian corporate look’. The measurements taken between Airport City Park (LCZ1) and PWD (LCZ5) during the mobile traverse showed a rather different trend. The initial temperature of 34.5°C recorded at Airport City Park (LCZ1), had dropped by 2°C upon reaching PWD (LCZ5), which is located in the inner part of the CBD. The stationary data revealed a similar trend - with Airport City (LCZ1) recording 38.5°C, whilst Accra Regional Hospital (LCZ5) recorded 1.5°C. The relative humidity on the other hand, had increased by 2.5%. An observation worthy of mention is that, unlike the large expanse of hardscapes found in and around the Airport City Park (LCZ1), there are numerous huge avenue trees and several patches of greenery in some parts of the core of the CBD. Both stationary and mobile traverse data gathered during the survey revealed that the locations with higher temperatures had low relative humidity levels. Also, areas with dense vegetation generally recorded lower temperatures and higher humidity.

CONCLUSION

This study reveals the existence of the UHI phenomenon in Accra. It has also supported the significance of the use of the LCZ framework in investigating the magnitude of UHI. It underpins the impact of urbanization on the climate of Accra. The study has revealed that during the day in Accra, areas with compact built types (LCZ1 and LCZ5) are generally warmer than areas with lightweight/open low-rise (LCZ6). It is also evident from the study that the LCZ4 areas with vegetation in the CBD of Accra are cooler than the LCZ1 areas. With the data gathered, UHI will be analyzed and understood in the context of urban fabric. Through building energy simulations, the study will subsequently highlight the differences in monthly cooling loads or energy demand values which will benefit facility manager’s annual building energy performance projections. Through this study, different or new urban planning and building design skills set aimed at determining the appropriate percentages or expanse of areas required for the provision of environmental cooling example, bioclimatic considerations such as greenery/vegetation and water bodies could be proposed. Findings from the study will equip building construction professionals with the requisite design detailing as a means to reduce cooling load and avoid overheating. Using the case of Ghana, the study will re-echo the extent to which built environment professionals would appreciate the need to soften the external environment and also consider appropriate bioclimatic factors for new developments. The research could reveal aspects of current building regulations or building specifications for the study area which may no longer be relevant, for which reason new or revised building regulations may be needed to address strategies to mitigate UHI effect on energy efficiency.

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STATE OF BUILDING INFORMATION MODELLING (BIM) ADOPTION IN NIGERIA

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Construction Industry has had its biggest breakthrough since the development of Building Information Modelling (BIM). The industry has been changing over time; United States has been at the forefront of adoption and implementation of BIM while Australia, United Kingdom and some other developed nations are moving in full force concurrently. At the same time, developing countries are battling with BIM uptake. The BIM awareness and adoption in Nigerian Architecture Engineering and Construction (AEC) is significantly low; research to adopting this innovation has received very little attention. This piece of work (as part of preliminary investigation of a PhD work) is aimed at exploring the state of BIM within decision makers in Nigerian AEC. Semi-structured interviews were conducted with stakeholders in the industry (Contractor, Consultant and Clients); the transcribed interviews were analysed using qualitative content analysis. The information revealed that, the key players are generally not familiar with the term “Building Information Modelling” or “BIM” although mostly aware of some of its tools (i.e. AutoCAD, Revit etc.). Only a few uses some BIM tools at organisational level ‘lonely BIM’ and operating model based ‘BIM stage 1.’ Moreover, no legislative provision on BIM adopting or regulation. Nevertheless, the government is open for new concepts in promoting and advancing the industry only when they are convincing enough. Lack of experts on BIM is a major barrier to its adoption at all levels. Recommendations are made based on the findings based of the exploration for the industry to compete with its global counterpart.

Keywords: BIM, CAD, innovation, adoption, construction industry

INTRODUCTION

Engineering business is going digital and integrated; there still remain significant move and development to achieving it globally. Building Information Modelling (BIM) is the most recent paradigm shift in construction industry and the promising concept determine to shape the industry’s fragmentation (Zhao et al., 2016). BIM is defined as a set of interacting policies and processes being enabled by technologies in generating a methodology to procure building works from inception to completion down to the entire lifecycle of a building in a digital format (Succar, 2009).

There are numerous application of BIM, to mention but a few with: design coordination, energy performance simulation, scheduling and quantity take-off, clash detection and 3D visualisation (Cao et al., 2014, Eastman et al., 2011, Monteiro et al., 2014). There are several arguments regarding BIM benefits over the years. Autodesk (2008) claimed a time saving up to 91% on checking and coordination, 50% on developing a design while using Revit® Architecture software compared with the conventional Computer Aided Design (CAD). However, countries have been adopting it with individual experiences (in

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BIM adoption in Nigeria

benefits), depending on their level of adoption as such; and perhaps their challenges before the adoption. For example, McGraw Hill Construction (2014) study reveals the most significant immediate and long-term benefits derived by Australia and New Zealand; these include but not limited to: reduction in errors and omissions, reduction in rework; and business reputation, reduction of project duration and construction cost respectively. Even though every country has its reasons to adopt BIM, there are still some common goals amongst several countries. These include, improving the industry’s productivity and unifying its standards by changing its way of working (BIM industry working group, 2011; NATSPEC, 2012; Hjelseth, 2017).

BIM adoption has gone far in the most developed countries; however, there remain a long way to go in the developing countries especially Nigeria. Despite several years of discussions and researches in the area of BIM concept and its adoption, Nigerian construction industry haven’t receive attention till 2013 when the first conference paper title “Readiness of Nigerian building design firms to adopt building information modelling (BIM) technologies” by Abubakar et al., (2013) came into the academic mainstream. It was the first grasp to study BIM in Nigeria; although, has its very limited in context (focused on designers only). Moreover, the study was mainly on assessing the readiness of the first line adopters of BIM in the industry. The assessment came up due to lack of clarity on whether the industry is ready or not in adopting the technology; not the process - this is a sign of starting point or “readiness ramp” (Succar and Kassem, 2015). Furthermore, the starting point wasn’t evaluation on awareness or usage but searching for a significant match towards its adoption.

There is little or limited research on BIM on a general level beyond specific discipline and or city, also there is lack of direct input (interview) by key stakeholders of the industry. These can be noticed in the eleven available published works. The previous research concentrated on trying to assess BIM (within a limited profession or location) or assess BIM’s roles and benefits in general - there was no meeting point into identifying the present stage of the key BIM fields (Technology, Process and Policy). Moreover, no any available Noteworthy BIM Publications (NBPs) within this study context (Kassem et al., 2013). This paper presents pilot data related to the state of BIM adoption in Nigeria. We investigate its awareness and adoption level, discuss challenges and possibility of its adoption in Nigeria.

This piece of work aimed to determine the state of the above key BIM fields from the key players (designers, constructors and the client). The objectives are to evaluate: the BIM awareness and knowledge; as well as its adoption challenges.

LITERATURE REVIEW

BIM has gone beyond being just a drawing and documentation tool; and it is not solely about software, but represents a more collaborative method of working (NBS, 2015); most importantly, it remains the most potential development in the world of construction industry (Chan, 2014). There is significant adoption of BIM at design and construction stages in countries like United Kingdom (UK), United States (US), Germany, Australia and New Zealand. On the other hand, UK’s BIM uptake could be seen as not meeting the expectations with the present alternating adoption rate. The 2018 National BIM report revealed a skyrocket adoption rate of 12% (total of 74%) after the substantial slowed down between 2014 and 2016 (NBS, 2017); several literatures reported huge move of awareness to adoption which appeared a big leap though the motivation comes from coercion (Dainty et al., 2017). The UK government’s interest in leading BIM is not yet realised, albeit there is a significant boost a year after the expiration of the BIM level 2
mandate. The BIM adoption in the US was initially generated acceptance and get promoted by the Architects, American Institute of Architect (AIA) lead its adoption at its early stage and then government subsequently realises its potentials and therefore takes the control by developing standard between the year 2005 and 2008 (National Institute of Building Sciences 2015). The “NBIMS Version 1 - Part 1: Overview, Principle and Methodologies” released by facility information council (FIC) for public use was the first standard, and subsequently taken over to be overseen by buildingSMART alliance. The National BIM Standard-US is now the developer of standards and guidance documents for all aspects BIM. As of 2012, the US recorded an average of 71% BIM adoption leading the world in adoption rate (Construction, 2012). Moreover, large, medium-to-large and small-to-medium companies were found to be the most (in descending order) adopters, hence size of an organisation has significant influence on the likelihood of adopting BIM.

In the last five years, BIM research focuses largely on interoperable technology leaving collaborating people and integrated processes behind. Despite several reports lamenting the shortage of facilitators in promoting BIM process, more than 70% of publications from Automation in Construction (2013 - 2017) focused on interoperable technology perspective (Hjelseth, 2017) rather than promoting the adoption process or collaborating the people. Previous studies suggest that, national government and institutional frameworks is largely influencing BIM adoption (Edirisinghe and London, 2015); but in some cases (i.e. UK) it is the reflection of the mandate rather than the government (as major client) playing the capabilities driven role (Davies et al., 2015). Moreover, developing policies by the European countries is considered as a strategic transformation of their construction sector. However, recent study by Dainty et al., (2017) argue that so much emphases is given to BIM as a panacea to all the ingrained problems of the industry and also assumed BIM policy or mandate is a route to its adoption. Apparently, a diverse opinion can be seen in this regard, but there are still several case studies where policy added value and resolved snags around the world (Edirisinghe and London, 2015). Dainty et al., (2017) considered the policy favourable to the large firms - ‘Matthew Effect.’ We see this argument as a means for transfer of directional pressure of diffusion from Top-Down to Middle-Out, hence the medium and small firms will subsequently benefit from the policy action (Top-Down).

**BIM in Nigeria**

There is a very limited awareness and knowledge of BIM technology in Nigeria (Onungwa et al., 2017); and this is generally associated with lack of awareness of the concept, or lack of trained staff on the BIM tools or both (Abubakar et al., 2013; Onungwa et al., 2017). Kori (2015) reveals that large and medium firms were found to be leading the BIM adoption in the Nigerian AEC while the small firms are less advanced regarding policy and process adherence therefore has less adoption. On the other hand, the present adoption is traced at organisational level which is term as a “lonely BIM” (Hamma-adama et al., 2017) and operate at Stage 1 BIM. Primarily, the Nigerian construction industry is fragmented: all the professionals are generating information and managing them separately (Onungwa et al., 2017). Structural and services designs are still on conventional CAD (2D) system with few (mostly Architects) utilising 3D CAD system for visualisation purpose (mostly) or as a presentation drawing (Hamma-adama et al., 2017; Kori, 2015). Ultimately, the culture of the industry is very conventional, hence require behavioural change. The most difficult move amongst the change requirements for a successful BIM adoption is the behavioural change (Hardin and McCool, 2015), as it involves perception and process change. Change is possible only when people are aware
or possess knowledge of the subject matter; is the Nigerian construction industry needs the awareness or the minimum knowledge of the concept before it gets diffused?

**RESEARCH DESIGN**

The aim of the paper is to explore the state of BIM adoption in Nigeria from the key players (designers, constructors and the client). Industry professional interviews are as a primary data source. Professional interviews are used broadly as a direct source of information (e.g. Davies et al., 2015). Thus, a qualitative approach to content analysis is considered as a suitable approach to this exploratory study (Carney, 1972). Generally, exploratory studies are based on nonprobability sampling of respondents; while its analyses have been frequently used to create hypotheses for further study (Guest, et al., 2011, p. 8). And, it’s focused on fewer respondents as reported by Marshall et al., (2013) is on the bases of single case qualitative methodology.

Bryman (2001) describes qualitative content analysis as a process of utilising a textual data systematically in the development of emergent themes. Thus, the concepts used are driven and generated through interpretation of respondents’ statements (Wood, 2001). Carney (1973) describes this method as a destination for most exploratory studies as ‘it gets the answers to the question to which it is applied’. Moreover, Roberts (1999) asserts that the ability of this approach to have coded revisited at any time for confirmation makes it reliable for qualitative data analysis. Upon these, this method best fits the intended study.

**QUALITATIVE FINDINGS**

This section focuses on the analysis of collected data that were generated through semi-structured interviews with consultant, contractor and the clients/authority who are the industry’s stakeholders. These interviews were carried out face to face and audio recorded for the purpose of transcription. It is mainly to explore the inside of the industry in the key area “BIM”. The method allows the interviewees to interact freely, express their views and comment on general aspect the key area, hence provides opportunity to the interviewer for generating a direct, relevant and addition information (Trumbull, 2005).

**Data Collection**

The study sample involves four parties whom are the critical stakeholders in the BIM adoption and implementation. This sample of four was selected by considering their importance in the industry’s decision making as well as priority. The sample consists of three parties (consultant, contractor and client) each having one representative plus additional one from client who happened to be representing a development control body - Federal Capital Development Authority (FCDA). In the light of Ryen’s (2016, 32) assertion of “research subjects have the right to know that they are being researched, the right to be informed about the nature of the research and the right to withdraw at any time”. A number of interview invitations were sent via email with highlights on the research subject and objectives. The invited participants responded positively with a proposed schedule for the interview. Considering research ethics and privacy policy, the consent (with condition of anonymity) of the participated professionals were sought to audio-record the sessions which were granted and the interviews lasted between eight to twenty-two minutes. Table 1 presents the study interviewees profile.
Table 1: Demographic Profile of the interviewees (Author generated)

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Organisation size</th>
<th>Organisational Annual fee volume</th>
<th>Organisation Role</th>
<th>Project type</th>
<th>Organisation location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviewee 1 (CPM)</td>
<td>&gt;20 staff (large)</td>
<td>&gt;$10M (large)</td>
<td>Contractor</td>
<td>Mainly building works, then road construction</td>
<td>Abuja, Bauchi, Gombe, Jigawa, Kaduna, Kano and Lagos</td>
</tr>
<tr>
<td>Interviewee 2 (CLE)</td>
<td>&gt;20 staff (large)</td>
<td>&gt;$10M (large)</td>
<td>Client</td>
<td>Building and Infrastructure</td>
<td>Abuja</td>
</tr>
<tr>
<td>Interviewee 3 (CLA)</td>
<td>&gt;20 staff (large)</td>
<td>&gt;$10M (large)</td>
<td>Client/development control</td>
<td>Building and development control</td>
<td>Abuja</td>
</tr>
<tr>
<td>Interviewee 4 (COA)</td>
<td>11-20 staff (Medium)</td>
<td>$500K-$10M (small-medium)</td>
<td>Consultant</td>
<td>Building works</td>
<td>Kaduna</td>
</tr>
</tbody>
</table>

The interview questions were specifically made flexible enough to explore the participants’ experiences and trends of innovation in their respective organisations. The questions were designed on the basis of previous researches and the current study objectives.

Data Analysis

Adopting the steps (Figure 1) identified by Creswell (2009), the fetched data were analysed thoroughly and rationally thereby achieving a precise interpretation of interviewees’ knowledge and abilities (Spiggle, 1994).

Following the successful interviews, the transcribed interviews are considered the raw and primary data. The data are then coded based on the pre-identified themes from previous studies and the set objectives.

Figure 1: Data analysis process adopted from Creswell (2009)

STUDY FINDINGS

The study findings are presented in three main themes. The three themes are; Level of Awareness in the key areas of BIM, the evaluated capabilities of the stakeholders, and BIM adoption and challenges in the industry. Although the transcriptions language has not been tidied, quotations were used to justify this study assertions.

BIM Awareness and Knowledge

There is basically little knowledge of BIM even at awareness level. The practitioners’ point of view is that, they have limited knowledge in terms of awareness of the BIM not to talk of adoption.

My knowledge on Building Information Modelling is pretty below limited, is an area that I will say I heard of it virtually today through the research student and it appears quite exciting to me… CLE

I only have general point of view, primarily from any work as an Architect…; …my knowledge is restricted to a general sense, and we don’t have that here… CLA

On the other hand, some of the stakeholders debunked their level of BIM knowledge and they seem to lack clear understanding of what ‘building information modelling’ mean.

Am not aware of anything Building Information Modelling. CPM
To be honest, this is the first time am hearing about building information modelling. COA

Moreover, after going deep into the conversation, they mostly acknowledged to have used some of the lower level BIM tools (2D and 3D CAD systems). Hence, there is an indication of limited and lower level BIM tools utilisation: a little trice of ‘file based collaboration’ with 3D CAD for object visualisation and appreciation.

…the one we are using is coming from consultants even, the consultants we are working with are using that 2dimensional AutoCAD, CPM

…I have used AutoCAD, yes, Civil CAD, yes, but know it to have harmonise it into BIM I will say no, but as isolated software for design, yes… CLE

…I do a design in AutoCAD, COA

There is an indication of ‘lonely BIM’ especially from the highly developed (multi-disciplinary) consulting firms; they are practicing collaborative BIM concept at organisational level only.

…the firm has its own in-house engineers: Mechanical, Structural and everything; we come together within the office…; and do all the design within the same software that we have. Do that in-house not with any other consulting firms… COA

**Stakeholders Capabilities**

It was perceived that, the consultants are relatively using BIM tools (i.e. AutoCAD and Revit) however not knowing them as BIM tools and also not utilising to their full potentials (i.e. integrating the tools in their work not the opposite).

I know software like Revit does that to some extend and then like 3D Home views COA

It was observed that, the contractors are reliant on the kind of tool consultant uses at the design stage. They mostly adopt what the consultants are using because of their interdependence. Thus, do not mind using whatever the consultant uses and provided them with - designers are then the first line of adopters (Abubakar et al., 2013).

…I do a design in AutoCAD, COA

…the one we are using is coming from consultants even; …2D AutoCAD. CPM

Government is a major client for the construction sector in Nigeria; and also a client for big projects. One of the interviewees revealed that, the Federal Capital Development Authority (FCDA) is the pilot organisation for the adoption of e-governance as well as innovations in the building industry.

… FCDA is the pilot agency in the entire country ...because we are more likely to succeed, then other Agencies were to key in and learn from us… CLA

The members of the authority (FCDA) have been using some BIM tools for infrastructure (i.e. AutoCAD and Civil CAD) for infrastructural design; however, the usage level is not to integrating their system but sort of design and design checks only.

…yes, AutoCAD yes, Civil CAD yes, but know it to have harmonise it into a BIM I will say no, but as isolated software for design, yes I have used it severally for infrastructural design works… CLE

There is strong indication that, the knowledge of BIM tools and the concept is more prominent with the consultants (designers) than clients and contractors (Abubakar et al., 2013); and this vindicated the assertion in the BIM+ and construction manager’s survey of 2017 in the UK that, local authorities did not understand BIM. …and that more than 70% said of clients in general did not understand the benefits of BIM"
BIM Adoption Challenges

None of the interviewees ever participated in a project where BIM was used. This can be seen as a clear lack of understanding and knowledge of the BIM concept. However, a ‘lonely BIM’ at modelling and collaboration stage can be noticed with the highly established consultancy firms.

…the firm has its own in-house engineers: Mechanical engineers, Structural engineers and everything; …and do all the design within the same software that we have. Do that in-house not with any other consulting firm… COA

All the dynamic countries on adopting BIM have BIM policies and guidelines, and a sort of blueprint to the adoption process. For Nigeria, there is no clear legislative provision on the use of software and other innovative aids in the construction industry. Regulatory bodies and development control agencies are normally enforcing building codes (i.e. British Standards (BS), Code of Practice (CP) etc.).

For a policy regarding use of software, explicitly stated no! CLE

I will not tell you outrightly that am aware of any kind of legislative backup… CLA

Legislatively, there is none! COA

There is a plan for adopting digital procurement, funded by World Bank and United Nations Development Programme (UNDP). The FCT minister then was fully committed and involved in doing it, but after he left, all the process subsequently stopped! Moreover, no planned implementation policy set in place as such every aspect of the programme virtually failed. Also, it was noticed that there is no policy to enforcing the use of new design or construction tools (i.e. BIM).

…No legislative support and no any policy enforcement in relation to use of software. Since there is no policy, then the enforcement cannot come in. CLE

…am not aware there is any legislation …e-procurement for now is just an option. CLA

Legislatively, there is none! That is why am even looking at the institute (Institute of Architects) basically entirely…. …Since there is no legislation in that regards, then no legislative backup to enforcing this process. COA

It was observed that funding is one of the challenges of digitalisation in the industry. However, there are few intervention from some government agencies which still doesn’t work as the intended digitalisation in the pilot authority (FCDA) also stopped.

…I do know that federal ministry of science and technology is doing something in that regard, and then we have some Agencies that has been assisting, like NITDA… CLA

It became evident with the failure of the digitalization (e-procurement) process in the pilot agency. The earlier proposed e-procurement suffered a lot of setbacks, amongst which the refusal by contractors to register online - this is imminent for over a decade.

Now when we wanted to launch a pilot for e-procurement, for example, one of the requirements entail having contractors to be registered in our electronic data base and that is where we were stocked because most of them were not compliant… CLA

For the authority, they have a strong interest and appear ready to adopting BIM, although their understanding is quite limited. Funding has been considered a big issue couple with lack of experts in the field of BIM adoption and implementation. On the other hand, there is a need for an articulated proposal to the government regarding its potential benefits to the country’s construction sector. Those who know it very well are expected to play a vital role to informing the government, while strong pledge is required by the government heads to adopting and implementing BIM.
I think the government is more than ready and willing to do that… there is no knowledge, no expertise along that area at all; I think BIM is when a proposal is articulated well and presented to the department of engineering (FCDA) I am sure we would work toward that line to make things much easier for us, we appreciate this. CLE

Am a government person but unfortunately I have to speak to you from personal point of view, we need a champion, everything we achieved here it was because of Nasiru El-Rufai, he was personally interested, he was personally involved. CLA

Electricity is one of those factors associated with speedy ICT adoption everywhere including the construction industry. However, Nigeria is suffering from huge shortage of electricity which has been lingering for decades.

…there is a major problem of power; if you ask me, I think power was one of the major reasons that has stolen the development… we had issues even with the people we are supposed to be serving and the ever issue of power that will always remain the big problem if we are going to embark on any endeavour… CLA

**Thematic Finding**

Contractors associated lack of BIM tools utilisation with the type of training received by graduates of higher institutions (university). New innovative way of working is not taught in schools that is why the old ways still remain. Also, the trend of the adoption should start from training in schools, to designers and subsequently the contractors.

The best way to adopting this system is marketing, and the marketing must start from school. Because whatever training I get from school will be what to be using until I get training with this BIM; …the marketing will start from schools …link with the construction company… CPM

There are also issues with built professional societies and regulatory bodies; the new innovations should have been driven by these societies and bodies, the example of this can be seen in the US. But many professionals are yet to be digitally compliant.

…by the way one need to understand that not everybody within the profession is also digitally compliant. COA

The professional organizations would have been the focal points for professional developments; centres where new innovations are introduced, marketed and even trained. Consultants perceived the same idea of BIM adoption as in the US where Architects originally lead its adoption and before the government intervention.

It’s quite a good initiative; …presented and accepted by the professions within the industry before… the process of being legislated upon by the government… COA

Succinctly, lack of BIM trained personnel which is associated with training received in the higher institutions and also the lack of involvement of professional bodies coupled with low awareness contributed to the adoption challenges. No legislative provision on BIM adoption, as such no regulation. Moreover, no trace of BIM demand by clients (private or private) which is seen in Sweden (Davies et al., 2015).

**CONCLUSION**

The purpose of this paper was to determine the state of the key BIM fields (Technology, Process and Policy) from the key players (designers, constructors and the client) in the Nigerian AEC. The exploratory study reveals that: Lack of BIM awareness across the entire stakeholders, especially clients and contractors coupled with significant deficit of experts in the technology. Lack of accessibility of the technology and power (electricity) issues - Infrastructure; lack of streamlined BIM adoption process and professional bodies’ involvement; no policy and guideline or regulation to adopt the technology and the
process; there is a trace of adoption within designers at organisational level only. To facilitate adoption, the following recommendations are made: Presenting a comprehensive proposal (by the professional bodies) to the government, proposing a government driven policy; developing an *all-in-one* blueprint for adoption through awareness and training by developing an effective adoption framework.

**REFERENCES**


EMPIRICAL STUDY ON BIDDING COMPETITIONS FOR
QUALITY IN JAPANESE PFI

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The empirical analysis in this paper focuses on the bidding competition for quality (non-price element) in Japanese private finance initiatives (PFIs). Most Japanese PFIs implement comprehensive evaluation bidding, which consists of both price and non-price elements. Practically, non-price competition is regarded as more important. However, because it is difficult to evaluate a non-price element quantitatively, the effect of bidding competitions for the non-price element has not been hitherto clarified. As such, this study aims at determining the effects of non-price competition in the bidding of Japanese PFIs. To show the effect of the number of bidders (proxy of the degree of competition) on the bidding result, this study uses ordinary least squares and two-stage least squares regressions with instrumental variables, which are widely used in this field. The data are the public data of Japanese PFI obtained from documents from the government (orderer) announcing bid winners and the sample size is 100. From the regression results, when there is a higher number of competitors then the score required to win in the non-price element is higher. This result is considered robust because the problem of endogeneity was controlled for by using econometric techniques. Therefore, the bidding competition for non-price element would be functioning effectively in Japanese PFIs.

Keywords: PFI, bidding, non-price element, two-stage least squares analysis

INTRODUCTION

This study focuses on bidding competition in Japanese private finance initiative (PFI). PFIs attempt to realize high quality at low prices by utilizing private funds and know-how in the provision of public services that had hitherto been offered by public entities. In Japan, they were introduced by the enactment of the PFI Act in 1999. Subsequently, business amounting to approximately JPY 5.8 trillion has been achieved in the 664 cases up to March 2017.

Bidding in PFIs is implemented under comprehensive evaluation bidding system, whose competition consists of two elements: price and non-price. The successful bidder is the firm to obtain the highest sum of these two elements. Waara and Bröchner (2006) says that the importance of non-price element on bidding is increasing. And Holt, Olomolaiye and Harris (1994) found an important element other than a price in the decision of the successful bidder through a survey of construction industry of the UK. However, it is difficult to evaluate the non-price element because most of these refer to business quality, which is difficult to evaluate quantitatively. Although the empirical studies on price are done by Harada (2013, 2015), the non-price element has not been studied. Therefore, the effect the competition through PFIs in Japan is not evaluated adequately in the literature.

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This paper thus empirically studies the bidding competition for the non-price element. The structure of this paper is as follows. Section 2 reviews the relevant literature. The hypotheses and the methodology are presented in Section 3 and the data in Section 4. Section 5 shows the results of the regression analyses and the policy implications based on these results are discussed in Section 6. Finally, conclusions are provided in Section 7.

LITERATURE REVIEW

Bidding consisting of two elements has been studied under the theory of multi-dimensional bidding in economics. For instance, Che (1993), who studied multi-dimensional bidding theoretically, has shown that in an optimal bidding mechanism (scoring rule), the quality selected by a bidder possessing private information is less than the quality that maximizes the social surplus, even if it is the most efficient private firm. This is the information rent granted to the private firm possessing the private information. Che (1993) also demonstrated that, when the number of bidders increases, the information rent decreases because of competition and approaches the quality that maximize social surplus. Additionally, Asker and Cantillon (2010) have shown that, in government procurement that takes price and quality into consideration, it is preferable to induce competition through bidding rather than negotiate with a private firm possessing private information. Theoretically, competition through bidding may thus have the effect of increasing the quality of a project.

As previously mentioned, Harada (2013, 2015) studied the effect of competition in the bidding for price, showing that an increased number of bidders led to a reduction in the successful bid price. However, almost no empirical studies on the effects of competition through bidding involving a non-price element exist. The reason for this may be that to analyze bidding for the non-price element quantitatively is difficult due to data constraints.

In Japanese PFIs, the judgement processes up to the decision of the winning private firm must be announced by official documents. These documents include details such as the points given to each private firm’s proposal for the non-price element relevant to the project. Here, the official documents for each project are used to obtain the data.

HYPOTHESES AND METHODOLOGY

Theoretically, the hypothesis of this study is:

[Hypothesis] When the number of bidders increases, the quality of a project increases as well due to competition effects.

Because it is difficult to measure the quality element itself quantitatively, it is decided to use the point of the non-price element in the bidding as a proxy variable of the quality. The hypothesis to analyze in this paper is shown below.

[Hypothesis for analysis] When the number of bidders increases, the point value for the non-price element for the winning bidder increases as well.

To investigate this hypothesis, an ordinary least squares (OLS) regression model is used, whose dependent variable is the point value in the non-price element for the winning bidder and the independent variable is the number of bidders.

Endogeneity among the point values for the non-price element of the winning bidder and the number of bidders may exist, as shown by Harada (2015). For example, many private firms believe that a project seems profitable when the government expects a too high winning bid price and the point value of the non-price element in such projects may be
high as well, matching the high expected price. These situations occur simultaneously and cannot be considered the result of the bidding competition. In other words, this is the problem of endogeneity due to “simultaneity.”

As OLS is not adequate when there is endogeneity existing, two-stage least squares (2SLS) is used, with exogenous variable as the instrument variable. Harada (2015) coped with the problem of endogeneity using the instrumental variable “the number of PFI projects that were implemented in the same period.” This paper follows this previous study, using the instrumental variable “the number of PFI projects implemented during the same period.”

**DATA**

The sample is selected from projects for which at least two firms participated in the bidding and whose implementation policies were publicly announced by the 2011 fiscal year. The sample size is 100. The data are mainly from official documents announcing the judgement processes and the "PFI Almanac 2016," published by the Japan PFI/PPP Association.

First, for affecting the bidding result when the non-price element is deemed most important, the allocated points to the non-price element are used as control variable. In Japanese PFIs, there are numerous projects announcing the allocation of points through an advance comprehensive evaluation. For example, a project allocates 30 points to the price element and 70 points to the non-price element, meaning a form can obtain a maximum of 100 points. Another project allocates 150 points to the price element and 350 points to the non-price element, for a maximum total of 500 points. Generally, when the point value allocated to the non-price element is high, the government emphasizes the non-price element. This variable is thus used to estimate the emphasis the government places on the bidding result.

Figure 1 shows the number of projects according to the point values allocated to the non-price element. There are only 13 projects allocated point values for the non-price element below half of the total value. The fact that there are 39 projects for which the allocated point values to the non-price element exceed 70% means that, in Japanese PFIs, the non-price element is important.

![Figure 1: Number of projects by points allocated to the non-price element](image)

Next, in Figure 2, on the proportion that a firm who obtained the highest point value for each bidding element became the winning bidder, there were 56 projects (56%) in which the firm with highest point value for the non-price element won the bid, and 14 projects (14%) in which the firm with the highest price won the bid. There were 26 projects (26%) whose bid was won by the firm with the highest values for both elements and four...
projects (4%) whose bid was won by the firm with the second highest point values for both elements.

Figure 2: Proportion of winning firms with highest values for each element

Finally, the relationship between the points in the non-price element and number of bidders is identified from the data. The point rates for the non-price element are obtained by dividing the winner's point value for the non-price element by the allocated points in the non-price element. For example, if the winner's point values for non-price element was 260 and the allocated points were 300, the point rate for the non-price element is 260/300 = 0.8667. The number of firms submitting proposals are used as number of bidders, representing a proxy for the degree of competition through bidding. Figure 3 shows the point rate for the non-price element by number of bidders. From this figure, the lowest point rate is 0.631, when only two firms participate in the bidding.

Figure 3: Average points for non-price element by number of bidders

If over three firms participate in the bidding, the rate is over 0.7. As such, increasing the number of bidders from two to over three increases the point rate of the non-price element. This difference is significant with 1% of levels of significance in ANOVA\(^2\).

**EMPIRICAL RESULTS**

From the previous section, competition through the non-price element largely affects the decision on the winning bidder. Further, it is thought that the number of bidders affects the points for non-price element obtained by the winning bidder. This section verifies whether these relationships are statistically significant using OLS and 2SLS. The

\(^2\) F value in ANOVA is 4.39.
descriptive statistics are shown in Table 1. The regression formulation is identified as the log linear function to improve the coefficient of determination. It shows below.

\[ \text{Ln (Point ratio in non-price element of the winning bidder)} = \alpha + \beta_1 \ln(\text{Number of bidders}) + \beta_2 \text{Allocated point ratio to non-price element} + \epsilon. \]

Table 1: Descriptive statistics

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>Average</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point ratio of non-price element for the winning bidder</td>
<td>Points</td>
<td>0.7266</td>
<td>0.1502</td>
<td>0.2280</td>
<td>0.9905</td>
</tr>
<tr>
<td>Number of bidders</td>
<td>Firms</td>
<td>3.9100</td>
<td>1.6917</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Allocated point ratio to non-price element</td>
<td>Points</td>
<td>0.5874</td>
<td>0.1470</td>
<td>0.15</td>
<td>0.89</td>
</tr>
</tbody>
</table>

The estimation results are shown in Table 2, where the coefficient on the number of bidders is significantly positive at the 1% significance level, which means that more bidders participating in the bidding increases the points for the non-price element. This relationship is also confirmed by 2SLS, considering the endogeneity between the number of bidders and the points for the non-price element for the winning bidder. In conclusion, the bidding competition is effective for the non-price element.

Next, the coefficient on the point ratio allocated to the non-price element are also significantly positive, meaning that more allocated points to non-price element lead to high point ratio of this element for the winning bidder. As such, the bidding scheme selected by the orderer would affect the bidding result.

Table 2. Regression analysis results

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>2SLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>t value</td>
</tr>
<tr>
<td>Constants</td>
<td>-0.8050</td>
<td>***</td>
</tr>
<tr>
<td>ln(Number of bidders)</td>
<td>0.1574</td>
<td>***</td>
</tr>
<tr>
<td>Allocated point ratio to non-price element</td>
<td>0.4388</td>
<td>***</td>
</tr>
<tr>
<td>Sample</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.1081</td>
<td></td>
</tr>
</tbody>
</table>

***: 1% significance, **: 5% significance, *: 10% significance

DISCUSSION

Here, the policy implications are presented as per the estimation results. First, the bidding competition is effective for the non-price element from the fact that more bidders participating in the bidding increase the points obtained by the winner for the non-price element. Particularly, when there are three or more competitors, the point rate increases by about 10 percentage points compared to when there are two firms. In Japan, a decreasing trend for the bidders per one bidding has been pointed out, and this may lead quality declines for projects.

The instrumental variable in 2SLS is the number of other PFI projects for which bidding was implemented during the same period. As this number increases, the number of
bidders per one project decreases (Harada 2015). Accordingly, if possible, it may be effective the timing of bidding implementation does not overlap with other PFI projects.

Next, from the fact that the point value allocated to the non-price element increases its point rate for the winning bidder, the bidder’s presentation could be affected when the orderer announces the information on the point allocation for the two elements. In other words, the intention of the orderer to emphasize the non-price element is thought to reach the bidder through point allocation. Therefore, the orderer emphasizing the non-price element is one tools to set an extreme score distribution (e.g., above 70%).

CONCLUSION

An analysis focusing in particular on competition through the non-price element was conducted on the bidding in Japanese PFIs. From the analysis, Japanese PFIs have been emphasizing the non-price element and when the number of bidders increases, the point rate of the non-price element for the winning bidder increases as well. From these results, the bidding competition is shown effective for the non-price element.

The limitations of the study are as follows. First, the bidding competition consisting of two elements, price and non-price, is occurring simultaneously through bidding. For example, it may lead a high price to increase the point value of the non-price element. Accordingly, to clarify the actual state of the bidding competition, it is necessary to implement simultaneous equations.

Additionally, this study adopted the point rate of the non-price element as a proxy variable for quality due to data constraints, but further consideration is necessary at this point. It is thus difficult to analyze quality quantitatively, but it is important to study it. To overcome the data constraints, a questionnaire survey is another example of a tool to be used in future studies.

ACKNOWLEDGEMENTS

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REFERENCES


EXPLORATION OF TIME DELAY AND COST OVERRUN IN LIBYAN PUBLIC HOUSING PROJECTS

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There is great concern in Libya about the delays in public sector projects. Libyan construction projects habitually deviate from estimated timelines and financial profiles. Such frequent failures impose a financial burden on the state and causes significant delays in the implementation of these essential public projects. Globally, there has been considerable debate on how to minimise risk factors that affect completion of such construction projects. Whilst literature specific to Libya reveals ineffective project management practices typify Libyan construction projects with extensive time and cost overrun not only accepted, but seen as routine practice. As long ago as 2004 the Libyan government acknowledged that their contractors by and large provided a highly ineffective and inefficient service with little credence given to the need for effective risk management yet little action to address these failings subsequently followed.

Contributing to this body of work, the results from an exploratory qualitative survey based on a series of 16 semi-structured interviews undertaken with Libyan construction professionals are reported. The rich data emerging from the interview process provides a valuable insight into the specific nature of Project delay and cost overrun in Libya. Despite the respondents emphasized their unfamiliarity with risk management, a myriad of potential root causes emerged from the interviews suggesting project overruns in Libya are a resultant effect of failings to initiate effective project management.

Keywords: time delay, cost overrun, developing nations, Libya

INTRODUCTION

As Libya struggles to recover from the conflict in 2011 with two different governing powers, post-conflict recovery is massively dependent on accessing the 48.36bn barrels of oil held in vast oil reserves, the largest in Africa and amongst the largest in the world (OPEC 2015). To fully exploit these oil reserves, the Libyan GNC has instigated $140bn of investment between 2016 and 2026. This includes the development of oil and civilian infrastructure alongside 500,000 new homes. Ensuring timely completion and financial control is critical to the success of these projects. Yet delay and financial overruns are reported to severally impact 69% of construction and engineering projects undertaken in Libya (Ghadar, 2017), thus understanding root causes of delay and overrun and developing strategies to mitigate their impact is essential if the NGC’s objectives are to be achieved (Kusakci et al., 2017). Consequently, this research aims to explore the underlying causes of delay and overrun. Literature relating to time delay and cost overrun is reviewed. The results of an initial exploratory study collecting data from 16 construction professionals exploring root causes of project delay and cost overrun is

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presented. Finally, the paper concludes by proposing further research to validate the findings from this exploratory study.

REVIEW OF LITERATURE

A project is considered successful when it is completed on time, within budget and in accordance with specifications (Aziz 2013). In practice, these three dimensions are strongly interdependent and correlated. Inability to achieve these objectives manifests as delay and overrun (Adam et al., 2017) with delay and financial overrun seen as endemic. An assertion supported by several large multi-national studies including Morris’ (1990) work investigating overruns in India, that revealed 65% of the 290 projects analysed experienced cost overrun. A finding confirmed by Flyvbjerg et al., (2002) analysis of 258 infrastructure projects that revealed engineering projects have an 86% probability of exceeding their initial budget estimate. Despite the literature focusing on civil engineering projects, these overruns of this magnitude are not limited to civil engineering. Baloi and Price’s (2003) analysis of 1,778 World Bank funded projects across a range of project typologies again revealed a sizable majority (63%) exceeded their initial budgets. Literature continues to reaffirm the truly global perspective in the literature appraising the nature of project overrun. This literature, consisting of 1,748 publications, has been comprehensively critiqued in the work of Adam et al., (2017). Despite revealing exponential growth in literature, the work of Adam and colleagues reveals little by way of a consensus related to the dominant risks giving rise to delay and cost overrun. Nevertheless, Adam et al., (2017) advocate eight clusters of risk exist in the extent literature, these are shown in table 1. Although it is acknowledged the significance of each cluster manifests differently once a temporal analysis of literature is considered. Table 1: Principle root causes of delay and overrun (adapted from Adam et al., (2017)’

<table>
<thead>
<tr>
<th>Cause</th>
<th>Instances</th>
<th>Cause</th>
<th>Instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>Lack of stakeholder communication, inefficient communication</td>
<td>Material</td>
<td>Shortage of equipment, poor material planning</td>
</tr>
<tr>
<td>Management</td>
<td>Poor site management, inadequate managerial skills, poor monitoring &amp; control, slow decision making, client change, poor labour planning</td>
<td>Organisational</td>
<td>Unsuitable management structure, poor organisational structure, poor process procedures</td>
</tr>
<tr>
<td>Psychological</td>
<td>Optimism bias, Deception</td>
<td>Project</td>
<td>Project complexity, project duration.</td>
</tr>
<tr>
<td>Financial</td>
<td>Delayed payments, poor financial planning, price fluctuation</td>
<td>Weather</td>
<td>Harsh weather conditions, Unforeseen ground conditions</td>
</tr>
</tbody>
</table>

Notwithstanding the comprehensive nature of the literature, Amadi and Higham (2017) raised concerns about potential bias evident in the geographical contextualisation of the research. Noting the majority of primary data is collected in developed rather than developing nations, where potential challenges associated project delivery are more perspicuous. Although studies focusing on developing nations are limited (Amadi and Higham 2017) those that have been undertaken reveal the eight root causes determined by Adam et al., (2017) remain relevant. However, their prioritisation changes significantly with studies contextualised in developed nations advocating project related issues to be the most significant factor impacting on overrun. A situation not replicated in developing nations where corruption, client and consultant induced events impact significantly on project outcomes (Adeyemi and Masalila 2016). In furtherance of this argument Fang et al., (2004) opine causes of delay and overrun are habitually unique to the nation of interest. Different social and economic systems in tandem with historical, religious and cultural backgrounds routinely influence construction methodology and project management practice. Consequently, the specific nature and propensity of events identifiable within each of the root causes is likely to change. Thus, a clear distinction is
needed between cause and explanation (Adam et al., 2017). Whereby explanations will often not be directly transferrable.

**Time Delay and Cost Overrun Risk in Libya**

In comparison to other developing nations, Libya has been the focus of limited research appraising the manifestation of risk within the project environment leading to project delay (Abubaker et al., 2008, Elharare et al., 2016, Ghadar 2017, Kusakci et al., 2017). Albeit Libya can be identified as one of the most impacted with delays of 69% not uncommon. Abubaker et al., (2008) is at pains to argue that project delay is both complex and multifaceted. Failings in project management, poor client understanding and performance are largely associated with the extensive delays and overruns identified. There is, almost universal agreement within the literature that ineffective project management is the main contributor to delay.

Elharare et al., (2016) investigated the nature of project delay in Libya through analysis of survey responses gleaned from 300 construction professionals. The findings suggested a combination of human, project and external factors induced delay, analysis revealed the client’s misguided perception that procurement could deliver both cost reductions and increased quality lay at the heart of delays. Ineffective project management resulting from the appointment of either inexperienced or un-qualified project managers further compounded these failings (Assaff and Al-Hejji 2006, Tumi et al., 2009, Adujnah 2010). An interpretation contested by Abubaker et al., (2008) and Ghadar (2017) who espouse project managers are experienced but simply unfamiliar with modern construction methodologies and advances in project management. These failings are further compounded by client’s slow, ineffective decision making and poor payment practices (Tumi et al., 2009, Ali and Arun 2012). Leading to further time and cost overrun as projects are abandoned until payments are received (Tumi et al., 2009, Adujnah 2010, Mohamed 2010) or lengthy legal disputes are instigated (Assaff and Al-Hejji 2006).

Even with robust arguments suggesting poor project management and client failings remain at the core of poor project outcomes. El-Hasia (2005) narrated that Libyan national procurement policy sits at the core of project failure. Libyan procurement policy is often criticised for being both overly vague and extremely unsupportive of modern procurement practice. Yet the imposition of the policy means one-size fits all approach to procurement, whereby 92% of projects are procured using traditional design-bid-build together with the Libyan standard form of contract regardless of suitability (Ghadamsi 2016). This alongside a disregard for contractor selection (Elsayah 2016) and imposition of un-realistic timescales suggests projects are doomed to failure before they have begun.

Yet the challenges Libya presents as it struggles to recover from the conflict in 2011 with major security issues, a deregulated market, vulnerable legal framework and lack of central governing power has led to chronic shortages of skilled labour, materials and equipment (Shebob et al., 2012). Triggering extended periods of delay whilst materials are sourced, labour recruited and extensive re-work undertaken. Even though the impact of wider contractor-oriented delay does not dominate the literature, a small number of studies narrate similar assertions. Tumi et al., (2009) observed endemic materials shortages on projects clustered around Benghazi City. Similarly, Adujnah (2010) suggests contractor induced delay makes a significant contribution to project overrun, with materials shortages, lack of experience and challenges of sourcing skilled labour negatively impacting on project delivery.
Extant literature is already replete with factors that engender cost and time overruns. International literature advocates risk related to project overrun can be hierarchically categorised into eight principle root causes. However, Libyan literature does not replicate these assertions. Albeit the Libyan literature, due to the dominance of quantitative design, fails to satisfactorily explore the root causes of project failure. The body of work nevertheless presents a narrower perspective of the root causes of delay and cost overrun. Even so it must be acknowledged the number of studies looking at time delay and financial overrun are limited, with an exhaustive review literature identifying only 26 studies, 10 of which are doctoral thesis. Furthermore, the majority are over 10 years old. Thus for the most part this body of work fails to reflect the significant changes following the first Libyan Civil War. Aziz’s (2013) exploration of post-conflict Egypt emphasises the importance of exploring how conflict and regime change impacts on the root cause of project delay.

RESEARCH DESIGN

As narrated earlier, the majority of Libyan research focused on risk associated with project overrun routinely adopts a realist, post-positivist design, using large scale surveys to gather rigidly framed opinion data from random samples of construction professionals (Tumi et al., 2009). Whilst this provides a national perspective of the risks leading to delay and cost overrun, it fails to consider specific nuances identifiable within individual projects (Fang et al., 2004, Adam et al., 2017). Survey designs are usually influenced by the most common causes of delay or cost overrun identified in the literature. Thus introducing bias by limiting the response options available. The need to ascertain the nature of delay and cost overrun within the context of a project without the constraints seen as a major limitation within extant literature called for the adoption of a qualitative research design. Through which delay and overrun could be comprehensively explored. Consequently, a phenomenological approach, making use of an inductive research strategy (Creswell 2015) was adopted to explore key themes, understandings and attitudes of those who work within the project environment on a daily basis (Flick 2009).

Data Collection and Analysis

The research presents the findings of detailed interviews with a range of construction professionals, drawn from 23 public housing projects, executed by 15 different contractors in the Libyan cities of Subrata and Surman. Galvin (2015) espouses interviews sample sizes of between 8 and 17 reflect the norm for qualitative research, whilst Guest et al., (2006) suggests saturation is routinely achieved after 12 interviews. It was therefore resolved to adopt a discriminate sample of 16 participants (see table 2). Creswell (2015) advocates discriminate sampling as a way to maximise the opportunity of relevant data collection from a small sample.

Participants were invited to take part in a semi-structured interview held at their office and lasting approximately 45 minutes. This ensured the interviewee has sufficient space to offer new meanings to the research focus by drawing on the nuances of their individually constructed experiences (Denscombe 2014). The interviews sought to establish key thematic areas from which a broader research agenda can be established. To aid the interviews, the questions focused on an initial analysis of project delay and cost overrun to allow different actors to reflect on the potential causes of the established delay. The interviews were recorded with the consent of participants, fully transcribed and loaded into Nvivo qualitative analysis software before being thematically analysed. Open coding was used to identify sub-categories associated with the central themes outlined above. Once a large number of nodes were identified, axial coding revealed
relationships between nodes and sub-nodes. As the analysis continued, each category was developed to reflect the content of the data collected and draw out more detailed categories. In developing this process, the data was repeatedly analysed.

Table 2: Research Participants

<table>
<thead>
<tr>
<th>Exp. Stakeholder</th>
<th>Exp. Stakeholder</th>
<th>Exp. Stakeholder</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Years) Group</td>
<td>(Years) Group</td>
<td>(Years) Group</td>
</tr>
<tr>
<td>R1 20 Consultant</td>
<td>R7 23 Contractor</td>
<td>R13 30 Client</td>
</tr>
<tr>
<td>R2 27 Consultant</td>
<td>R8 21 Contractor</td>
<td>R14 16 Client</td>
</tr>
<tr>
<td>R3 26 Consultant</td>
<td>R9 20 Contractor</td>
<td>R15 20 Client</td>
</tr>
<tr>
<td>R4 19 Consultant</td>
<td>R10 12 Contractor</td>
<td>R16 21 Client</td>
</tr>
<tr>
<td>R5 24 Contractor</td>
<td>R11 22 Contractor</td>
<td></td>
</tr>
<tr>
<td>R6 26 Contractor</td>
<td>R12 18 Contractor</td>
<td></td>
</tr>
</tbody>
</table>

Factors Contributing to Delay and Overrun

Management
Management represented the most significant cause of the delay with 10 risk events identified by participants. The most significant related to frequent post contract change with clients failing to have: “a clear view concerning the targeted design and specifications of the project, therefore change orders were frequently issued during the construction phase” (R1). An observation reinforced by a number of contractors who suggested levels of post contract change diminished their ability to appropriately plan the project. Whilst the interviewees accept a small number of changes are often necessary to resolve unexpected design issues, it was argued the vast majority of change related to: “the specification of materials [that] where unnecessary and could be avoided” (R2) as they should have been resolved during the design phase.

Impact of change represented the second most significant cause of overrun, with 11 respondents identifying delays in decision making as major triggers of unnecessary and avoidable delay. It was suggested “clients respond slowly to any queries or requests submitted either by contractors or consultants. Resulting in delays in project progress and in some circumstances complete stoppage of the work on site” as a result: “continuity of work was controlled by the client’s response time not the programme developed” (R10). When asked about the frequency of this situation, one contractor simply responded: “they are very frequent” (R5) but also contradicted the views put forward by consultants, suggesting they were equally indecisive.

Despite post-contract management failings dominating, a number of avoidable pre-contract problems were also identified as triggers for delay. For instance, it was suggested clients employ: “unqualified decision makers in [their] senior management [who] were taking decisions at the top of the client’s organisation that normally led to undesirable situations” (R4). When pressed on the nature of these undesirable situations it was suggested: “unqualified decision markers push through crucial decisions without asking related departments to prepare detailed studies that would enable them to make appropriate decisions” (R13).

This approach to decision making, it was suggested, occurred throughout the project, with impulsive decision-making identified as a fundamental risk by consultants: “rash behaviour by the owners’ senior management in taking important decisions led to massive delays in project progress” (R10). Yet it remains unclear how this correlates with slow decision-making identified earlier. Although its impacts are clear, with one client suggesting this: “would often necessitate successive change orders” (R15) thus triggering significant periods of delay. Furthermore, it was suggested this approach often resulted in
unclear specifications, a lack of detailed ground investigations, incomplete drawings and poor project planning information. The majority of the interviewees identified management failings across stakeholders as a fundamental cause of time delay and cost overrun across the 23 Libyan housing projects. It is clear from the findings that inexperience amongst both the client’s own staff and the contractor’s team together with ineffective and slow decision making are causing catastrophic delays.

Financial
The interviews revealed a number of financial factors that led to project delay and cost overrun, although these seemed to differ between project and wider economic factors. There was consensus that poor project management by clients, resulted in poor financial planning: “the volume of contracts signed each year for public housing projects is much larger than the available budget” (R4). This in turn would lead to poor payment practices, with contractors encountering: “considerable delay by the owner in payment for performed work” (R6) impacting: “company cash flow and result in slow work progress at the site” (R6). However, one contractor also confirmed: “frequent delays in decision making increased the cost burden on the contractor due to the wages paid to labour during the work stoppage” (R8). Poor financial management, both in terms of financial planning for individual projects, and failings at strategic levels within the client organisation were seen as resulting in very limited budget management, which would consequently led to poor payment practices. Subsequently resulting in extensive delays, as contractors either slowed the progress of the work or abandon projects completely until payment delays were resolved.

Labour, Material and Equipment Shortages
A number of interviewees identified high variances in materials prices throughout the contract period: “the prices of materials where not fixed and faced noticeable variations up and down during the contract” (R9), or at worse the unavailability of essential materials: “due to increasing demand for construction materials…there was a shortage in the availability of materials in the local market” (R5). This situation gave rise to material and equipment theft from site: “theft of materials and equipment from the site happened several times during the previous years and caused stoppage of the work at the site many time as well” (R8). Whilst respondent three suggested: “due to the lack of security, project materials were stolen from the site from time to time” (R3). As a result the contractor would: “import materials in limited quantities to the site, resulting in additional time and cost” (R8). Security and political instability within Libya are having a serious and sustained effect on labour, material and equipment sourcing often leading to extensive re-work as a result of the workforce’s inability to meet quality standard required by the client triggering further extensive delay.

Policy and Political Impacts
Although political challenges were not as apparent at the start of the projects, two Libyan civil wars have introduced a significant amount of risk to the project. These risks emerged as some of the most significant in terms of frequency of identification. The first, however, pre-dates the wars, relating to robust legislative control of procurement and the recruitment of labour, or more specifically the barriers to recruiting skilled labour internationally. Respondent 10 suggested: there was difficulty in bringing in technical labour from abroad, due to complex government regulations” (R10). A point reinforced by respondent 3, who suggested if these procedures had been eased the project could have been delivered more efficiently as the: “international workforce exhibited the essential skills needed that are severely lacking in Libya” (R3). This problem is compounded by
the lack of skilled labour available due to the: “significant under-supply of labour caused by massive increases in project delivery” (R14).

Unsurprisingly the majority of respondents alluded to the joint impact of post-conflict political instability and security failings as contributing to the delay and cost overruns encountered. “Since 2011 up to November 20 2016 there is no political stability in the Libyan state” (R1). A perspective reinforced by respondent 5 who observed: “the changes in government over the last 6 years affected the political stability of the state” (R5). When asked how this instability translated into project risk, respondent 4 suggested it resulted in time being wasted: “waiting for documents and approvals from political government agencies, with political instability also affecting project funding and frequent changes of decision makers at senior levels further delaying the project” (R4). However, this lack of political stability also translated into an insecure work environment, further impacting on both labour recruitment and site security. The interviews reveal the challenges post-conflict Libya presents, with major security issues, a deregulated market, vulnerable legal framework and lack of central governing power leading to lawlessness creating a severely challenging environment for the delivery of major projects.

**Procurement Policy**

The majority of those interviewed identified procurement processes and legislation underpinning the process of public sector procurement as a major risk contributing to project overrun. The first factor identified, which is intrinsically linked to the financial risk, related to the over-procurement of public projects, as a result of poor client management and understanding of the procurement process. The participants identified the procurement process itself to be highly flawed, with projects put to the market with incomplete and inaccurate information.

It also became clear that the problems experienced during the construction phase where exacerbated by poor tendering practices. Six interviewees identified the lack of contractor vetting as a major risk. Suggesting this resulted in inexperienced contractors being awarded contracts. Resulting in a situation whereby: “some construction companies involved in this project where established recently and have no experience” (R4). Giving rise to: “poor performance during the construction stage resulting in massive delays in project delivery” (R2).

It was suggested this failure to pre-qualify contractors also brought about financial challenges, as contractors where not always capable of sustaining the cash flow needed to deliver the project. Respondent 4 acknowledged: “the weakness of the financial state of some companies involved in this project made those companies incapable of accommodating payment delay” (R4). Whilst a government representative revealed this lack of financial robustness had: “affected the continuity of the work progress in terms of company’s poor cash flow preventing them employing different package contractors to work concurrently”. It is clear the lack of flexibility in existing procurement policy and poor contractor vetting are seen as fundamental barriers to successful project delivery.

**DISCUSSION**

Risk and its translation into project failure through time and cost overrun has continued to present a fertile ground for research, however, literature exploring overrun in a Libyan context remains limited, in part due to the dominance of the adoption of large-scale quantitative surveys that seldom offer any deeper reflection from the participants on the context of risk, why these risk events occurred or how indeed they could be effectively managed. The Libyan literature espoused the dominance of three fundamental root
causes: Management failure, overly prescriptive procurement policy and wider economic failings associated with post-conflict instability. Whilst not reaching any firm conclusions, the findings from the study suggest a significant disparity between previous quantitative studies undertaken in Libya and experiences of practitioners.

Whilst the findings of this research reaffirm the significance of these factors, the interviews revealed an array of potential explanations for delay and overrun. Suggesting delay and overrun in Libya is far more complex and interlinked that the extent literature suggested. Indeed, analysis of the qualitative data reveals the root causes of delay synthesised in Adam et al’s (2017) review of extant literature, shown in table 1, are closely replicated in the Libyan context, when the findings are mapped against Adam et al’s (2017) root causes as shown in table 3. The mapping reveals seven of the eight identified root causes are relevant to Libya, with psychological causes not emerging during the interviews. However, a ninth root cause, political, is proposed. Although explanation is grounded in Libya this is potentially relevant to other developing nations where political interference is likely to be significant. Such findings contradict Amadi and Higham’s (2017) assertion that extant literature, contextualised within developed nations, fails to adequately reflect the situation in developing nations. It can also be argued the findings only partially support Fang et al’s (2004) suggestion that country specific research is required to capture specific nuances of project delay.

Given the majority of projects are highly impacted by delay and overrun, those interviewed accepted risk is poorly reactively managed and is often introduced through easily fixed failings in project management (PM). The study reaffirms the earlier view that PM failings are often at the core of delays. Moreover, the study reaffirms the argument that unqualified project managers are often engaged to oversee projects. (Assaff and Al-Hejji 2006, Tumi et al., 2009, Adujnah 2010, Ghadar 2017). However, unlike previous studies, the participants revealed failings in PM are not occurring within the professional team employed to deliver the project but are embedded at a senior level within client organisations. Leading to irrational, ineffective and slow decision making, reinforcing the assertions made by Tumi et al., (2009) and Ali and Arun (2012). The findings further revealed those same senior professionals where also the primary decision maker for the client. Despite lacking expertise, they routinely failed to seek technical advice from consultants before providing instruction to the contractor. Resulting in legal disputes and extensive claims confirming the observations of Assaff and Al-Hejji (2006).

Despite the Libyan construction industry feeling the impact of on-going conflicts the situation observed by Aziz (2013) in post-conflict Egypt, is only partially replicated here. Although conflict has impacted on project and undoubtedly increased the propensity of delay, as a result of labour and material shortages, challenges to security and uncertainty in the funding of major projects. The majority of those interviewed did not feel the situation, in terms of ineffective project delivery had changed significantly due to the conflict.
Table 3: Findings mapped against Adam et al.’s (2017) root causes

<table>
<thead>
<tr>
<th>Cause</th>
<th>Instances identified in Libya</th>
<th>Cause</th>
<th>Instances identified in Libya</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>Lack of stakeholder communication, insufficient communication, incomplete drawing &amp; specifications</td>
<td>Material</td>
<td>Shortage of equipment, poor material planning, material unavailability, material thefts</td>
</tr>
<tr>
<td>Management</td>
<td>Inadequate managerial skills, poor monitoring &amp; control, delays in client decision making, frequent client change, lack of clarity in sample approvals, Lack of ground investigations, Lack of contractor experience, haphazard decision making, unqualified decision makers</td>
<td>Organizational</td>
<td>Unsuitable management structure, poor organisational structure, poor process procedures</td>
</tr>
<tr>
<td>Political (New Root Cause)</td>
<td>Political instability of the state, Labour shortages, Lack of security in state and lack of policing, complexity of legislation</td>
<td>Project</td>
<td>Project complexity, project duration.</td>
</tr>
<tr>
<td>Financial</td>
<td>Delayed payments, poor financial planning, increases in material prices.</td>
<td>Weather</td>
<td>Unforeseen ground conditions.</td>
</tr>
</tbody>
</table>

CONCLUSIONS

The study has not reached any firm conclusions on root cause of time delay and cost overruns in Libya or developing nations more widely due to the exploratory nature of the study and limited sample size. The findings from this research, do however, raise questions about the Libyan construction industry’s ability to reduce cost and time overrun successfully. Furthermore, important questions are raised as to the varsity of the assertion that a clear disparity in underlying cause of delay and overrun exists between developed and developing nations. With the findings revealing a close mapping of root cause between Libya and the wider literature contextualised in developed nations. The research findings further suggest that whilst cost overrun and project delay are highly complex and multi-faceted construct. The professionals interviewed identified a number of key barriers to reducing and overcome project failure including: ineffective strategic management within the client organisation reinforced with inefficient management at project level, the complexity of state legislation that prevents the recruitment of international construction experts and also much needed site labour, the impact of the ongoing conflict on project delivery due to security failings and uncertainty in the political environment and highly ineffective procurement processes and contractor vetting. The findings have also dismissed the current three factor perspective argued in the limited Libyan literature providing for the first time, a phenomenological perspective on the complexity of project delay and overrun. Further confirmatory research is now recommended to validate the initial findings from this exploratory study.

REFERENCES


AN ANALYSIS OF THE CRITICAL RISK FACTORS IN OIL AND GAS PIPELINE PROJECTS USING A COMPREHENSIVE RISK MANAGEMENT FRAMEWORK

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Risk Factors (RFs) associated with the design, construction and operation of Oil and Gas Pipeline (OGP) projects have a serious impact on the safety of a project. The limitations of the effective risk analysis techniques due to a lack of reliable risk data - particularly in insecure countries like Iraq where OGP are suffering from sabotage attacks - frequently cause great challenges in the attempt to mitigate these risk factors and provide a systematic risk management system. This paper, therefore, aims to analyse OGP's RFs more accurately using a more systematic and holistic Risk Management Framework (RMF). The RMF was designed under three steps. Step 1 focused on carrying out a comprehensive review to identify the RFs in OGP projects in different countries and some of the Risk Mitigation Methods (RMMs) used in these projects. Step 2 used a questionnaire survey to analyse the RFs regarding their influence on OGP projects and to evaluate the RMMs based on their degrees of effectiveness to mitigate the RFs. The ranking of the RFs indicated that proper attention needs to be paid to the question of what motivates third-party disruption to OGP in Iraq like sabotage, terrorism and theft risks. Step 3 was about recommending some RMMs to mitigate the RFs in these projects based on the results of the survey. The RMF and its recommendations could be used to more effectively manage the RFs in OGP projects in troubled countries that have just begun to address such risks.

Keywords: pipelines, risk management framework, risk mitigation methods

INTRODUCTION

Although Oil and Gas Pipelines (OGPs) are a safe mode by which to transport petroleum products, these pipelines are still subject to several threats that cause pipe failure. OGP mainly suffer from Third-Party Disruption (TPD); corrosion; planning, design and construction defects; natural hazards; and operational errors (Wan and Mita, 2010). Peng et al., (2016) define TPD as any accidental damage in OGP due to external Risk Factors (RFs) like soil movement, surface loads that compress pipelines, natural phenomena, mechanical failures, or human activities near to pipelines. Muhlbauer (2004) suggested that TPD also refers to any direct or indirect action that may be carried out individually, or by groups, to affect the safety of OGP projects - like terrorism, sabotage, theft and cyber-attacks on control systems. TPD has been recognised as one of the most dominant causes of OGP failure globally (Wan and Mita, 2010).

Iraq's oil reserves are the fifth-largest in the world (EIA 2016) and its gas reserves range between the world’s 10th to 13th largest (IEA 2012). Meanwhile, the inadequacies regarding the management of the RFs in OGP projects make pipeline failures inevitable.

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and hinder oil export activities, which results in massive economic losses to the country. Hence, there is a vital need to contribute to solving these highlighted crucial problems in Iraq and other troubled countries by employing a holistic risk management method to focus on the most vulnerable segments of pipeline safety. This research, therefore, aims to develop a Risk Management Framework (RMF) to identify and analyse the RFs and Risk Mitigation Methods (RMMs) in OGP projects more systematically and holistically to help the stakeholders to mitigate the RFs in these projects successfully.

**LITERATURE REVIEW**

As Peng et al., (2016) observed, risk management has four steps: (1) Identify the RFs and RMMs. (2) Analyse the RFs regarding their degree of influence on a project because dealing with each RF as if it is the most critical one results in heavy losses in terms of resources (Srivastava and Gupta, 2010). (3) Respond to the risk and mitigate the consequences, which means to apply suitable methods to mitigate the RFs. Therefore, it is significant to evaluate the RMMs regarding their degree of effectiveness. (4) Risk monitoring and control, which is a continuing work-cycle of the three steps to provide up-to-date information about the existing and new RFs and RMMs during the project's stages, and to ensure the project's safety.

Effective risk mitigation requires appropriate knowledge, an up-to-date database about pipeline failure causes (Balfe et al., 2014), and accurate values about the probability and severity levels of the RFs to identify the factors which require prioritisation. However, the data that the existing risk analysis methods contain is uncertain with regard to the probability and severity of the RFs. For example, the data is it not available or is there a possibility that it is incorrect. (Yazdani-Chamzini, 2014). In addition, these methods are not accurate enough to calculate the probability of TPD risks because a historical database about such risk has not yet been established (Peng et al., 2016). Moreover, these methods are either too generic or too specific when dealing with the RFs, as they are analysing only one or two RFs at the same time (El-Abbasy et al., 2016). For example, studies about OGP risk in European countries mainly focus on corrosion and stress-strain risk. This is because OGPs in these countries are less subject to sabotage risk because their pipelines are underground and in safe areas. Researchers in the USA are focusing more on the terrorism risk, especially after 9/11, in addition to corrosion because OGPs in the USA are underground. Studies about this topic in Africa are focusing more on the social factors of risk, such as sabotage and thefts. This is related to poverty levels, as stolen products might be sold on the black market. Therefore, these studies are not applicable in Iraq or other countries in a similar situation where the OGP network is aboveground, and they are subject to all of the mentioned RFs.

Regarding the development of RMF, Mubin and Mubin (2008) developed a risk model for gas pipeline projects in Pakistan. This model identifies the RFs during the construction stage based on analysing a number of local projects and reviews from local clients and contractors. Monte Carlo simulation was used to estimate finishing the projects on time and budget. The authors created a data bank to store the model's findings and provide recommendations for the risk management process. Schwarz et al., (2015) proposed a risk management procedure to support decision-making processes in projects. The model started by defining the project's scope, the risk management criteria and identifying the RFs using checklists. The authors used the Artificial Neural Network (ANN) and experts’ judgements to evaluate the RFs. These two models identify RFs only from local projects. El-Abbasy et al., (2014) used a historical database and ANN to predict the conditions of offshore OGPs in Qatar and to prioritise the maintenance work.
for these pipelines. This study uses an available database to identify the RFs. Unfortunately, there is no such database available in developing countries, where the documentation is not in the best condition and there are no appropriate records about OGP accidents. None of the reviewed models has identified and evaluated any RMMs to mitigate the RFs. The current study adapts these models to develop a more holistic and applicable RMF for OGP projects in troubled countries like Iraq by bridging the highlighted gaps in them (see Figure 1).

Figure 1: The design of the Risk Management Framework (RMF)

From the preceding text, it is clear that effective risk management is unachievable if the facilities for identifying the RFs and RMMs are not at the required level, and the probability and severity of the RFs and the effectiveness of the RMMs are not accurately evaluated.

Comprehensive investigations were carried out to identify OGP RFs in different countries across the world, especially in insecure ones. These investigations helped to overcome the problem of lack of information about OGP failure causes in Iraq, because there is no database about them. Li et al., (2016) classified factors influencing global investment in shale gas into five types, namely: economic, political, geological, technological and internal risks. Mubin and Mubin (2008) classified RFs that obstruct the construction and operation of pipeline projects in Pakistan into seven types, namely: political, socio-economic, technical, organisational, natural catastrophe, financial, safety and security, and environmental risks. In the current study, in order to include OGP RFs that affect the general safety of OGPs in addition to the economic challenges, and to include RFs present during the entire project, they have been classified into five different types depending on their characteristics, as follows: (I) Security and Societal (S&S); (II) Pipeline Location (PL); (III) Health, Safety and Environment (HSE); (IV) Operational Constraints (OC); and (V) Rules and Regulations (R&R) risks (see Table 1).

RESEARCH METHODOLOGY

Developing an RMF is a part of the methodology in this paper. Figure 1 explains the steps of work for this framework. Step 1 was about identifying the RFs from the literature review. Additionally, a number of RMMs were suggested to mitigate the RFs in OGP projects in Iraq. These methods were classified depending on an estimate about when they could be applied during the projects (see Table 2). These investigations did not provide any information about the probability and severity of the RFs and the effectiveness of the RMMs in the study area, Iraq. Therefore, a questionnaire survey was needed to gather stakeholders' perceptions about them.
Step 2, therefore, saw the development of a questionnaire survey based on the findings from step 1. A pilot survey was distributed to improve the clarity of the questions. The survey was distributed using an online survey tool. The potential respondents were informed that their responses would be treated confidentially. RF probability levels were analysed on a scale (rare, unlikely, possible, likely and almost certain). RF severity levels were analysed on a different scale (negligible, minor, moderate, major and catastrophic). RMM effectiveness degrees were evaluated on a further scale (ineffective, slightly effective, moderately effective, very effective and extremely effective). A Likert scale was used in this paper because it is a commonly used scale for subjective measurements. This scale is sensitive and small deviations are highly meaningful (Cummins and Gullone, 2000).

Initially, a 7-point Likert scale was used in the pilot survey, but the participants observed that it was difficult for them to use. Therefore, a 5-point scale was suggested for the survey. The survey asked the participants to rank the project stages from 1 to 3 regarding their priority for application of the RMMs; where 1 means high priority and 3 means lower priority. The respondents were asked, are the underground pipelines (which are subject to corrosion, geological, construction and maintenance risks) safer than the aboveground ones (which are subject to sabotage and theft risks) or vice versa?

The values of Risk Probability (RP) and Risk Severity (RS) of each RF (Table 1) and the degrees of effectiveness of each RMM (Table 2) were calculated by determining the means of the scale. Based on the character of the RF, some RMMs were suggested to mitigate the RF. For example, avoiding insecure areas, using an anti-terrorism design, having protective barriers and patrols could mitigate the risk of terrorism and sabotage by direct action. Meanwhile, laying the pipelines underground can help to minimise the opportunities for terrorists and saboteurs to attack them. However, terrorists and vandals still have an opportunity to damage OGPs. Educating government-public corporations about managing the safety of OGPs and reporting any case of vandalism could help to reduce pipeline attacks, but the government cannot entirely stop terrorists and vandals from attacking the pipelines. From these examples, the RMMs were classified into direct and indirect RMMs in the way that the RMM(s) will mitigate the RF(s) (see Figure 2).

RESULTS

Before analysing the survey, it was important to test its reliability. Cronbach’s alpha correlation coefficient (α) was calculated by using SPSS to test the survey's reliability level (Shavelson and Haertel, 2006). The α of the survey was found to be 0.910, where 0.7 indicates a minimum level of reliability (Pallant, 2001). This means the results are reliable.

In total, 198 respondents completed the survey: 14 were consultants, planners or designers; 71 were site engineers; 41 were operators; 29 were administrators; 10 were owners or clients; and 33 were either students (they are employers and postgraduate students at the same time) or lecturers in oil engineering departments at different Iraqi universities. With regard to level of experience, 74 respondents have less than five years of experience, 67 have between five and 10 years, 29 have between 10 and 15 years, and 28 have more than 15 years of experience. Three respondents do not have a degree, 28 have a high school certificate or diploma, 106 have a bachelor's degree (engineers), and 61 have a master's degree or PhD. The results of analysing the RFs and RMMs are shown in Table 1 and Table 2.
Table 1: The identified RFs from literature and the results of the survey.

<table>
<thead>
<tr>
<th>RFs</th>
<th>Authors</th>
<th>Risk Type</th>
<th>RS</th>
<th>RI</th>
<th>R*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terrorism and sabotage</td>
<td>Nnadi et al., (2014)</td>
<td>S&amp;S</td>
<td>3.99</td>
<td>4.49</td>
<td>3.58^1</td>
</tr>
<tr>
<td>Corruption</td>
<td>Nnadi et al., (2014)</td>
<td>R&amp;R</td>
<td>3.98</td>
<td>4.32</td>
<td>3.44 2</td>
</tr>
<tr>
<td>Insecure areas</td>
<td>Srivastava and Gupta (2010)</td>
<td>PL</td>
<td>3.72</td>
<td>4.11</td>
<td>3.06 3</td>
</tr>
<tr>
<td>Lawlessness</td>
<td>Peng et al., (2016)</td>
<td>R&amp;R</td>
<td>3.61</td>
<td>4.19</td>
<td>3.03 4</td>
</tr>
<tr>
<td>Thieves</td>
<td>Nnadi et al., (2014)</td>
<td>S&amp;S</td>
<td>3.69</td>
<td>4.08</td>
<td>3.01 5</td>
</tr>
<tr>
<td>Corrosion and lack of protection against it</td>
<td>Nnadi et al., (2014)</td>
<td>OC</td>
<td>3.69</td>
<td>3.99</td>
<td>2.94 6</td>
</tr>
<tr>
<td>Improper safety regulations</td>
<td>Guo et al., (2016)</td>
<td>HSE</td>
<td>3.69</td>
<td>3.95</td>
<td>2.92 7</td>
</tr>
<tr>
<td>Improper inspection and maintenance</td>
<td>Nnadi et al., (2014)</td>
<td>HSE</td>
<td>3.66</td>
<td>3.92</td>
<td>2.87 8</td>
</tr>
<tr>
<td>Low public legal and moral awareness</td>
<td>Peng et al., (2016)</td>
<td>S&amp;S</td>
<td>3.71</td>
<td>3.86</td>
<td>2.86 9</td>
</tr>
<tr>
<td>Weak ability to identify and monitor the risks</td>
<td>Nnadi et al., (2014)</td>
<td>OC</td>
<td>3.63</td>
<td>3.90</td>
<td>2.83 10</td>
</tr>
<tr>
<td>Stakeholders not paying proper attention</td>
<td>Nnadi et al., (2014)</td>
<td>R&amp;R</td>
<td>3.53</td>
<td>3.96</td>
<td>2.80 11</td>
</tr>
<tr>
<td>Lack of proper training</td>
<td>Nnadi et al., (2014)</td>
<td>R&amp;R</td>
<td>3.65</td>
<td>3.77</td>
<td>2.75 12</td>
</tr>
<tr>
<td>Exposed pipelines</td>
<td>Rowland (2010)</td>
<td>HSE</td>
<td>3.67</td>
<td>3.68</td>
<td>2.70 13</td>
</tr>
<tr>
<td>Shortage of modern IT services</td>
<td>Nnadi et al., (2014)</td>
<td>OC</td>
<td>3.67</td>
<td>3.65</td>
<td>2.68 14</td>
</tr>
<tr>
<td>Limited warning signs</td>
<td>Nnadi et al., (2014)</td>
<td>HSE</td>
<td>3.63</td>
<td>3.66</td>
<td>2.66 15</td>
</tr>
<tr>
<td>Easy access to pipeline</td>
<td>Srivastava and Gupta (2010)</td>
<td>PL</td>
<td>3.63</td>
<td>3.65</td>
<td>2.65 16</td>
</tr>
<tr>
<td>Lack of risk registration</td>
<td>Nnadi et al., (2014)</td>
<td>R&amp;R</td>
<td>3.57</td>
<td>3.70</td>
<td>2.64 17</td>
</tr>
<tr>
<td>Little research on this topic</td>
<td>Nnadi et al., (2014)</td>
<td>R&amp;R</td>
<td>3.62</td>
<td>3.57</td>
<td>2.58 18</td>
</tr>
<tr>
<td>Design, construction and material defects</td>
<td>Guo et al., (2016)</td>
<td>OC</td>
<td>3.33</td>
<td>3.85</td>
<td>2.56 19</td>
</tr>
<tr>
<td>Conflicts over land ownership</td>
<td>Macdonald and Cosham (2005)</td>
<td>PL</td>
<td>3.49</td>
<td>3.61</td>
<td>2.52 20</td>
</tr>
<tr>
<td>Threats to staff</td>
<td>Rowland (2010)</td>
<td>S&amp;S</td>
<td>3.32</td>
<td>3.73</td>
<td>2.48 21</td>
</tr>
<tr>
<td>Public poverty and education level</td>
<td>Nnadi et al., (2014)</td>
<td>S&amp;S</td>
<td>3.45</td>
<td>3.41</td>
<td>2.35 22</td>
</tr>
<tr>
<td>Operational errors</td>
<td>Nnadi et al., (2014)</td>
<td>OC</td>
<td>3.10</td>
<td>3.61</td>
<td>2.24 23</td>
</tr>
<tr>
<td>Inadequate risk management</td>
<td>Nnadi et al., (2014)</td>
<td>HSE</td>
<td>3.23</td>
<td>3.40</td>
<td>2.20 24</td>
</tr>
<tr>
<td>Leakage of sensitive information</td>
<td>Wu et al., (2015)</td>
<td>S&amp;S</td>
<td>2.98</td>
<td>3.51</td>
<td>2.09 25</td>
</tr>
<tr>
<td>Geological risks</td>
<td>Guo et al., (2016)</td>
<td>PL</td>
<td>2.75</td>
<td>3.18</td>
<td>1.75 26</td>
</tr>
<tr>
<td>Natural disasters and weather conditions</td>
<td>Nnadi et al., (2014)</td>
<td>HSE</td>
<td>2.65</td>
<td>3.07</td>
<td>1.63 27</td>
</tr>
<tr>
<td>Vehicular accidents</td>
<td>Nnadi et al., (2014)</td>
<td>PL</td>
<td>2.46</td>
<td>2.71</td>
<td>1.33 28</td>
</tr>
<tr>
<td>Hacker attacks on the operating or control systems</td>
<td>Srivastava and Gupta (2010)</td>
<td>OC</td>
<td>2.24</td>
<td>2.97</td>
<td>1.33 29</td>
</tr>
<tr>
<td>Animal accidents</td>
<td>Mubin and Mubin (2008)</td>
<td>PL</td>
<td>1.89</td>
<td>2.02</td>
<td>0.76 30</td>
</tr>
</tbody>
</table>

^ For example RI for (Terrorism and sabotage) = (3.99 X 4.49)/5 = 3.58 (Sa’idi et al., 2014). * R means ranking.
Critical Risk Factors in Oil and Gas Pipeline Projects

Table 2: RMM classification and effectiveness.

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>Direct Risk Mitigation Methods</th>
<th>Indirect risk mitigation methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terrorism &amp; sabotage</td>
<td>Avoid the insecure areas</td>
<td>Use underground pipeline</td>
</tr>
<tr>
<td>Thieves</td>
<td>Anti-terrorism design</td>
<td>Government-public cooperation</td>
</tr>
<tr>
<td>Geographical location “insecure areas”</td>
<td>Use underground pipeline, Protective barriers &amp; perimeter fencing</td>
<td>Avoid the registered risks &amp; threats</td>
</tr>
<tr>
<td>Public’s low legal &amp; moral awareness</td>
<td>Government-public cooperation</td>
<td>Anti-terrorism design</td>
</tr>
<tr>
<td>Threats to staff</td>
<td>Foot &amp; vehicle patrols</td>
<td>Avoid insecure areas</td>
</tr>
<tr>
<td>The pipeline is easy to access</td>
<td>Use underground pipeline, High technology &amp; professional remote monitoring</td>
<td>Government-public cooperation</td>
</tr>
<tr>
<td>Geological risks such as groundwater &amp; landfills</td>
<td>Foot &amp; vehicle patrols</td>
<td>Avoid insecure areas</td>
</tr>
<tr>
<td>Vehicle accidents</td>
<td>Use underground pipeline, Protective barriers &amp; perimeter fencing</td>
<td></td>
</tr>
<tr>
<td>Animal accidents on the pipeline</td>
<td>Use underground pipeline</td>
<td></td>
</tr>
<tr>
<td>Corrosion and lack of protection against it</td>
<td>Anti-corrosion measures such as isolation and cathodic protection</td>
<td>Proper inspection, tests &amp; maintenance</td>
</tr>
<tr>
<td>Weak ability to identify &amp; monitor the threats</td>
<td>Foot &amp; vehicle patrols</td>
<td></td>
</tr>
<tr>
<td>Shortage of IT services &amp; modern equipment</td>
<td>Use underground pipeline</td>
<td></td>
</tr>
<tr>
<td>Design, construction &amp; material defects</td>
<td>Use underground pipeline, Protective barriers &amp; perimeter fencing</td>
<td></td>
</tr>
<tr>
<td>Operational errors</td>
<td>Use underground pipeline</td>
<td></td>
</tr>
<tr>
<td>Lack of proper training</td>
<td>Use underground pipeline</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2 shows the suggested RMMs to mitigate the RFs in OGP projects in Iraq. The RMMs were ranked based on the survey results.

By comparing Table 1 with Figure 2, we can see some RFs do not have any suggested RMMs. Therefore, in Figure 3, more RMMs which were not mentioned in the survey have been suggested to mitigate the first three RFs.
Figure 3: The suggested RMMs from outside the survey.

As some of the RFs shown in the above figure did not have any associated RMMs, it was necessary to identify more RMMs than those included in the survey (Figure 3). As suggesting RMMs for RFs like corruption is beyond the authors’ knowledge, these RFs needed to come from very high levels of government.

The project stages were ranked regarding the priority for application of the RMMs by calculating the total response as follows. 1- Planning and design stage (with a total of 1.520); 2- construction stage (with a total of 2.045); 3- operation stage (with a total of 2.434). As 1 indicates the highest priority, the lowest total is the top rank. Fifty-eight out of 198 respondents chose aboveground as a comparatively safe pipeline network; while 140 respondents chose underground pipelines as the safer option to transport petroleum products in Iraq.

DISCUSSION

Risk management is a continuous process of identifying and analysing the RFs, risk response and risk control actions. Identifying the OGP RFs and RMMs based on a wide-ranging review provides accurate and appropriate knowledge about the safety of pipelines. Because there is no reference by which to analyse the risk factors and the risk mitigation methods, collecting information from various and trusted sources, i.e. government agencies, academic organisations and professionals (i.e. consultants, planners, designers, operators and researchers), ensures more verified analysis of OGP RFs and RMMs as the information has been gathered from field-experienced individuals. The respondents’ demographic information enhanced the results because all the stakeholder categories were represented in the survey. Collecting stakeholder perceptions about OGP RFs and RMMs could reduce the time and the cost of investigations into OGP RFs. However, this method relies on their willingness to cooperate with the researchers, which is one of its disadvantages. Analysing and ranking the RFs and RMMs helps the stakeholders, decision-makers and policymakers to apply sustainable RMMs and risk management strategy during the different stages of pipeline projects.

Managing and mitigating the risk factors in these projects is not limited to one project stage. Therefore, different risk mitigation methods were suggested to mitigate the risk factors during the projects' entirety. Anti-corrosion measures such as isolation and cathodic protection were rated as an effective RMM because corrosion is one of the most common causes of OGP failure. The disadvantage of this method is that, in addition to the extra cost, it may slow down pipeline construction and installation processes as protections need to be applied. Applying advanced technological and professional remote monitoring (e.g. aerial and satellite surveillance, Global Positioning System (GPS) and smart camera systems) has some advantages, for example, surveying large areas of the pipeline network in a short period of time. The presence of these methods could serve as a deterrent against TPD, providing quick risk prediction and alerts, and these methods
also offer the ability to exchange photos of the pipelines. However, these methods also have disadvantages including high capital investment for equipment, machinery and operational costs, and additional training for personnel on new software. Foot and vehicle patrols are less effective RMMs as they are very time consuming, do not cover large areas of the OGP network and need to be carried out at frequent intervals to be effective. That said, this method has some advantages like only requiring a moderate capital investment for equipment and machinery, and it is effective against TPD during inspection periods.

Ranking the RFs based on an RI method has some limitations. For example, the RF with a high RS value could be considered as a critical RF that needs urgent mitigation work. However, the same RF does not achieve a high rank if it has a low RP or vice versa. This means the RI method does not adequately reflect the criticality of the risks. This study has other limitations, such as the RMF cannot be used to link the RFs or draw OGP failure scenarios and calculate the consequences of any hazardous event. Also, it does not provide a decision support tool that has an automated system to analyse the information (e.g. RFs, RP, RS, RMMs and the effectiveness of RMMs).

The RMF could be applied to mitigate the RFs for other critical infrastructures like water supply network; transportation system (e.g. railway, high ways, fuel supply, etc.); energy supply infrastructure (e.g. transmission and distribution lines, nuclear power generators, etc.); telecommunication and communication facilities; etc. The RFs may be different in these projects, but insecure situations cause similar types of risks. Therefore, the methodology of identifying and evaluating the RFs and RMMs could be similar.

**CONCLUSIONS**

There is a need for an accurate evaluation of the RFs and RMMs in OGP projects, specifically regarding the issue of TPD, because they have not been accurately evaluated in the past. The proposed RMF provides a comprehensive and systematic risk management approach in OGP projects for organisations that have just begun to mitigate OGP RFs more effectively. In this paper, a new database has been created to store information about identifying and analysing the RF and RMMs.

While the survey results identified various problems and risks that cause pipeline failure, TPD (such as sabotage, corruption, insecure areas, lawlessness and theft) is recognised as one of the most common issues obstructing OGP projects in Iraq. In contrast, natural disasters and weather conditions, vehicle accidents, hacker attacks on the operating or control systems, and accidents involving animals are the RFs with the lowest impact on OGP projects in the country. Concerning risk mitigation, anti-corrosion measures such as isolation and cathodic protection, laying the pipes underground, and advanced technological and professional remote monitoring of the RFs are the most effective RMMs; foot and vehicle patrols prove less effective. The majority of participants agreed that moving pipelines underground is safer than having exposed ones. In addition, they said that the mitigation of the RFs in OGP projects should be started at the planning and design stage.

The future work of this study is as follows. 1- Use an Analytic Hierarchy Process (AHP) to compare the influential RFs. 2- Use a neural network analysis tool to draw some pipe failure scenarios to estimate the consequence. 3- Conduct some interviews with experts to analyse the cost-effects that result from applying the RMMs in OGP projects. 4- Use the Fuzzy Inference System (FIS) in the MATLAB toolbox to simulate the RFs as it is a powerful tool that deals with the uncertainty that results from the lack of data and experts'
judgements. The paper's findings (RP, RS and risk ranking) will be used as inputs for the FIS. The expected outputs will be a useful viewing tool for looking at RF weight, the risk matrix and the overall safety of pipelines. 5- Use one of the decision support methods that can analyse the inputs (e.g. RFs, RP, RS, RMMs, the effectiveness of RMMs and the cost) to help the stakeholders during the decision-making process.

REFERENCES


POWER PLAYS: DESIGNERS, USERS AND INTERACTIVE DIGITAL TECHNOLOGY

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The potential of emerging new digital technologies to support managing design and construction processes has been widely addressed in the literature. However, most studies stress the effect of technology on performing design activities whilst giving limited attention to the emerging new practices of designers and users engaging in these new, digitally-based work settings. We adopt a practice-based perspective to shift the focus from studying the impact of digital technologies on design work to understanding how the emerging practices of design stakeholders' engagement become configured in novel technological environments. The case examined is a ‘real-life’ design project for a new hospital in Sweden wherein a mixed digital technology environment was used to support designers' and end-users' engagement during a workshop for briefing the design of the operating theatre. The methodology draws on observation and video recordings of the design workshop performed in the VR setting. The particular environment features seamless integration of a multi-touch table and several immersive VR-systems that support interactive and collaborative design work. Analysis of interactions between designers and users in thinking about the designed space within the VR environment reveals three thematic aspects - around the intersection of design and medical practices and expertise in the VR setting, the participants' collaborative configuring of the design for the operating theatre and of the designing space encountered in the VR environment. The findings indicate distinct dynamics around the empowerment of users, enabled by the use of the interactive smart board, the negotiation and shaping of design through interaction of the two practices’ discourses, and how this relates to moving across the various representational means available - the range of technologies and bodily gestures and movement to visualise dimensions and enact the use of the space.

Keywords: design practice, design engagement, users' empowerment, VR

INTRODUCTION

The potential of emerging new digital technologies to support managing design and construction has been widely addressed in the literature (Whyte and Nikolic 2018). However, most studies stress the effect of technology on performing design activities whilst giving limited attention to the emerging new practices of designers and users engaging in these new, digitally-based work settings. We adopt a practice-based perspective to understand how the emerging practices of design stakeholders' engagement become configured in novel technological environments.

Whilst designers' and users' engagement has been extensively discussed in the literature on user’s involvement in the design process (e.g. user centred design, co-creation and

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participatory design approaches), there is limited discussion around how power is mobilised in these collaborative design sessions across designers and users, particularly in novel technology-based contexts. This paper takes an interest in the practices around the trading offs across designers’ and users’ different expertise. The paper examines the design engagement practices emerging in a mixed digital technology environment by focussing on the power dynamics configured across designers and users collaborating in this setting. The case examined is a ‘real-life’ design project for a new hospital in Sweden where a digital technology environment was used to support designers’ and end-users' engagement during a workshop for briefing the design of the operating theatre.

LITERATURE REVIEW

Empowerment and disempowerment are recognised as inherent aspects of practice activities, which are both configuring and supported by particular power regimes. Particularly, non-routine contexts drive reconfigurations of practice arrangements through redistribution of power and political issues (Nicolini 2007). More specifically design practices are indicated as inherently political and conflictual, unfolded through negotiation rather than consensus (Ivory 2013). Whilst power is mentioned as a basic concept in the user engagement design literature (e.g. participatory design), this is rarely explored in-depth (cf. Halskov and Hansen 2015). There is limited empirical account of how power is distributed between designers and users (cf. Bratteig and Wagner 2012). Where power in design engagement is discussed, underlying themes are aspects around designers’ facilitating expertise and strategies for configuring designers’ authority in interacting with their users, and consequences of power rearrangements -both positive, through decision making and transformative participation and challenging, through raising issues of, for example, accountability. Luck (2007) notes the combination of two distinct types of expertise mobilised by architects in engaging with their users -professional role/ expertise of design practice and authority as facilitator in the design meeting/ workshop. Design practice expertise involves mastering strategies for establishing authority in interacting with the users. Such strategies include discourse modalities for pursuing/defending ideas against users through transforming the conversation from dialogue to monologue by performing multiple turns and employing the power of ‘summary’ as a trick of advancing conclusions, dismissing evidence brought by users to advance a point in influencing the design, or stressing the superiority of design expertise by reference to the ability of foreseeing real life consequences of the design (Luck 2007, 2007 b).

The strategic and persuasive nature of influence -mobilised through, for example, argumentation and narratives whose aim spills beyond consensus- in design engagement is also noted by Bratteig and Wagner (2012) and Ivory (2013). These strategies configure an asymmetric relationship between the architect as design expert and the user as lay person, reassuring the conventionally assumed institutional order (Luck 2007). However, designers' "power of making"-based on expert skills and competencies, mobilised to impose/inflict designer’s discourse in technical decisions- may conflict with the users' "power to" as agency i.e. capacity to shape action, through users’ choices on how to actually use a design (Bratteig and Wagner 2014).

The salient positive consequence of empowerment reflects in the active impact through decision making. In this sense, users' empowerment in design engagement relates to "transformative participation" (Till 2005), where power is ability to make happen and transform (Bratteig and Wagner 2012). However, Nicolini 2007 raises attention to questioning the idea of empowerment beyond positive associations, to actually
understand the change in the broader arrangements of practice. For example, changing power relations in practice may bring further consequences through aspects of accountability accompanying the out of routine uptake of power (id.). Arguing the avoidance of a "symmetry of ignorance", Till (2005) indicates challenges around reformulating rather than relinquishing designer's expert knowledge, to enable both recovery of the users’ knowledge and needs and guidance through enacting design expertise. Design engagement may also raise challenges around the potential dual loyalty and double agency of design participants encountering conflicting demands among different stakeholders (Bratteig and Wagner 2012). This study contributes to the literature on power in design by bringing empirically-based insights on the power dynamics configured in designers and users' engagement practices emerging in novel technology contexts.

METHODS

This study focusses on the design interactions between users and designers in thinking about the designed space to investigate the design engagement practices and the power dynamics emerging in a novel, digitally-based setting. This research draws on a practice-based perspective, which is consistent with ethnographic and video-based studies of naturally occurring interaction (Heath et al., 2010). The case examined is a ‘real-life’ design project for a new hospital in Sweden wherein a mixed digital technology environment was used to support designers' and end-users' engagement during a workshop for briefing the early design of the operating theatre.

The workshop had 9 participants and it lasted for four hours. The participants were different stakeholders from healthcare and construction: Anaesthesiologists, theatre nurses and architects. The participants had to account for the brief requirement indicating an ambitiously small area for the operating theatres (62-65sqm each). The aim to keep the room size as small as possible whilst ensuring the equipment fitted and sufficient space was available to accommodate the use of the operating theatres was the main design constraint to be addressed in the workshop. A particular combination of interactive technologies including VR was available to support the participants' collaboration during the workshop. The technology system consisted of three head-mounted displays (HMD-s), an interactive smartboard (SB) and two large projection screens- seamlessly integrated to enable both collaborative and individual design experience.

The research used direct observation, field notes and video recording of the workshop. Video data was captured using two fixed video cameras, placed in elevated positions to support capturing an overview of the participants’ motion around and between the different stations in the workshop room. The analysis draws on a collection of short instances illustrating the situated ways of trading off across the designer and users’ different expertise, to look at how the workshop participants mobilise power to configure the design of the operating theatre suite in this newly encountered, mixt digital technology-based setting. The empirical material is organised in four subsections indicating various layers of mobilising and enacting power across the architect and nurses within the non-routine setting. This approach draws on video ethnography based studies of workplaces and of interactions (Heath et al., 2010).

FINDINGS AND DISCUSSION

Desks Versus Cabinets: Users’ Seizing Power Over the Drawing Space

This episode is selected from the early moments of the four hours workshop. The sequence initiates the longer process of shaping the optimum solution for the design of
the operating theatre. It illustrates the participants’ work on designing the smaller operating theatre, by deciding on and placing furniture and equipment in the smart board (SB) version of the room which has been sized according to the preliminary brief. The design interactions captured in this fragment focus on the SB area of the workshop, enabling multi-touch interactivity whereby multiple participants can work together and/or independently using the digital pen or their fingers. The library of objects on the SB includes standard furniture/equipment for operating theatres.

Figure 1: Episode 1

Working on the layout of the smaller operating theatre (OT1) and adding a desk from the components library on SB, the architect expresses verbally her view that the room should have more cabinets than desks and immediately pursues her discourse by proceeding to search for cabinets in the library of objects (E1, 12:34). The architect's intention is firmly disagreed by Nurse 2 which, drawing on her medical practice experience, argues the need for more desks: "we cannot have too little desk space" (E1, 12:49). Despite Nurse's 2 counterargument, the architect insists to advance her idea on the need for more cabinets: "should we add one more cabinet?" (E1, 13:47), intention dismissed again by the nurses: "we need more desks here" (E1, 13:52). Consequently, the nurses focus their group attention on addressing the need for more desks independently from the architect's support. Disconnecting from the architect's work on adding more cabinets, the nurses orient their collaborative actions towards establishing common sense on what type of desks they need—through both verbal interaction and through gestures of pointing towards the layout on the SB. Moreover, Nurse's 3 comment on the need for a desk (E1, 14:01) triggers Nurse's 5 reaction of starting to search for the desk to place it in the location indicated by her team members, whereby actually interfering with the architect's drawing moves on the SB version of the layout (E1, 14:03). Consequently to this interruption, the architect stops drawing and steps back from the SB (14:08, figure1), action with further lack of effect on the nurses' discourse and followed by the architect's gesture of raising her palm to hand over the digital pen to the users (14:09, figure 1). The architect's action remains with further lack of impact on Nurse's 5 work on adding desks on the SB.

The sequence 14:00-14:08 (E1) illustrates both verbally and non-verbally the clashing intersection of design moves (verbal and drawing gests on SB) across the architect and nurses through the two different practice perspectives pursuing different focus—desks versus cabinets. Whilst more participants can use the smartboard and change the design at a time, the order of moves is materially constrained and the priority of moves needs to be negotiated. Negotiating the smartboard as a designing space emerged in close connection with negotiating the lead in the discussion around shaping the layout. Whilst traditional design briefing involves the architect’s lead in developing graphical representations of the design to reflect and guide further refinement of users’ ideas on the emergent design, in this case the technological setting (the smart board) enables the users’ active engagement in developing through actually representing the design layout, as a
means of empowering the users. Episode 1 (E1) illustrates the transition from the conventional design expert-lay person relation where the architect is leading the drawing space whilst (supposedly) accounting for the users’ views to the users’ uptake of the drawing space, through the nurses’ seize of power over the smartboard. The shift of roles is marked at instance 14:09 where the architect relinquishes power over the smart board by handing over the pen to the users.

This data indicates a reconfiguration of power arrangements in the workshop, through the architect’s enforced release of power on the design through handing over the pen as release of design control in consequence to the users’ uptake of the drawing space via the interactive smartboard. The episode also shows the users’ resistance to and interruption of the architect’s discourse and line of argument, mobilised to seize power over the drawing space through the use of the smartboard.

**Intersection of Expertise: Resisting the Architects’ Argument**

Figure 2: Episode 2

The fragment succeeds an episode where the nurses develop the idea that the smaller operating theatre (OT1) is not of sufficient size for performing their usual operating theatre practices and advance the choice for the larger version (OT2), idea agreed by the architect- “certainly this (OT2) feels better”. However, Episode 2 illustrates the architect’s reattempt to persuade the nurses on the smaller room solution, initiative further resisted by the users. The architect begins to build up an argument to influence the users’ view around the potential suitability of the smaller room, through argumentation on the similarity with the larger room option- “But it (OT1) feels almost like that (OT2) room” (E2, 05:35) and by suggesting that a larger area might be unnecessary- "the really big room may be too big…and maybe not needed" (E2, 05:36). In response to noticing the users’ disapproving reaction, the architect is temporarily suspending and reframing her discourse: “Or what do you say?” (E2, 05:42). Initiated by Nurse 2-"The large room feels quite alright" (E1, 05:48), the nurses’ joint reaction shows a consensual protest within the user’ team by constructing a shared medical practice discourse to develop collaboratively the argument on the lack of space in the smaller operating theatre room in terms of unsuitability to accommodate activities to be performed in the room. By rich reference to their current practice, the three nurses bring own medical practice expertise in the workshop setting to counter-argue the architect’s attempt to pursue the idea of a smaller operating theatre room and build a collaborative, consensual discourse formulating the argument for a larger operating theatre room. Through a combination of verbal and bodily means, the nurses mobilise their expertise on the use of the space towards configuring the design. The nurses’ emphasis on workflows and logistics of the designed space highlights the importance of the medical equipment and of considering it during the design of the operating theatre- spatial dimensions and buffer area needed around the equipment for enabling performing the medical practice in the operating theatre.
The episode illustrates another layer of mobilising and enacting power in the design workshop by users resisting the architect's attempt on pursuing the idea of a smaller sized operating theatre, through exerting own medical practice expertise on the actual use of the space. The nurses' viewpoint has consequences on the architect's reframing of the situation and is further considered in shaping the layout by highlighting the relevance of the use of the space over the square meters enabled through the design. The ongoing design solution is to account for more than spatial dimensions -design constraint considered through the brief- but essentially for the practice activities to be performed in the future building. The episode also indicates the architect’s particular role- as both facilitator and design expert- and the dual concern on both recovering and addressing the users’ needs to incorporate their vision on how operating theatre practices would be performed within the designed space, whilst also complying with the spatial constraints indicated through the preliminary brief.

These findings resonate with the literature on power in design by revealing 1) an instance of tension between the architect's power of making design and the users' power to make own use of the design (Bratteig and Wagner 2014), 2) the dual loyalty and double agency (Bratteig and Wagner 2014) enacted by the architect to address both the brief and the users' needs, and 3) the double expertise (Luck 2007) mobilised by the architect as both facilitator and design/technical expert.

**From Negotiation to Consensual Sharing of Power**

The three fragments (E1, E2 and E3) in this subsection capture the workshop participants' interactions mobilised to configure the design of the operating theatre suite by transitioning across envisaging, shaping and testing the preferred solution. The analytical focus is, again, on the design engagement practices and on the situated ways of arranging the power relations in the mixt digitally-based setting.

Configuring the design: Envisaging the solution: The architect uses reference to previous design experience of hospital design to introduce the suggestion of a compromise solution (E3, 06:12, 06:30), idea accepted by the nurses' team and further developed in collaboration with the architect. The sequence shows both the enactment of architects' design expertise- through mobilising experience of previous projects, inferring the suggestion of a compromise solution- "...larger operating theatre room…70m2…on the other hand, no preparation room close to the operating theatre" and the users' active engagement in making decisions about the design- "Can we make the preparation smaller?"(Nurse 3). The episode infers the architects' argumentation skills deployed to strategically introduce the reference to the example of a precedent hospital project and advancing the idea of an operating theatre suite without an adjacent preparation area, suggestion influencing the nurse towards considering adjusting the dimensions of the preparation room. The nurse mobilises her experience-based knowledge to shape the architect's making sense of the actual use of the space- "you only use it twice a day?"(E3, 06:44)-, insight supporting the envisaged solution of resizing the room. These interactions enable collaborative development of the design across the architect and nurses and sets context for the architect's intentional sharing of power on the design by inviting the nurses' active involvement in shaping the compromise solution.

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Figure 4: Episode 4

Configuring the design: Shaping the solution: Episode E4 illustrates the architect's and Nurse's 2 work on establishing shared understanding around the spatial dimensions of the current version of preparation room. The participants employ bodily demonstrations of the spatial size to explore the life-sized scale possibility of further design intentions: "Could we make the room narrower? (...)It's 3.45m" (E4, 08:05; 08-15). The architect followed by Nurse2 steps outside the SB and starts to walk around the room to imagine the 3.45 m dimension. In the same time, Nurse 3 continues to design the preparation room using the SB. Nurse 2 draws on her experience of the space used for performing her current medical practice - "how the room is like today" (E4, 08:34) - to mobilise her insights as reference for estimating together with the architect the spatial dimensions of the current version of the proposed design. This fragment indicates a consensual work towards establishing common appreciation of the layout across the architect and users to further refine it towards a collaboratively agreed solution. The nurse indicates the current version of the preparation as being of large size - "It's really long!", idea re-enforced by the architect - "There is quite a lot of air", and leveraged to open up the possibility of resizing it as a smaller room, adjustment which would enable increasing the size of the operating theatre, envisaged as satisfactory solution. Importantly, the architect deliberately releases power over the design by openly inviting the nurses to formulate their need around the spatial dimensions of the preparation room: "How big do you need the room to be?" Concurrently with the architect's and Nurse's 2 bodily simulation of the spatial dimensions, Nurse 3 explores options for configuring and adjusting the layout of the preparation room - placing equipment on the SB version of the room (Figure 4). This sequence shows the users' direct engagement by actually configuring the design through the use of the interactive smartboard.

The fragment indicates the redistribution of authority/ control over the design proposal through the architect relinquishing power over the design - "How big do you need the room to be?" (E4, 09:12)- to engage with the users beyond the brief and openly inviting them to express their needs around and actively develop the design. The design engagement practices become configured through mobilising the two different types of participants' expertise. The episode also suggests a layer of equally distributed balance of power relations in the design workshop through the enactment of both Nurse's 2 medical practice expertise - mobilised to shape a shared appreciation of the spatial dimensions of the preparation room in reference to her current workplace and practice- and the architect's design and facilitating expertise - enacted to recover the nurses' experience of and needs for the space and pursuing compliance with the brief requirement on the total area for the operating theatre suite. Despite the broad range of immersive visualisation technology available in the setting, in this instance, the participants chose to imagine and check the spatial dimensions of the preparation room through bodily simulation, by stepping outside the smartboard, walking around in the room and moving arms to imagine the size and the use of the space. Nurse's 3 use of the SB concurrently with the architect's and Nurse's 2 bodily demonstrations indicates the multiplicity of levels of interacting with the designing space- distributed work across multiple participants using different technology in the same time, whilst connecting their actions through verbal and bodily interaction.
Configuring the design: Testing the solution: After furnishing the resized version of the preparation room using the interactive touchscreen, Nurse 3 is calling the architect and Nurse 2 back to the SB, to examine her proposed solution. Nurse 2 -who had previously enacted a bodily demonstration of the spatial dimensions of her current preparation room (E4) - is invited to check the latest iteration of the room -configured by Nurse 2- using the individual immersive VR (HMD). The participants reorient their engagement with the design from bodily simulation of the space to using the SB in combination with the HMD: "now you have to go in and test your new room in VR!" (E5, 11:00). Starting 12:15 (E5), Nurses 1 and 3 work on the SB version of the layout - furnishing, placing equipment and avatars- to imagine the use, simulating performing activities in the designed space and inhabiting the design with virtual users. This concerted effort is aimed to support Nurse's 2 VR experience of testing the spatial dimensions and their appropriateness in relation to current work place. Episode E5 confirms the earlier initiated shift from the conventional design lay-expert relation to users designing -by drawing/furnishing (Nurse 3) and testing the spatial outcomes of the layout (Nurse 2) - and the architect facilitating.

Episodes 3, 4 and 5 indicate the transition and iteration across the multiple technologies available in the workshop- the use of SB concurrently with HMD, bodily enactment and virtual avatars- to configure, imagine and test spatial dimensions and experience and their appropriateness in relation to current work place. This data shows the interrelatedness between the design and the designing space. The time and context of introducing various representations and technology relates to both the stage of the evolving design and the discourses employed by various participants to advance and persuade the others on certain proposed solutions (e.g. demonstrate the dimensions of the space by bodily measurements; use of VR to test consequences of design intentions, use of avatars to simulate scenarios of performing activities in the space).

Overall, the fragments in this subsection (E3, E4, E5) show the rearrangements of power relations across the architect and nurses in the workshop through the users' active involvement in configuring the design and the architect's deliberate release of control over the design and open invitation for users' to express their need for the space and to explore layout solutions. These findings illustrate the transition from negotiation and tension to a more consensually constructed and balanced power relation in the architect and nurses engagement. This layer of rearranging power positions in the design session connects with an inversed relationship across the architect and the nurses, whereby users are designing and the architect is rather facilitating, whilst not relinquishing design/technical expertise. The data also shows the multiplicity of the technology available in the setting that enables this transition.

These findings relate to the literature on power in design by indicating the nurses' "transformative participation" (Till 2005) in developing the brief -by impact on design decisions and actually configuring and testing the layout through the use technology (SB, HMD, avatars) or bodily simulations for imagining the space-, whilst also revealing the architects' avoidance of a "symmetry of ignorance" (Till 2005)- through reconfiguring the design discourse by suggesting an alternative, compromise solution (E3). Another way in which the findings (E3) relate to the literature on power in design is by indicating the architect's argumentation skills for influencing the users' framing of the design situation (Bratteig and Wagner 2012).
Accountability for the Proposed Design Solution

Episodes E6 and E7 close the analysis section by illustrating empirical instances of mobilising issues of accountability around the chosen design solution across the two practice perspectives—the architect and the nurses team.

Acquainting the compromise: Episode 6 illustrates the participants' work on examining the consequences of the previously shaped design intention. The architect mobilises design expertise to explore further consequences of the design for the preparation room, solution collaboratively shaped through negotiation/tension and consensus with the users: "Maybe it is too narrow if you should turn things around" (E6, 14:08). In response, Nurse 3 acknowledges the compromise made when choosing the solution—opting for a smaller area for the preparation room to enable two larger operating theatres—the preparation might be "too narrow" for turning equipment around (E6: 14:08), but "it's better this way instead of getting a smaller operating theatre" (E6:14:10). The fragment indicates the nurses' accountability for the power of making the design decision through recognising the unsatisfactory consequences of the chosen design solution and acknowledging the compromise.

Accounting for the power of the brief: After testing the experience of the resized preparation room using the individual immersive VR-HMD-, Nurse 2 returns to the smartboard to check if the final layout configuration provides satisfactory consequences for the operating theatre suite and if the solution complies with the area requirement of the brief: “Do we still manage to fit the total space of the operating theatre rooms into the total space requirement?” (E7, 15:08). Nurse 6 checks the final spatial dimensions on the SB and confirms both the satisfactory solution for the operating theatre and the compliance with the brief (E7, 15:24; 15:43). Relatedly, Nurse 6 indicates their final solution -70sqm- as relevant for the design of future operating theatres (E7, 15:45). By revealing the nurses' concern with checking consequences of previously realised design intentions at the global level of the project by accounting for the brief, the data shows that whilst the nurses resisted the power of the architect's argument, they recognise and accept the power of the brief.

Together, these fragments (E6 and E7) reveal the impact of the changed power relations by showing that users' authority in choosing the design solution connects to issues of accountability for the chosen design option. In this situation, the users' accountability is expressed through acknowledging the compromise and through accounting for the brief—therefore accepting the power of the brief despite of previous resistance to the power of the architect's argument. These findings relate to the literature insights around the challenging consequences associated to users' empowerment, beyond positive connotations of decision making and authority, through triggering issues of accountability (e.g. Nicolini 2007).

CONCLUSIONS

The findings show the design briefing practices as situated intersection of design and medical practice expertise, socially and materially configured around the mixed digital technology available in the workshop. The design engagement practices were realised through negotiation, disagreement, shaping shared understanding, and consensus. The study highlights power as fluid, dynamic and flexible—seized, relinquished, or enforced in many different ways. The study also challenges lay-expert distinctions between users and designers, shows a ‘weakening’ of the architect’s conventionally assumed political authority over the design process and a role shift whereby users are doing design and the
architect is facilitating. Lastly, the study shows that it is the multiplicity and interactivity of the technology available in the setting which allows power to be more fluid and dynamic in the particular workshop - a democratising effect of technology.

These dynamics - users’ seizing power over the drawing space, resisting the architect’s argument, re-configuring the design, and accountability for the design solution - suggest both positive and challenging implications for managing design and for users’ expectations / requirements. The users’ direct involvement in framing, reframing and configuring the design and the rebalanced relation between designer’s ‘power of making’ (design) and users’ ‘power to’ (shape by choosing how to use the design) suggests the potential for more substantive engagement as key stakeholders. At the same time, users’ empowerment as enabled by interactive digital design technology brings challenges around 1) reconsidering the architect’s position by avoiding a ‘symmetry of ignorance’ (architect’s total release of design power / expertise) and 2) managing the redistribution of accountability around design decisions. The study is relevant for design briefing practice and practitioners and for participatory design approaches. The findings are also informing on the design of modern operating theatres and for the literature on the use of interactive digital technology to support design briefing. The study also contributes by applying a video-based approach to understand design engagement practices and design power dynamics configured in novel digital technology settings.

REFERENCES


PROJECT DECOMMISSIONING FOR WHOM AND BY WHOM? STAKEHOLDER SHAPING OF SOCIAL VALUE IN A DECOMMISSIONING CASE STUDY

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Studies of project performance have generally recognised the role stakeholders play in shaping a collective understanding of ‘success’ and ‘failure’. While these have typically focused on new-build, there is a relative lack of emphasis in decommissioning buildings at the end of life. This paper draws on case study interview research into social value in nuclear decommissioning to examine how ‘success’ or ‘failure’ in decommissioning and remediation projects is framed, and the implications of stakeholder engagement in shaping notions of ‘success’. In examining the development of Dounreay, it was found that the key stakeholders change over time - both those creating and influencing the circumstances for success, but also those who will be most affected and how they respond. The contribution of this paper is to raise the possibilities of fragmentation in becoming a productive force for good. Fragmentation allows for changes in stakeholders’ interests and influences over time and space to emerge and diverge when revisited, re-examining the boundaries of 'success' and 'failure'.

Keywords: decommissioning, social value, stakeholders, success/failure

INTRODUCTION

Ever since Freeman (1984) argued for the need to think beyond the shareholder to consider the needs of stakeholders, there has been numerous studies that examine stakeholder management practices in project contexts (see e.g. Mok, Shen and Yang, 2015). Consideration of broader stakeholder needs has since challenged the simplistic orthodoxy that project success is merely the meeting of such traditional measures as time, cost and quality (Atkinson 1999). There is growing recognition of the tensions that can result between meeting the iron triangle of project performance and the capturing of lasting impacts of projects (Eriksson et al., 2014). Indeed, as Eskerod, Huemann and Ringhofer (2015) argued delivering valuable impacts to project stakeholders can be a challenge as they noted that stakeholder disappointment continues to be a common cause of unsuccessful projects.

In a recent systematic review of scholarship on project stakeholder management, Mok, Shen and Yang (2015) identified how much scholarship tended to focus on formalising stakeholder management processes often in small-scale projects and typically focussing on the planning stage of the project life cycle. Such emphasis is inadequate for a number of reasons. First, in finding universal, systematic approaches to managing stakeholders, there is relative neglect in understanding the unique specificities of the institutional context in which projects are situated (Engwall, 2003). Second, by focussing mainly on

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the planning stage of the project life cycle, there is an implicit assumption that project managers can design interventions that can satisfy often conflicting needs of a multitude of stakeholders at the front-end of projects; this ignores the reality of stakeholder management as an ongoing process rather than a 'done deal' achieved through planning (Eskerod, Huemann and Savage, 2015). Third, as Mok, Shen and Yang (2015) noted, scholars have been relatively silent on stakeholder management practices in megaproject contexts where the character of stakeholders and their needs are likely to change over time. Thus, it is all the more important to consider stakeholder management not as a planned entity but an ongoing, emerging process (Friedman and Miles, 2002; Turkulainen et al., 2015; Chan, 2016).

In this paper, we address these deficiencies by drawing on case study research into a megaproject by examining how stakeholder management - as an ongoing process - can have significant consequences for the ways in which project success and failure is defined. The case study context is unique; while much research, even on mega construction projects, is on new-built, the context in this study is on nuclear decommissioning and remediation. Thus, we also contribute to the literature by broadening out beyond planning to consider the dynamics of stakeholder management during the end-of-life stage of the asset/project life cycle.

This paper reviews literature in relevant fields of stakeholder management, leading to the findings of an empirical case study investigating the changes over time in stakeholders defining the social success of a project.

**Stakeholder Management: A Planned or Emergent Process? Considering Stakeholders**

'Efficient stakeholder management' is listed as one of 11 specified areas as key for success identified in the literature by (Caldas and Gupta, 2016), with governance and stakeholder engagement suggested as necessary for success. However, the term ‘efficient’ to describe stakeholder management is contrary to their suggestion that all stakeholders’ interests should be aligned which may decrease the efficiency.

Similarly, (Aaron Shenhar and Vered Holzmann, 2017) state in their final discussion comparing successful megaprojects that all stakeholders should be aligned, committed and aware of their role. But such a far reaching statement brings in to question whether all stakeholders can or should be made fully aligned.

**Stakeholder Perspectives of Failure**

At what point in time failure occurs during the lifetime of a project will change how it is felt and framed (Atkinson, 1999), and the point in time when a project’s success is measured, either concurrent or retrospectively, may change how the failure is viewed (Davis, 2016). As such, in decommissioning and remediation work the project will come to the end of its intended life raising questions about what failure means after the project has in some ways disappeared with ownership and responsibility changing. Failure can mean a lack of success criteria being met but a project may fail in another, less obvious way, such as nuclear energy often achieving technical success but managers not giving focus to the complex project environments and loosing community and political support which ends the project (Locatelli et al., 2014).

To encompass the complex environments of projects and those involved (Savage et al., 1991) developed the stakeholder matrix to examine opportunities and threats on the project, which has been developed over the years, such as to manage stakeholder influence against power (Ackermann and Eden, 2011), offer strategic approaches to the
categorised stakeholders (Karlsen, 2002) or determine probability of impact on the project (Olander, 2007). These metrics are used to group and prioritise stakeholders to most effectively manage them - a process of fragmentation that contrasts to the literature advocating to include all stakeholders in the process. (Friedman and Miles, 2002) posit that distinguishing different stakeholders allows appreciation of the different types of contractual relationships. Their model explores how relations can change over time, linking with stakeholder influence and legitimacy. However, the theoretical developments of stakeholder management over decades often fall short in application, particularly with increasing complexity of projects (Jepsen and Eskerod, 2009; Eskerod, Huemann and Savage, 2015).

Making Sense of Projects

Clegg et al., (2016) suggest that as a project unfolds the sensemaking of stakeholders will change and develop, with different parties responding to the same cues to make their own ongoing interpretation of the project. Making common sense allows the project manager to get all stakeholders to frame the project in the same way, but in a megaproject the numerous stakeholders and long timeframes mean the sensemaking becomes complex and often divergent.

Sensemaking does not need to have the finalised definition in concrete, just plausible enough to move forwards sensibly (Clegg et al., 2016) and arises from language games in organisational discourse (Kornberger et al., 2006). As such the story of a megaproject is expected to develop and change with the many narratives contributing to the story, linking between retrospection and emerging themes to make forecasts.

Project managers often make claims to rationality early on (Clegg et al., 2016). This may be an essential step in moving forwards with a megaproject before the complexities question this rationality, with the ways in which sensemaking happens affecting the outcomes. However, a belief in this rationalism removes space for contestation and change, inhibiting productive resistance within a project (Courpasson et al., 2011). Sense is not a common end point and a fixed goal such as demonstrated by (Chan, 2016) that expertise in construction is not a set 'thing' but an ongoing, developing process.

Projects on a Larger Scale

Megaprojects tend to exaggerate the impacts of projects, and in turn often fail even more often for many reasons (Aaron Shenhar and Vered Holzmann, 2017). Managing megaprojects with traditional project management processes in the linear, rational, value-neutral way ignores the changing power relationships affecting the project. The size, duration and complexity are key traits of megaprojects that make power relations and sensemaking an essential part of their operation (Clegg et al., 2016).

This complexity is felt also in determining success with megaprojects as the actors or criteria involved grow and change resulting in common failure (Flyvbjerg, 2014). (Aaron Shenhar and Vered Holzmann, 2017) list the 3 secrets to success of megaprojects as clear strategic vision, total alignment, and adapting to complexity. Vision is given credit for ensuring long term success, with alignment and adapting to complexity responding to shorter term goals to deliver on time and in budget, but with all three aspects relying on multiple stakeholder points of view and input to achieve success. It is significant to note the role of stakeholders in the ultimate success of a megaproject.

However, a significant outcome of Davis (2014) research was that for some stakeholder groups there are no common success factors, meaning their visions are difficult to align if at all, but also that an understanding of these wide variations is essential to framing how
failure is framed. This research was developed on to investigate the methods used to measure success (Davis, 2016). Based on a literature review in project management all commonly used and presented tools and theories do not incorporate the variance in stakeholder perception, although the literature suggests attempting to align visions.

**Complex Relationships**

Previous research has investigated the power relations of stakeholders in megaprojects (such as Ninan and Mahalingam, 2017) or the influence on success/failure of a megaproject (such as Zidane et al., 2015), often suggesting that the engagement and inclusion of stakeholders should always be brought to an earlier stage and integrated for better project management. But Clegg et al., (2016) acknowledge that all objectives, goals and strategies of stakeholders will most likely not be aligned in megaprojects. The contexts make for complicated negotiations and decision-making.

Clegg et al., (2016) offer a simple demonstration of power as the projection of costs to get things to work in favour for the project. This type of power can be seen as necessary to make projects happen as it is not always a bad thing, but a process of creating a social reality (Ciçmil and Hodgson, 2006). Positive power practices can be utilised to understand the sensemaking essential in the process of MP development and management, working together to align visions and negotiating interests. The usual process of projects creates a dynamic set of power relations, changing over time depending on the issue, with agreeable groups changing, or possibly realigning power arrangements to create changes. But this paper questions whether positive power practices can utilise fragmented stakeholders and include strategic groups for productive good.

This strand of the literature takes the view that stakeholder management is about sense-making compared to the earlier demonstration that stakeholders can be managed formally as an entity. But, in both cases, there is rarely a problematisation of who the stakeholders are and how changing the stakeholders can have significant implications of how the project is viewed as valuable.

**THE DECOMMISSIONING CASE STUDY**

Social implications are a defining characteristic of megaprojects (Flyvbjerg, 2014) transforming society and impacting millions of people. The social implications contribute to defining the failure and success of megaprojects, achieved through stakeholder management (Mišić and Radujković, 2015) or social responsibility (Ma et al., 2016). Infrastructure projects often have cost overrun, and with the bigger more complex (mega) projects this encourages less exploration of innovative long term planning for more focused immediate productivity (Eriksson et al., 2014). In The Oxford Handbook of Project Management, (Flyvbjerg et al., 2011) made a call for more research into Major Project failure, to create a more robust theoretical standing in the field which may lead to less failure in practice. This paper responds to the calls to further investigate social impacts in megaprojects by investigating the case of "social value" in a decommissioning megaproject, comparing stakeholders views of success, providing a context to investigate the issue without suggesting it should be generalised (Flyvbjerg, 2006).

**Case Context**

With the introduction of the UK Public Services (Social Value) Act in 2012 the public sector needs to demonstrate 'social value' as part of any project delivery, this calls into question as to what is 'success' in terms of a socially valuable project.
The Nuclear Decommissioning Authority (NDA) UK is a non-departmental public body reporting to the Department for Business, Energy and Industrial Strategy, which focuses on delivering value for taxpayers' money whilst delivering suitable technological solutions within challenging social contexts. They are keen to engage with varied stakeholders to find the most valuable outcomes, responding to local communities and governmental groups such as the Public Accounts Committee. The wide array of interested parties, on local to national scales, adds a societal complexity typical of megaprojects.

Dounreay Ltd is one site of the NDA's wider estate. It is situated in a rural community with the nuclear work playing a significant role in the lives of the district. The area was initially chosen for nuclear energy development due to the remote location, but also as the community had a willingness to embrace a new industry and create jobs. As nuclear energy is being decommissioned in the area the NDA are managing a sustainable transition to site closure.

For this paper the focus fell on the relationships between Dounreay Ltd., as the local representative of NDA and other stakeholder groups to investigate how engagement has changed over time, and whether it has impacted perceived social value.

DATA COLLECTION AND ANALYSIS

Using interview data from two case study organisations in nuclear decommissioning, we analysed the stakeholders involved in shaping the 'success' criteria in social impact assessments and examined the character and consequences of their engagement.

Participant interviews were undertaken (n=9) with stakeholders representing groups from the site organisation to local faith groups to get varied perceptions of relationships. The participants were chosen through a purposive sampling process making initial contacts through industry connections then using a snowballing process. Inclusion criteria were over 18, living within geographical zone, and have connections with Dounreay, either directly or indirectly. The sample size reflects the opportunistic sampling with targeted aims, rather than stratified sampling of the population of the region. This case study was deemed as reaching closure as the interviews were contributing similar answers and verified by grey literature (Eisenhardt, 1989). As a working theory building case study, future iterations between theory and data and case comparison will determine final research closure.

Semi-structured questions were used focusing on the participants' role and involvement, if any, with the site or societal issues. The participants mostly talked freely when prompted by the questions with a social value theme. These were audio-recorded and transcribed verbatim. The context of the interviews was enriched with other data collected, primarily meeting observations (n=2) but also researcher notes taken on site visits (n=5) and information of the area gathered by documentation and publications (flyers, newsletters, industry reports), elaborating the context of interviewee claims made whilst sense-checking. The interview participants were checked against the data informing the fieldwork such as meetings observations, site visits, grey literature and informal conversations.

The analysis will look for emerging themes, and use comparison to sense-check the emerging ideas (Eisenhardt and Graebner, 2007). The lead researcher conducting the interviews wrote notes whilst recording allowing for initial reflections and emerging themes (Eisenhardt, 1989). The transcripts were reviewed and thematically coded.
Dounreay Ltd is not a pseudonym as anonymisation was only applied at an individual level to maintain confidentiality but also keep the context clear. The external factors and description of Dounreay, not least the location, are interesting when discussing the social implications of the project.

**Case Study Outcomes**

Preliminary outcomes suggest there have been drivers and demands created by stakeholder input from both top-down and bottom-up influences. Change of mission due to higher level organisational changes impacted progress. However, with the organisations still trying to define the overall design and planning end goals, shaped by and shaping the social implications, local communities and interested groups have been given opportunities to contribute. In this there was consistent emphasis around the idea of open and transparent, keeping “communication in plain English”. But there was a reiterated emphasis on trust: “It all boils down to relationships”.

**The Social Value Timeline**

The story of the social value success of failure has been defined by different criteria, developed and changed over time. With three main phases being seen in the changing environment over time, it is also worth considering how the opportunities for success and failure differ from the local to national perspective, that is to say stakeholders in different places will make sense of the impacts differently.

*Table 1: Phases of organisational social value*

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticipation of new nuclear (Begin 1954)</td>
<td>Responding to shut down (Begin 1988)</td>
<td>Clear site mission for closure (Begin 2000s)</td>
</tr>
<tr>
<td>Local threats</td>
<td>Development in a rural area, traditional industry</td>
<td>Fear of loss of jobs; uncertainty of site future</td>
</tr>
<tr>
<td>Local opportunities</td>
<td>Building a new cosmopolitan society, bringing opportunities</td>
<td>Responding to environmental concerns of nuclear</td>
</tr>
<tr>
<td>National threats</td>
<td>Large financial investment and development</td>
<td>Change in political support of nuclear energy (research)</td>
</tr>
<tr>
<td>National opportunities</td>
<td>History making research for UK</td>
<td>Focus on sustainable future energy planning</td>
</tr>
</tbody>
</table>

**Phase 1. New nuclear: Excitement of building a new society**

The building of a nuclear site is reflected on by all participants as a positive thing for the area: there was a decline of the agricultural and fishing industries, so the prospect of new jobs was appreciated. But they also spoke favourably about the legacy they felt it brought; attracting a "cosmopolitan" society with the influx of scientists and many pastimes they brought with them, and also the international scientific impact.

**Phase 2. Nuclear shut down: Showing resilience through changing times**

After a planning decisions in 1986 to build new reprocessing plants, in 1988 the UK Government then announced a phased end to research and development at Dounreay. This aligned with the Government's decision to privatisate energy in the 1990s, halting all nuclear build. In the lead up to this that a chemical explosion caused damage on site and the first radioactive particles are detected in the environment. Without a clear mission of what decommissioning meant for site-end state many employees were unsure of their future, still hoping for jobs for life.
Phase 3. Site mission to decommission: Planning for alternative industries and investing in the future

This phase slowly emerged, responding to planning uncertainties on the site as decommissioning as a goal was refined. A 60 year decommissioning plan was introduced in 2000 costing £4.3 billion, but after the NDA was established a review was undertaken in 2007 bringing decommissioning targets brought forwards to 2032 at a cost of £2.9 billion. A senior member of staff labelled this phase as the “mission to solely turn the site into waste”. This change in mission was in response to higher level government pressures, but also driven by the aims within the organisation.

Influencing Success and Failure

As the story changes the key stakeholders change - both those creating and influencing the circumstances for success, but also those who will be most affected and how they respond. Outlined below are the broad key stakeholder groups and how the prioritisation changes over time.

Table 2: Key stakeholder groups in each phase

<table>
<thead>
<tr>
<th>Priority influencers</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government and scientists</td>
<td>Government</td>
<td>Government</td>
<td>Local government, regulators;</td>
</tr>
<tr>
<td>Feeling greatest impact</td>
<td>Existing community and</td>
<td>Employees; British</td>
<td>Local community and</td>
</tr>
<tr>
<td>Secondary groups</td>
<td>industry</td>
<td>energy users</td>
<td>business</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environmental groups</td>
<td>Unions</td>
</tr>
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<td></td>
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</tbody>
</table>

Scientific and political leaders

UK science leaders and political figures in the first phase created the new nuclear, and then diverged to come to the conclusion of shutting down UK nuclear. In the third phase these groups set national regulatory restrictions, but also engage locally.

Workers’ unions, organisation leaders and employees

Unions are influential in organisational change, with the workers and leaders shaping the organisational aims and impacts.

Public

The people affected by nuclear energy development, either directly or indirectly, which will have many varied stakes and interests changing their felt impacts across groups. This can be the local community or the national population.

Other industry and business

Those industries and businesses which are competitors, collaborators, operate in similar locations, contribute to the supply chains or can be impacted by a nuclear site are considered as influential and may be able to apply pressures on the site.

Campaign groups

Environmental pressures which led to the shutdown of nuclear have often been overtaken with labour and social movements.

The priority influencers of the site works remain as the government throughout, although the specific groups may change (from Political leaders vocally leading the change, to local representation and the NDA public body). It is the groups being impacted, and therefore feeling the social value and defining them as successful, that change.
The Ever-Changing Stakeholder

The literature does not adequately grasp the possibilities of the plurality of stakeholders when discussing stakeholder management. There are two ways to consider the ever-changing stakeholder. Firstly, that stakeholders come and go, or emerge as important and less important. As some fall out and others emerge as influential, this would alter what they regard as valuable. Thus, we add to a growing body of literature that shows that project success is not a fixed entity but that success is only success in the current time and space. Second, a stakeholder can also intrinsically change in character, shifting their position. Thus, change also where a stakeholder changes their own position over time (which is very plausible in a megaproject). Such an example would be how Greenpeace has played many roles as stakeholder over the years (Friedman and Miles, 2002), eventually with the co-founder becoming a pro-nuclear energy campaigner (Nisbet, 2009).

CONCLUSION

This paper aimed to investigate how the appreciation of stakeholders' perceptions on success and failure can lead to more productive processes in stakeholder engagement, whether through integration or fragmentation.

Changes to what constitutes ‘success’ happen regularly as organisations iteratively define the overall design and planning end goals that are influenced by and in turn influences the identification of the relevant stakeholder groups. The power and influence of stakeholders change over time as notions of ‘success’ or ‘failure’ become clearer. Thus, stakeholder groups emerge as design and planning end goals become constructed, which in turn raises new opportunities for other stakeholders to become involved.

Integration of these emerging stakeholders is difficult and the desire to integrate relevant stakeholders is also questionable in larger, more complex projects since decommissioning projects can span a long time and across a vast space. Alternatively, Pitsis et al., (2004) suggest integration is not essential for relationships, as fragmented parts can make up a whole. This is not new thinking, with a 1969 government report suggesting that grouping all stakeholders together for one labour solution did not offer to solve all the problems, even though some statistics may show the benefit on productivity. (Lewis, 1969). In taking time to consider fragmentation as a positive the report was able to see new perspectives of stakeholders.

One limitation of this work is that all participants interviewed were local stakeholders to the Dounreay site. However, in responses they spoke of both the local and national environment of social value. These 2 levels of scale highlight an interesting question of how social value outcomes vary between on-the-ground and higher level. This links with Goldthau's (2014) work on the scales of investigating the sociotechnical relationships of energy infrastructure governance, but may have further implications in placing stakeholders and their perspectives of social value on different scales.

Recommended future work for this study would be to compare this to another case study to allow for comparison if the idea of fragmentation always holds up for megaproject work. It would also be interesting to analyse the influence and impact of stakeholder groups further, to demonstrate the usefulness and impact of fragmentation.

REFERENCES


SHORTAGES OF SKILLS AND COMPETENCES: 
CONSTRAINT TO PRIVATE SECTOR REAL ESTATE 
FUNDING IN THE EMERGING ECONOMIES 

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There is a growing demand for real estate developments in the emerging economies due to 
population growth and the increasing middle class. This paper examines how shortages of 
skills and competences in the emerging economies have affected the ability of real estate 
private developers, including their access to funding for real estate projects. Through 
critical analysis of literature and case studies in Nigeria and South Africa, the study 
examined real estate developments with a view to assessing the impact of skills and 
competences on the development process and their ability to source project funding 
internally and externally. The findings suggest that the shortage of skills and 
competences amongst real estate private sector developers in the emerging economies is a 
major deterrent to both internal and external investors due to several factors including low 
production and substandard housing, inadequate environmental assessment which has 
resulted in reduced sales. A notable example is the case study cited in the Lekki area of 
Lagos, Nigeria where the Ocean waters floods the houses because of inadequate design 
and construction as a result of deficiencies in the skills and competences of the developers 
who built the estates. There is a need for enhanced skills and development of 
competences supported by a strategic framework with an enabling policy environment, 
legal framework, macroeconomic management regime that encourages private sector 
participation in real estate development.

Keywords: competences, private sector developers, funding, Lekki, Langa slums

INTRODUCTION

The real estate sector is capital-intensive but private sector developers often have 
challenges with accessing funding in the emerging economies (Zhang, 2017). Arguably, 
a major contributor to the funding challenge is the lack of skills and competences 
(Olaleye et al., 2008). The nature and level of skills and competences can be attributed to 
the system of formal or informal training and work experience required to perform given 
Tasks and duties (Hewage et al., 2011). Skills and competences in the real estate sector 
are in shortfall as compared to the needs of the sector. There is also a shortage in the type 
of experiences required. Blanksby and Illes (1992) argued that the operators in the real 
estate sector need talents with complex skills and competences sets. These skills and 
competences include technological literacy, an understanding of the global financial 
markets, fluency in multiple cultures, entrepreneurship, extensive network of varied 
relationship, contemporary leadership attributes including the ability to lead in a multiple 
and virtual organisation (Fulmer and Conger, 2004). Enhanced managerial and personnel 
skills and competences are also increasingly important as it helps to meet the demands of 
the financiers (Nitz, 1996; Rector, 2002). The aim of the study is therefore to analyse the

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impact of shortages of skills and competences on the ability of the real estate private
developers to access funds and to implement successful projects.

METHODOLOGY
The methodology adopted is two-pronged approach. First, a desk review is carried out
focusing on the type of skills and competences required by private sector real estate firms
in the emerging economies, the impact of skills and competences on the real estate sector
and the ability of the developer to access funding. Second, the research will draw on the
experience of two case studies, which are Lekki in Nigeria and the South African Langa
slum to analyse the impact of skills and competences on real estate development projects.

LITERATURE REVIEW
Skills and competences are required in the appraisal, funding and implementation of real
estate projects. Boyatzis (1982) described skills as the sequence of behaviour that is
functionally related to attaining a performance goal (Scott and Rochester, 1984). Skill is
therefore associated with the ability to perform a task well. However, competence is the
ability for the professional to exercise his or her skills in a fair and ethical manner (Meyer
et al., 2015). Competence enables skilled personnel to be termed a professional (Lester
2014) as it depicts superior work performance (Boyatzis, 1982). Competence is the
ability to apply knowledge and skills to achieve an intended result. An individual
becomes competent through a combination of education, training and work practice
(Cheng et al., 2003) resulting in the ability to perform tasks and roles to the expected
standard.

Skills Needed by Private Sector Developers
This paper draws from the works of Boyatzis (1982), Katz (1971) and Muthuveloo (2017)
on generic skills and competences to determine the framework of skills and competences
needed by private real estate firms to access funding for projects. The paper therefore,
classifies the skills and competences needed by the management and employees of private
real estate developers to access funding into five, namely, human, technical, conceptual,
political and financial skills and competences. This classification is in agreement with the
CIOB (2013) report exploring skills in the UK construction industry. This study
however, incorporates a more detailed human, political and financial skills needed by the
manager and his/her team to facilitate execution of real estate projects including securing
funding.

Human Skills and Competences
The human skills and competences include non-cognitive skills, social and self-
competences (Meyer et al., 2013). Social competence includes teamwork,
communication skills, adaptability, integrity and emotional intelligence (Salovey and
Meyer, 1990). Self-competence on the other hand includes independence, ability to cope
with pressure, learning abilities, reliability and willingness to work (Meyer et al., 2015).
Diligence and discipline can be added to the human skills and competences. The former
British Prime Minister, Winston Churchill once said that, “the price of greatness is
responsibility” (Oyedepo, 2017). Discipline implies possessing a sense of mission in the
pursuit of a task, while, diligence simply means hard work (Oyedepo, 2017). Humility
can also be added to the human skills and competence (Rojas, 2013). Private sector real
estate developers should harness the human skills and competences in achieving
execution of real estate project with effective communication, motivation, teamwork and
mutual trust.
Technical Skills and Professional Competences

Technical skills and professional competences refer to the skills and knowledge an employee needs to have in order to practice their occupation. It includes interdisciplinary knowledge, skilfulness and accuracy of execution. Technical skills and professional competence positively affect production, subordinate job satisfaction and subordinate ratings (Hysong, 2008). Technical skill and professional competence is valuable to a developer and their team as a source of credibility and a means to identify with subordinates. Good examples of technical skills and professional competences a private sector real estate firm needs are, availability of skilled personnel like Architects, and Engineers, with virtual, design, negotiation, teaching and training and technological skills (Hysong, 2008). It is the limited technical skills and competences amongst construction professionals that leads to inappropriate designed projects amongst other types of construction failures (Edirisinghe et al., 2016). Technical skills and professional competences is mandatory for successful project execution and this constitutes a part of the historical traits financiers look out for as conditions precedent to funding (Rector, 2002).

Political Skill and competences

Political skills and competences are needed by managers to effectively influence all stakeholders in the path of their job (Montalvo and Byrne, 2016). Political skills in the light of real estate funding are skills the manager and personnel need to influence all stakeholders, which include, subordinates, superiors, government agencies and the financiers. These skills are innate as well as taught (Brouer et al., 2015). Political skills are important antecedent of performance outcomes, particularly when increased social interactions are part of the manager’s job requirement. Consequently, political skills and competences helps the real estate manager to relate effectively with all the stakeholders of a project and to navigate the real estate development process that is often complex. Political skills include social astuteness, savvy and positioning (Mintzberg, 1985). A manager and personnel with political skills and competences should be skilled in agreeableness, which signifies that s/he is sympathetic, kind, altruistic, generous, fair and eager to help others (Banister and Meriac, 2015). A person can be considered politically skilled and competent when she / he has social intelligence. Managers in the real estate sector are encouraged to obtain political skills and competences to succeed in their organisations as well as succeed in accessing funding for their projects.

Conceptual skills and cognitive competences

Conceptual skills and competences are the “thinking abilities” needed by managers and personnel of private real estate development firms. These are logical thinking, analytical abilities, inductive and deductive reasoning. Conceptual ability is to integrate and apply obtained knowledge through the power of analysis. Conceptual skills and competences reflect the ability of the manager and workers to use information to achieve knowledge, derived from data originating from various sources (Este, 2012). Lack of conceptual skills and cognitive competence arguably could contribute to the lack of up-to-date skills and competences experienced in emerging economies. It is reflective in paucity of new developments in contemporary built environment such as internet of things and building information modelling (Berst, 2016).

Financial management skills and competences

The managers in the private sector real estate firm and key staff need fundamental financial management skills and competences to be able to access funding for their
Shortages of Skills and Competences

projects in addition to the other skills sets. These skills are considered amongst the most critical management skills and competences. Financial skills and competences include cost benefit analysis, budget preparation, financial trend analysis and costing (Grizzle, 1985).

Impact of Skills and Competences on Real Estate Development in the Emerging Economies

A blend of all the skills and competencies is necessary for private sector real estate firms to be successful in project execution and to access funding for real estate projects. However, the real estate sector in South Africa is characterised with imbalances in skills and competences because of its unique historical and political challenges (Powell et al., 2016). The real estate sector in Nigeria is associated with lack of skills and competences essentially because of failures in the educational system and professional institutions. Fundamental problems of skills and competences include lack of qualified workers, lack of effective leadership, insufficient and lack of state-of-the art information and technological knowledge (Ozorhon and Karahan, 2017). Skills and competences affecting real estate developers in emerging economies can be analysed from four dimensions and they are capacity gaps and shortages, mismatch and lack of up-to-date skills and competences.

First, the problems of capacity gaps and shortages in skills and competences encountered by private sector developers in the emerging economies usually stems from the educational background of managers and personnel (Cappelli, 1999). The educational systems in most emerging economies apart from China have not been able to equip prospective workforce with adequate skills (Cook, 2017). The educational lapses also creates a skills and competence shortages, evidenced in lack of sufficient workforce. The shortage of skills and competences disrupts the developer’s ability to prepare bankable projects, develop and implement projects to meet up with project schedules. This can lead to longer project execution tenure, which could constitute a constraint to early payment of existing debts as well as inhibit access to new funding.

Second, there is also the problem of mismatch of skills and competences which occurs when available skills and competences of existing workforce are not consistent with what is required for their work. This mismatch can lead to increased cost to the firm, reduced productivity, high turnover rate of employee, low job satisfaction and unfulfilled career expectation for the employees (Yin, 2016). All of these can lead to cost overruns for the firm and could adversely affect its ability to pay back existing debt and inhibit access new funding (Mishkin and Eakins, 2015). Arguably, there is inadequate usage of human skills and competences in most private sector real estate development firms in emerging economies which can create a mismatch in skills and competencies resulting in demotivated workforce with a high labour turnover because of a lack of formal training and career structure in real estate.

Third, the lack of up-to-date and state-of-the art skills and competences are a notable challenge to private sector real estate firms in both South Africa and Nigeria. Skills and competences required by private sector firms in the built environment need to be continually reviewed and enhanced. The global economy is rapidly evolving and private sector developers need to enhance existing skills and develop new skills of the managers and workforce to remain relevant and competitive (Mothso, 2016).

There are catalogue of problems in terms of capacity gaps, shortages, mismatch and lack of up-to-date or state-of-the art skills and competences challenge, in South Africa and
Nigeria which has led to inappropriately designed and implemented projects, abandoned projects, collapsed building, disputes, arbitrations, litigations, loss of investor’s funds, termination of contracts and sometimes death of people (Edirisinghe et al., 2016; Thal et al., 2010). All of these constitute a major challenge to securing funding for real estate development projects (Rector, 2002). Lenders look at long-term records of accomplishment of the firm as well as their ability to repay back as a premise for funding projects (Rector, 2002; Nitz, 1996).

**ANALYSIS AND DISCUSSION OF CASE STUDIES IN REAL ESTATE SECTOR**

**Lekki Project in Nigeria**

Lekki is a city in Lagos, Nigeria with a reputation as an area with some of the most expensive real estate assets in Lagos and Nigeria as a whole. Lekki settlements with its catchments and wetland make up about 71% of Lagos State covering an area of 755 Km2. It is an environment with great potential because of its status of free trade zone with planned massive investments such as deep seaport, Dangote Refinery, International Airport and massive residential settlement (Adegboye, 2018).

Private real estate firms through land reclamations are responsible for much of the developments in the region (Ayeyemi, 2017). The reclamations displaced sensitive natural ecosystems consisting of wetlands vegetation and water bodies. Furthermore, the reclaimed land and developments are not adequately protected against ocean surge. Thorough environmental and social impact assessments were not done before commencement of reclamations. This inhibited the capacity to retain and dispel flood amongst other environmental issues, consequently contributing to massive flooding, collapsed buildings and death of people (Fatal collapse, 2016).

Inadequate usage of technical skills and competences during the reclamation and real estate project development process led to the problem of flooding, collapsed buildings and ocean surge bringing sea animals and reptiles to people’s residence (Danladi, 2001). Furthermore, the infrastructure in Lekki reflected in poor drainage channels built by developers, roads that are almost impassable in the dry season and dangerous in the raining season is as a result of inadequate technical skills and competences (Njoku, 2012). The problem of insufficient technical skills has also contributed to so many of the seemingly beautiful Lekki buildings with cracked walls that rendered some properties inhabitable (Adegboye, 2018). The catalogue of problems created as a result of mainly inadequate technical and professional skills and competences but also conceptual skills and competences negatively affected the planning, preparation, design and construction of the properties, the marketability of the properties and the ability of the developers to get further funding.

With appropriate technical skills sets and competences, well-planned and successful land reclamations would have been done in Lekki drawing on best practices and state-of-the-art knowledge from similar developments in Netherlands, China, South Korea and England (Wee, 2017; Tagliabue, 2008). Real estate developers in Lekki and their managers should have addressed the problems of capacity gaps and shortages, mismatch and lack of up-to-date skills and competences required to benefit from best practices as it would have mitigated against the flooding, cracked buildings, collapsed buildings and unsustainable infrastructure that is prevalent in most parts of Lekki. Furthermore, financiers will want to collaborate with private real estate firms who have a repository of successful projects as a proof of their expertise, skills and competences.
Langa Project in South Africa

Langa slum is one of the various slums in South Africa and visitors sometimes use it for slum tourism (Besner, 2013). The development of such slums is usually because of failing macroeconomic factors such as high unemployment rate, high interest rate and inflation (Fox, 2014). Langa slum is on the outskirt of Cape Town and it is an offshoot of municipal houses (Palin, 2018). The evolution of the municipal settlement to slums is arguably due to failure of government to work with the local community, developers and other stakeholders to address the needs of the community. It is also a reflection of lack of skills and competences as the settlements were not sustainable in the long-run because of population boom.

The dehumanising environment is not just a government failure but lack of involvement of private sector real estate firms who are primary players in the built environment, the impact of shortages and gaps in the skills and competences of the community real estate developers. The situation of this slum limit access to funding for an average developer that will want to provide housing in this neighbourhood.

According to Aljazeera’s report of 2016, the situation is bad for hostel residents in the slums as they do not have good sanitary facilities and live in very cramped up situation. Government has made provisions but are grossly insufficient (Hyatt, 2016). The availability of conceptual, political, financial and technical skills by developers and local community would have helped in collaborating with financiers and the government to provide a sustainable environment for the increasingly growing population. Political skills and competences were clearly needed in the project to influence key stakeholders to collaborate, particularly established developers to work with the local community and the government. Strong conceptual and financial skills were also critical to arrive at a scheme that is financial feasible and sustainable for it to work for the community and the established neighbourhood.

Furthermore, considering that a slum is now in existence, developers of the rich nearby neighbourhood, Cape Town can as a part of their corporate social responsibility use their skills and competences, to access creative and innovative funding which can be used to gradually upgrade the slums to decent settlements that will be self-sustaining creating a vibrant community. The real estate projects could be a basis to attract high tech jobs and activate of the community’s economy through the creation of skilled and unskilled employment (Berst, 2016). Based on past experience in India and other Asian city slums, using a blend of skills and competences would have helped in securing adequate funding which would have transformed slums into modernised settlements, and provided platforms to integrate the poor into the society (Roy, 2014).

Both case studies raises important issues about type of skills and competences required for each project, and associated factors that can be seen as key drivers for skills and competences such as standards in the development process and professionalism. First, the availability of appropriate technical skills and competences for the developer in Nigeria or political and conceptual skills for the community-led development in South Africa would have provided the opportunity to develop and implement real estate projects which would have been both successful and sustainable. Second, there is a need for standards for real estate development and a professional career structure. In the developed countries, unlike emerging economies like South Africa and Nigeria, standards are developed for professionals which are expected to be applied and enforced throughout. The standards will drive professionals to develop and maintain their skills and
competences to accommodate changes in practice, technology and regulations (Lester, 2017).

Furthermore, there is transparency amongst real estate professionals in the developed countries to enhance good practices and ethics due to a well-established career structure regulated by professional institutions to ensure that skills and competences are developed and maintained through continuous professional development (CPD) accredited programmes. The responsibility is therefore on the real estate developers to employ professionals that have acquired the requisite skills and competences, whether it is technical, political, conceptual and financial skills. Such skills and competences are important in attracting both local and international financiers and in providing assurance that real estate projects will be developed in line with best practices. There is an increase in the international mobility of funding through various mediums such as foreign direct investments, joint ventures, derivatives, securitisations and others (Melvin and Norrbin, 2012). The funders often provide covenants that will enhance their investment safety and return for different regions reflecting the macro-economic conditions and other factors including skills and competences.

There is therefore a need for a framework for the development of skills and competences in emerging economies to facilitate real estate development including accessing funding for real estate projects. The next stage of the study will focus on developing a framework to measure the different skills and competences of real estate firms in the development cycle based on the classification provided in the literature in selected countries including Nigeria and South Africa, which will also reflect established body of knowledge by professional bodies such as APM, CIOB and RICS.

**CONCLUSIONS**

This study shows how shortages of skills and competences can hinder the real estate development process and militate against the real estate developer’s access to funding for their projects. The study noted that a range of skills and competences are needed by the real estate developers such as human, technical and professional, conceptual, political and financial management skills and competences. The lack of appropriate skills and competences has a significant negative impact in the emerging economies visa-vis what the financiers require from developers. Based on case studies from the Lekki housing project in Lagos, Nigeria and the Langa slums in South Africa, insights and lessons were drawn in the development of real estate projects. Key lessons learnt included the flooding, collapsed buildings and unsustainable infrastructure in Lekki as a result of inadequate skills and competences, inappropriate development process that resulted in the Langa slums in South Africa as result of the Government failure, lack of collaboration with communities and involvement of developers with the appropriate skills and competences to transform the slums into sustainable real estate development. It was also noted that shortages of skills and competences mitigates against the real estate developers ability to access both local and international funding. Financiers will want to collaborate with private real estate firms who have a repository of successful projects and the skills and competences. The study recommends that private real estate firms should improve the skills and competences of their workforce which can be done through mentoring, education and training but this needs to be supported by an enabling policy environment, legal framework, macroeconomic management regime that encourages private sector participation.
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Shortages of Skills and Competences


THEY'RE COMING AT YOU: LATENT AND ACTIVE DESIGN AGENCY IN A ROBOTIC DESIGN STUDIO

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While digitisation research in design and construction is often associated with BIM, it also encompasses robotics. In the design studios and construction chains of the future are robots merely technological artefacts to be manipulated and controlled? How is, are robotic theories and narratives constitute in design and construction research futures? Robotics in Australian architecture school’s robotics is now commonplace, and architects are being taught how to use these machines. At least 8 of 17 architecture schools in Australia now have dedicated robotics workshops and facilities. In undertaking a rapid ethnographic study of one robotic design studio at a graduate architecture school, it will be established how robotic design and fabrication can be theorised in terms of Agency. Aligned with socio-material perspectives an Agency theory of robotics in design teaching in this setting is developed. This model of Agency, emphasising, Active and Latent Agency, explores the relationships between the industrial robots, practices of design and construction, pedagogical schemas and the design of a university campus building. The integrated model explains how latent and Active Agency, is embedded in and enacted through robotic technologies in a design studio. This model establishes how different socio-material practices both promote and constrain the flexibility of agency.

Keywords: robotics, architectural design, agency, socio-material practices

INTRODUCTION

Agency is central to understanding the emergence of industrial robotics in architecture and construction. The reason for this is that the idea of agency, the ability and facility to achieve through various means an end, is critical in thinking about the deployment and use of new digital technologies such as robotics. For proponents of the design, fabrication and construction, through the agency of robotics, is an essential digital technology now emerging in the design and construction industry. Menges proclaims robotics as the beginning of a “Fourth Industrial Revolution” that will have a “major impact” on design and construction. He argues that industrial robots will soon be powerful agents surpassing the linear instructions of machine coding and become capable of machine learning (Menges, 2015). Robots now inhabit the workshops of many architecture schools and studios. For example, each of Australia’s 17 architecture school now has or is associated with, a robotics workshop. For architects two general, and paradoxical, myths seem to prevail about industrial robotics and agency. The first myth is that robotics will increase the range of what architects can do to both design and construct. It will increase design agency by helping architects to more control construction fabrication more closely (Scheurer 2010). The second myth, in contrast to

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the first, is that industrial robots will diminish architectural agency by replicating the
work of architects.

Each of the above myths broadly suggests that importance of considering perceptions of
agency concerning robotics. The first myth is related to the perception of the useful robot
embodied with an active and transparent agency. And in the second myth, the robot is a
kind of golem creature with a latent and opaque agency that once released will turn on the
architects. Such motions and myths of the agency that have always been associated with
robots. For example, in one of the design studio sessions reported on here at the graduate
school of architecture it was drily remarked of the industrial robots “they’re coming at
you.” The primary research question is how do socio-material practices constrain or limit
the agency of people working with robots? The ethnographic setting for this question is
an architectural design in a graduate school. This studio aimed to teach architecture
students how to employ and design with robots. The primary setting for the studio was a
robotics workshop and studio rooms in a recently designed architecture school.

Definitions of Agency
In this paper, we contribute and extend the research around robotics in design and
construction. We achieve this by investigating concepts of agency and socio-material
practices in a robotic design studio at an architecture school. For many architects, the
architectural studio is central to the traditions and canon of architecture and the central
place of architectural production (Schön 1985, Lawson 2006). It is in this design studio
that new processes of digitisation are explored and rehearsed. Like other digital media
and technology robots in construction are material objects, also capable of symbolic
significance, investment and meaning (Pink, 2015). In this instance, the industrial robots
are embedded in the public sphere and teaching spaces of an architecture school. In this
context, the robots play a role in developing the architectural agency of architecture
students. These workshop based industrial robots accord with Lally’s words relating to
personal computers becoming, “extensions of the self through acts such as
personalisation, self-transformation and material projections of future self " (Lally, 2002).
Industrial robots are part of a medium via which organisational practices are performed
and through which the “social and the material are constitutively entangled in everyday
life” (Orlikowski 2007). Industrial Robots are not merely confined to a digital interface
because, in contrast to BIM and Parametric modelling, gesture and action are visibly
evident in Robotic processes; this makes a socio-material study of robotic agency more
cogent.

In the literature of agency theory flexibility is a crucial element. For architects, flexibility
serves as a measure of the range of options architects might. This range of options may
include both the means and the ends they might aim for and employ. As Enfield (2017)
Suggests flexibility relates to controlling, composing and subprehending or anticipating
the behaviour (subprehend is to anticipate or expect something, but not actively or
consciously). In short, flexibility refers to the degree to which agents have a degree of
control over the time and place of behaviour in order to achieve a particular end.
Flexibility is a measure of freedom. As Enfield (2017) states, how easily or “how freely
you can determine the elements of a course of behaviour and its outcomes, in multiple
senses: the physical carrying out of the behaviour, the planning and design of the
behaviour, the placing of the behaviour in an appropriate context, the anticipation or
subprehension of likely effects of the behaviour—including, especially, the reactions of
others—in that context." Active Agency can either have a high or low degrees of
flexibility. For example, in the robotic design studio, the flexibility of Active Agency in
the workshop and seminar spaces is demonstrated through the use of: gestures, teaching aids, coding examples, in-class quizzes exercise, presentations and discussions. However, the flexibility and Agency of these practices are limited by the Latent Agency embedded in the building in which these activities take place.

For architects Agency, and its flexibility is a central concern. Design Agency is the means of design in order to achieve the end of a designed building. In simple terms agency can be considered as the “relatively flexible wielding of means towards ends” (Kockelman et al., 2007). This paper develops a theory of Agency around concepts of active and Latent Agency. Active Agency is that agency that is visible and performed in the immediate present. Active Agency may take place through gestures, utterances, processes and workflows. Active Agency may be expressed through organisational activities such as meetings. Latent Agency is that agency that is seemingly stored or embodied in people and things. This Agency is not yet in the immediate present.

But also, with flexibility comes accountability: “the more agency one has over some process, the more one can be held responsible for its outcome and thereby be subject to praise or blame, reward or punishment, pride or shame.” (Kockelman 2007). Accountability relates to being evaluated, or an entitlement to the behaviour. In other words, accountability can is related to an agent's perception of entitlement to undertake the behaviour and to justify this with reasons (Enfield and Kockelman 2017).

Agency Model developed here

In the socio-material context of the robotic design studio that agency is both Latent and at other times Active. Few researchers in design and construction have applied this concept to the deployment of new digital technologies. A consideration of Agency allows for an investigation of how robotic affordances, their potential, are currently constituted in architectural design and construction. In focusing on a design studio in which robotics are taught to architecture students, it will be seen how agency, both Active and Latent is elicited, or drawn out of, at different times from different socio-material contexts. This focus begins to aid an understanding of how burgeoning robotic techniques are thought about in relation to future design and construction chains. In the design studios and construction chains of the future are robots simply technological artefacts to be manipulated and controlled? Alternatively, do the robots shape the agency of both architects and contractors, as these actors themselves attempt to shape the robots?

Robotic Narratives in Architecture and Construction Studies

Narratives of fabrication techniques and methods have predominated in applied design and construction research into robotics. Many of these robotic studies are imbued with hyperbole, and this is not dissimilar in tone to that identified by (Dainty et al., 2015) in a study of the so-called BIM revolution. In the robotics revolution, many of these studies focus on new frontiers of construction operations and production. For example, selected recent studies in this vein include: Autonomous robots in tunnelling (Menendez et al., 2018), Mapping of insulation and crawl spaces (Cebollada et al., 2018), Application of concrete (Lublasser et al., 2018), Bridge Inspections (Sutter et al., 2018), robotic Excavation (Kim et al., 2018) and even Fire curtain testing (Beckett and Ross 2017). In architecture, robotics has been taken up via overtly technical narratives and an underlying narrative of robotics as a risky technological frontier. For example, in describing the evolution of robotic fabrication at the Sagrada Familia Basilica, a project used to showcase robotic technologies in architecture across the globe, Burry writes that designers gain “when they embrace emerging technology as closely as possible at the first
opportunity by setting aside over anxiety about risk” (Burry, 2016). The Association for Robots in Architecture (RIA) has been a central node in creating and distributing a robotics narrative for architects, academia and industry. The technology frontier narrative, if it can be called that, that predominates at RIA is one focused on the façade; ironically another type of frontier. For example Rapid fabrication of ruled surface panels (Williams and Cherrey 2016), Fabric formwork (Culver, Sarafian and Koerner 2016), Robotic arcs and stone surface production (Steinhagen et al., 2016) and Towards a Micro Design of Acoustic Surfaces (Reinhardt et al., 2016).

Snooks and Jahn (2016) exemplify a narrative that predominates in architecture and the RIA. They argue that through robotic algorithms a new architectural aesthetics can be generated. They opine somewhat opaquely that there is now an “ontological closeness between physical and digital material, robot and computational agent, design and fabrication” (Snooks and Jahn, 2016). Such sentiments suggest that a mystical adjacency has formed between materials, agents and activities. However, in this theoretical narrative, these elements are not connected to socio-material practices. In architectural discourse, there have been a few countervailing, voices to this prevailing view of a digital realm isolated from socio-material practice (Ednie-Brown 2007).

In many of the above studies, Agency is seen as an Active and linear construct. A construct seemingly divorced from broader socio-material practices. In the above studies, alongside a kind of frontierism, the Active Agency of a joystick-like narrative also predominates. This narrative emphasises how robotic agency is directly controlled by humans to complete various tasks. However, the narrative focus of this Agency is on the end effectors of the robots rather than the operators. Even when the robots explore machine learning in these types of studies Active Agency is often overemphasised, and consideration of Latent Agency or flexibility is not often considered. Despite this, a few studies have departed from the above prevailing narratives of simplistic Active Agency and risky innovation frontiers. For example, (Kasperzyk, Kim and Brilakis 2017) argue that while prefabricated construction methods have apparent productivity benefits, they argue that these methods are not flexible in the face of design changes. They propose a Robotic prefabrication system, which can assemble and disassemble, naming this system “re-fabrication.”

**Theories of Socio-materiality, Innovation and Agency**

Within Construction Management, in contrast to the proponents of robotics in architecture, theories regarding digitalisation in design and construction have for the most part been developed around concepts regarding socio-material practices. Many of these authors argue that the culture of design practice, and presumably digitalisation, cannot be separated from the built artefact. Harty and Whyte (2009) employ Actor Network Theory to identify and describe and hint at the existence of ecologies of practice that delegate agency to both actors and nonhuman artefacts. They extend this idea to use Actor Network Theory to identify what they call hybrid practices, such as physical model making and drawing, that emerge in a large project delivery environment Harty and Whyte (2010). Whyte contends that digital infrastructure is not merely a single shared BIM model or entity but an interlinked system of digital and physical artefacts. (Whyte 2011). Sage and Dainty (2011) in a study of hierarchical and hierarchical power in an architect’s office point to the importance of considering practices that are both non-verbal and non-verbal. Further emphasising this theme of the socio-material, the hybrid and the physical, Schmidt and Dainty (2015) reinforce design practice as a dynamic process that becomes intertwined with the designed and built artefact. To support a theorisation of
In innovation theory models of Agency are seen to be redundant. Bock (2015) employs Foster's S “Curve theory”, presumably based on Christensen’s work, to suggest that conventional construction has plateaued regarding performance and that robotic construction will overtake conventional construction leading to the situation where robotics will become ubiquitous (Bock 2015). Hence innovation is theorised as a series of frontiers. A few Construction Management researchers have touched on agency theory but not explored it extensively. For example, Gluch and Bosch-Sijtsema (2016) look at the agency of sustainability experts in the AEC industry. However, these authors eschew a direct consideration of agency by contextualising agency through a framework based on institutional work.

**Research methods**

Socio-material theories of digitalisation in construction are arguably more subtle than those theories centred on simplistic notions of a technical agency or the frontier rhetoric—every innovation graph has a frontier—of innovation theory. The socio-material methodologies cited above accord with notions of distributed agency developed in the social sciences. Agency does not consign itself to an autonomous individual. The reason for this is because, as Enfield notes agency, “can be divided up and shared out among multiple people in relation to a single course of action” (Enfield 2017). In acknowledging socio-material practices, it is essential to understand how these socio-material practices, allow for, limit or enhance agency. In the educational setting agency is a vital outcome; architectural education is focused on maximising the design agency of the architects of the future. The teaching of robotics in architectural studios is a site where the response to architectural agency in the face of technological change and digitalisation can be examined.

Rapid ethnographic methods were seen to be the best approach to capture the nuances of socio-material practices and Agency in the design studio (Pink 2015). This approach accords with Mewburn's (2009) extensive study of gesture in architectural design studios. The studio was taught as part of an architecture program at an architecture school ranked in the top 20 of the 2017 QS rankings for architecture schools. The design studio was offered as part of the school’s Master's program for postgraduate architecture students. The students were of two types. Firstly, students who had previously graduated from a generalist undergraduate degree with some architectural subjects. Secondly, students with undergraduate architecture degrees from other countries in South East Asia. Most students in this cohort would not have previously studied robotics. The studio was visited many times including robotic workshops, seminars, studio criticism or feedback sessions, and lectures. One author of this paper was responsible for setting up and teaching the studio, and the other author attended studio sessions many times to observe. During these periods of observation, various notes were taken in notebooks recording interactions with students, gestures, material artefacts in the studios and workshops. The studio had the aim of introducing students to advanced design and fabrication technologies using 5-digit hands and 6-axis industrial robots.

**RESULTS**

Students in the studio were asked to employ the robots to design through robotic drawing a library on a prominent site in Melbourne. From the outside, looking into the studio, the design exercises of the class might suggest a disconnection for the practical...
implementation and teaching of robotic technologies. It was not presumed that students would have any existing, or latent, programming, digital modelling, or fabrication experience. In addition, students were required to “create an architecture from a sequence of strategically-assembled fragments experienced at four scales – edge, surface, volume, terrain.” Through emulation, exaggeration, and interpretation of anthropomorphic gestures using robotic technology, students were thus prompted to consider how a sequence of strategic marks made by human or machine might inform an unexpected, generative architectural language. Thus using the industrial robots, the students were encouraged to activate the Latent Agency of the industrial robots beyond simplistic notions of technical instruction.

The robotic design studio, workshops and seminar were held in a new Faculty building completed in 2015. Winning numerous awards and accolades the building has been a central component of the graduate school’s student recruitment, marketing and philanthropic strategies. The image of the building’s central space, with an iconic structure that housed studio teaching spaces, has had wide and continuing distribution across marketing materials and social media.

The strategic aim of the building’s design was to design a building that the building was to be a pedagogical building a building whose agency was ever present and active. The building itself was proclaimed to be “veritable education vehicle, a veritable architecture of pedagogy.” The building had four main criteria regarding its brief: “investigation into the future of studio; into the future of academic work; it needed to be a living building; and it had to be a pedagogical building—one that teaches us and that we learn from constantly.” Five architects were shortlisted, and a collaboration between two architects was appointed. At the time the winning scheme was announced in Faculty publicity proclaimed that the design indicated “a detailed understanding of the teaching and research activities of the faculty." The building, whose final budget was AUD 120M, and procured through a novated contract, was the first purpose-built architecture school in the world built in the new millennia. Processes of consultative user briefing space allocation did not proceed past the Design Development stage.

The design studio took place in a number of different spaces within the new building. These spaces are mostly unsuitable for the teaching of robotics or architectural design. Teaching in the studio spaces housed in the iconic atrium structure is difficult because of conflicting placement of whiteboards, pinup space, computers and AV screens. The studio also took place in the workshop area where four industrial robots were located. Because of its shape and size, the workshop is unsuitable as a teaching space. All of the robots were housed in orthogonal steel and glass cabinets. All of the workshop equipment is orthogonal including desks, chairs, benches and machines such as printers and 3D printers. This space within the building had been angled to accommodate the external urban design of the building. Hence, one end of the workshop is unusable as a space for equipment. Within the workshop, there are a range of material artefacts including, printers, ear muffs, books, pin boards and traditional workshop benches relocated from the previous building.

The angled wall of the workshop is entirely glazed and adjoining the main eastern entrance to the building. Various equipment had been placed up against this transparent wall, and the design studio used the space between the glazing mullions to hang models. Suggesting an open glazed wall allows views in from the main thoroughfare as people circulate through the building. However, this clear view during the day made it difficult to teach in the studio using a projection screen. Nonetheless, the robotic design studio
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often pinned up work on the glazed wall outside of the studio. The staff report to a
manager through a strict organisational hierarchy and this makes it difficult for approvals
to improve workshop facilities, such as blinds. The workshop is reliant on around 20
low-level casual staff to operate. Each semester 400 graduate and undergraduate students
are taught in the workshop.

The principal mode of teaching which appears to overcome the limitations of the building
is through gestures. Gestures were central to the teaching of robotics in the studio, and
the studio leader employed a range of range gestures to evoke what the robot arm would
do. These gestures were an extremely effective manner of teaching robotics as the hand
gestures helped to relate the movement of the robots to anthropomorphic gestures in
space. These gestures helped to bridge the gap for the students and enabled them to see
the relationship between coding and the robots.

DISCUSSION

A consideration of both Active and Latent Agency establishes how socio-material
practices may constrain and limit the agency of people working with robots. The
ethnography of the robotics workshop begins to reveal how agency links to the
emergence of robotics in design and construction. Active Agency can be defined as those
activities of Agency, no matter how momentary, that are visible and have a precise
physical and spatial dimension. Active Agency can be defined as those activities of
Agency, no matter how momentary, that are visible and have a precise physical and
spatial dimension. Active Agency may be phenomena like utterances, gestures, notes that
are currently in use or at hand and about to be used. Spaces, buildings and equipment
such as robots can also be active agents. In this instance robots and people working in
tandem brings to life and into the present a task or gesture which represents a state of
Active Agency. However, before this state of Active Agency, agency is latent, and this
latency might be embodied, or embedded, in people, minds, memories, robots, places and
objects. If Active Agency were taught in the robotics studio without recognising this type
of Agency, then the outcome of the studio would be a simple emphasis on coding,
emulation and process orientated movements; limiting the robots to simple procedures.
However, the studio pursues a higher degree of flexibility, by exploring design
methodologies, which allow the students to explore, and learn within themselves, latent
properties of robotic Agency.

Design Agency, the agency of architectural design, involves recognising an interplay and
oscillation between both Active and Latent agencies. This interplay should be an
important consideration in considering the theory and practice of digitalisation. In theory,
architects design buildings in ways that embed Latent Agencies that can be employed as
Active Agency in the future. In the robotics design, studio Design Agency is increased
through greater flexibility in an environment where accountability is decreased. In this
way, the architectural design studio students are a greater degree of agency in terms of
flexibility in order for the to explore and produce solutions that may not usually be
possible if the norms and practices of accountability outside of the design studio are
applied. The framework of the studio and the exercises of the students allow them to not
only learn about the active or visible agency of the robots. Design Agency, the ability
and flexibility to complete a design, is shaped and composed by both Active and Latent
Agency. In the educational setting of the design studio Active Agency is explored by
seeing, coding, playing and producing things, in this case, drawings with the Industrial
robots. Through this expertise, students learn about robotics and the knowledge, and the
skills they learn may be stored as Latent Agency. This Latent Agency is a potential
embodied in the settings, machines and humans. At a later point in time, when needed this Latent Agency shifts to being Active as humans, machines, and settings are brought together.

Power in socio-material settings impacts on Agency, both Active and Latent, with different degrees of flexibility and accountability. In this setting, the Active Agency of the industrial robots is limited by the Latent Agency, or Agencies, of the new building. The robots appear to inhabit the workshop as an afterthought after the building was designed. The building’s design and procurement path can be described by narrow norms of economic accountability and value management, executive style faculty governance and a novated contract limiting the architect’s design role. While the highly flexible process of Active Agency helped to deliver the project, no consideration was given to embedding Latent Agency, to be later available as Active Agency, in the building’s workshops and seminars spaces. As a technology itself, the new building limits the flexibility of Active Agency as classes take place. This limitation is despite the building’s design aspirations towards pedagogy and claim to be a “living” building. In other words, a living building that would foster an Active Agency through socio-material processes. Despite its marketing appeal, the building is not suited to fostering processes of Active Agency in robotics teaching. It then follows that the building does not embed a promising and Latent Agency in the architects and students that inhabit it: The flexibility of its Agency is now limited.

Concepts of agency, linked to theories of socio-material practice, can better link digital technologies to both practice and theory in design and construction. In previous scholarship, there has been a tendency to focus on socio-material constructs disconnected from the dynamics of agency. Agency has a material dimension, is immanent and is distributed between both individuals and objects in time. Agency is grounded in spatial assemblages: buildings, rooms, workshops, studio and seminar rooms and the various spaces which know these spatial entities together. Agency can be shaped by physical setting, such as buildings spaces and infrastructure. These Installations have “a momentum of their own”. Moreover, what characterises human installations “is their intentionality their design to a specific purpose: they support a project of activity” (Lahlou 2017). At the architecture school studied here, both installations and socio-material practices, are shaped in different ways, and that agency itself oscillates between being both Active and Latent Agency.

CONCLUSION

Further research on Agency in architecture and construction and its linkage to socio-material practices is needed to shift the prevailing discourse on digitalisation. Narratives of digitalisation based on joy-stick like notions of agency and innovation frontiers, should not dominate construction research futures. Developing the model of agency proposed here can establish how Active and Latent Agency is positioned within organisational rituals and regimes of power. The exercise of power and corresponding shifts in relationships and agency are not static and organisational theories need to adequately describe and explain in theoretical terms they dynamics of these intertwined and hybrid practices. Ideally, organisations must recognise the importance of Latent Agency connected to and available for processes of Active Agency. A consideration of robotics and Agency suggests how Agency theories might be better articulated, and in a sense how different theories, might themselves have greater agency.

The practicality of understanding Agency and its Active and Latent forms aids in building up a picture of digitalisation and technology implementation in design and construction.
New technologies can be fostered, and better implemented in different socio-material contexts, by recognising how Active Agency can be stored for retrieval as Latent Agency.

In the robotic design studio, a consideration of both Active and Latent Agency, indicates the potential of Agency for managing digital technologies as socio-material practices rather than technological artefacts to be simply manipulated and controlled.

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CONSTRUCTIVIST GROUNDED THEORY FOR SUPPORTING COLLABORATIVE-EMBEDDED RESEARCH IN CONSTRUCTION MANAGEMENT

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The last decade has seen a drive within disciplines such as construction management to collaborate with industry in order to extend the relevance and impact of research. In the UK, this drive can be seen in the Research Evaluation Framework (REF) and the promotion of collaborative research through funding programmes like Innovate UK, Horizon 2020, Knowledge Transfer Partnerships (KTPs) and post graduate placements. Collaborative research presents challenges especially for qualitative research when the researcher seeks to theorise in a context where the objective presents difficulties. Traditional approaches to applying Grounded Theory (GT) within collaborative-embedded research have found it difficult to achieve this. In this paper, the emergence of Constructivist-GT is argued to represent a shift towards the application of GT when conducting this type of research by actively embracing the inevitable prior knowledge, recognising bias and the use of existing theory during the entire research process. Although well established in other fields, the use of GT in the constructivist form advocated by Charmaz is relatively unexplored in Construction Management. The paper shows, through an ongoing collaborative project exploring the value of the estates performance information for the strategic management of the healthcare estates, the potential of Constructivist-GT to provide new insights and respect the role of the embedded researcher. This is intended to support other researchers when conducting qualitative research and need for an emergent methodology focused on theoretical contribution while retaining level of practice based pragmatism.

Keywords: collaborative research, Constructivist Grounded Theory, healthcare, C-GT

INTRODUCTION

The past decade has seen an increased drive from academia to collaborate with industry in order to extend the relevance and impact of research. In the UK, this trend can be seen in the Research Evaluation Framework (REF); the promotion of collaborative research through EU’s Horizon 2020, Innovate UK and Knowledge Transfer Partnerships (KTPs); post graduate placements/industry based projects for doctorates and staff; professional doctorates; and the advance of Engineering Doctorate’s with placement components funded by research councils. This funding landscape is progressing the opportunity for researchers to actively respond increasingly to practice. As academics are required to demonstrate the impact of their research, the opportunity to become an embedded partner within an organisation presents many opportunities to better reflect the needs and to actively influence practice. However, it could be argued that this has the potential to

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hinder the ability of the researcher to retain their impartial position and objectivity which is a requirement in the adoption of emergent approaches such as Grounded Theory (GT) and especially the form advocated by Glaser (1978) and Strauss and Corbin (1990). To achieve a value free standpoint can be difficult when considering researchers who are embedded within organisations due to their daily interaction with the environments that they study. Kathy Charmaz, when critiquing traditional approaches to GT, argues that in reality all the researchers will always make value-laden judgments on what they are hearing and seeing, with or without consideration of prior knowledge of the literature (Charmaz, 2005). In 2006, this author proposed a novel approach to GT founded on social constructionism which seeks to acknowledge the positionality of the researcher and recognises the existence of pre-established learning and knowledge whilst retaining emergent principles. The author also encourages the researcher to explore the state of art in a dynamic manner to help to identify gaps in existent works, place the research in context, refine, extend or revise existing theories, etc.; thus allowing its influence in the evolution of the categories (Charmaz, 2008).

Although well established in other fields, the use of this contemporary variant of GT remains limited in the field of CM. This research argues that this methodology has the ability to enable the co-production of research between academics and practitioners and the development of a theory that is recognised as usable within a specific context. This paper demonstrates the potential of Constructivist-GT Charmaz (2006) as an appropriate methodology when conducting qualitative inquiry in collaborative research, especially when the researcher is embedded in the organisation partner. Its application in practice and the benefits for using this methodology is showcased through an ongoing case study that explores performance measurement in the context of healthcare estates in NHS Scotland highlighting the potential of this approach. The research is co-produced with Health Facilities Scotland (HFS) with a researcher embedded within the organisation for the duration of three years. For the research, HFS felt it was necessary to have a researcher embedded in the organisation shadowing the relevant team thus allowing them to learn and reflect on the emerging findings with a view to shaping the research so that it responds to the real challenges they face in practice.

GROUNDED THEORY AND ITS DEVELOPMENTS

GT is described as the generation of theories derived from data about issues of importance in people’s lives in order to understand the social context (Glaser, 1978). Charmaz (2017a) states GT as a valuable methodology that generates fresh theoretical insight which informs emerging research directions and aids theoretical underpinnings and practice. In the context of management disciplines it has been argued that GT is particularly appropriate because it captures complexity, links well to practice and supports theorising of ‘new’ substantive areas (Saunders, 2011).

Three main variants of GT have evolved over time whose incongruity hinges on the nature of the relationship between researcher and participant (philosophical positions), the contending coding procedures and on an explanation of the field of what can be known and their contrasting use of literature (Mills et al., 2006). The traditional GT was founded by Glaser and Strauss (1967) and it is known as the positivist version. This was later remodelled by Strauss and Corbin (1990) as a response to the maturing nature of qualitative research. Mills et al., (2006: 28) argued that this approach "vacillates between post-positivism and constructivism, with a reliance on terms such as recognising bias and maintaining objectivity". In this version the contexts in which participants are situated acquire more richness in the data analysis and theory reconstruction. The most recent
approach to GT is the Constructivist-GT (C-GT) of Kathy Charmaz. Although adopting the methodological strategies of Glaser and Strauss’s classic GT, the Constructivist-GT approach does not endorse the same philosophical stance. This approach emphasises multiple realities, taking into account how the researcher and research participants’ standpoints and positions affect their interpretations, and create interpretive understandings located in these particularities of their production. Despite their differences, any form of GT shares a set of common features including coding, theoretical sampling, theoretical sensitivity, constant comparative methods, the creation of memos and diagrams, treatment of the literature, identifying the core category and verification.

Whilst GT has been effective in more sociological strands of CM looking at cultural issues, its application in other areas has been limited, potentially due to the tension between theoretical and practice based contributions.

What Does Embedded Research Imply?

Embedded research describes a mutually beneficial relationship between academics and their host organisations whether they are public, private or third sector. For the host organisation the relationship provides a bridge to academic knowledge and critical approaches to developing organisational practices and policies; whereas the researcher benefits from the research funding and the access to the data collection (McGinity and Salokangas, 2014). According to Eyre et al., (2015) in embedded research knowledge is co-created between the researcher and practitioners. While being part of an academic institution, researchers work inside the host organisations as members of the teams, collaborating with them to conduct research studies and share findings aimed to address the needs of the organisation and aligned with the organisation’s unique context and culture (McGinity and Salokangas, 2014).

The Case Study as an Example

This research illustrates an example of an application of the C-GT methodology in the discipline of CM, specifically asset management, in research funded by Health Facilities Scotland (HFS) and the Built Environment and Asset Management (BEAM) Centre at Glasgow Caledonian University (GCU). Showing the research findings is not the focus of this paper; but instead it illustrates the research process followed and the benefits for using C-GT when conducting collaborative-embedded research. The study sets out how measuring performance of healthcare estates is applied at the strategic level of management in order to identify its role and extend its current potential. This project was an initiative of HFS who started discussions with the academic team around delivering new strategies for performance measurement in order to move the general focus from the dominant indicator of backlog maintenance cost and to broaden this focus to other possible performance aspects of the estate. The aspiration of this research was to help HFS to increasingly gain data intelligence around estate performance in order to achieve optimisation of the value of the healthcare estates in the contribution to the delivery of the organisational long-term objectives. Thus, HFS initiated conversations with GCU in 2014 bringing a couple of initial questions that emerged from observable and perceived problems as a means to accomplish the aim. These were: what set of performance measures shape a healthcare estate and what constitutes the optimal performance for each of those measures? The research challenged the nature of these questions. Therefore, to establish meaningful research objectives an additional stage within the research was needed. This required a better understanding of contemporary practice in performance measurement as well as how it has been implemented. As a result, an emergent approach was needed to enable the research questions to evolve as a better understanding was

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established, whilst permitting co-production and respecting the integrity of an embedded researcher. As the research evolved it was apparent retrospectively that HFS held aspirations (initial questioning) for the research which were based on what emerged as a wrong interpretation of the problem. Drawing on the findings of a first stage, the research asked the following question, what is the current status of performance measurement for the management of healthcare estates at the strategic level?

**Being Embedded and C-GT**

The limited knowledge of the researcher in the field study and the lack of clarity on the line of questioning at the outset, demanded for an emergent methodological approach to be utilised drawing the researcher towards GT. Having explored the different approaches, it was identified that the traditional GT variants were not suitable as an appropriate methodology due to several factors including: 1) the challenge for remaining neutral or unbiased, and 2) the need for delivering a contextualised theory that responds to the issues and is recognised as usable in the organisation and similar context.

The challenge of remaining neutral and unbiased

Embeddedness allows researchers to get under the skin of the organisations and ask complex and difficult questions; giving access to multiple perspectives which as an outsider the research would not have access. This provides intimate knowledge of the organisation; thus the research can be tailored to meet the needs of the organisation. Nevertheless, this closeness may also bring the researcher closer to taken-for-granted events as they can see and hear what is happening, making it difficult to be an objective observer. In this project the researcher was required to interact with those co-producing the research as well as wider participants based in the organisation; working as part of the estates team that are responsible for the management of the tool studied, as well as ensuring their appropriate use from the NHS boards. This closeness to the team, the day to day observation and on occasion supporting them in some of their roles, led the researcher to adopt preconceived thoughts that hindered any aspirations to keep an impartial standpoint. The researcher naturally encountered the danger of the research being influenced, intentionally or unintentionally, by the preconceptions of individuals' (superiors) own and potential agenda’s which they want to see realised through the research. This presented the challenge of when co-producing research in that putting thoughts in her mind when designing and analysing the large number of interviews conducted with participants.

The need for the interaction between theory and practice

In the field of CM much discussion has been conducted about the value of theory with opposing arguments. But what becomes clear is that in the case of collaborative-embedded research, theorising does not give much scope to the development of a broad-range theory. Instead, aligning to the concept and implications of embedded research, it demands more contextualised theories that are relevant to the organisation, reflecting practical problems grounded in the empirical data collected and supported and contrasted with existing theories along the entire research process. This is supported by Biesenthal (2016) who believes in contextual theories. In addition, they cannot just be only descriptive or explanatory; a prescriptive element is required in the sense that it needs to speak directly to the practical concerns. In other words, a theory that is recognised as relevant and applicable within a specific context that includes what 'ought to be done' through the development of a framework or offering guidelines, recommendations, key actions, etc.
In the context of this research, it was apparent that HFS was also looking for an element of consultancy as the research developed in order for the findings to help them overcome the specific problems they are facing. They were not interested necessarily in the theoretical contribution, but more in a series of recommendations for practice which can be interpreted for their context from the theory. The argument when developing theory in collaborative-embedded research in the field of CM is that researchers need to have a level of pragmatism to be able to deal with the concerns of the organisation, bringing existing theory, criticality and doubt to the process. The traditional approaches to GT do not spark the level of pragmatism required (Bryant, 2009); but the emergence of C-GT presents an opportunity, with Charmaz (2017b) claiming that it has its methodological roots in the pragmatism tradition. Important is that this pragmatism has to be understood not from the term "the metaphysics of the real", but instead, as it is claimed by Bryant (2009), as a type of pragmatist where theories and concepts are best considered in terms of their usefulness rather than their truthfulness. The idea is not to disregard existing knowledge but to engage with it critically (Thornberg, 2012). As Reich (2009) stated "constructivism, like pragmatism, does not plead for constructions for the sake of constructions, but looks for solutions to problems of human import".

Sample for Data Collection
The data collection involved documentation analysis, observations when working at the office and during meetings, and interviews with four different types of stakeholders. This includes from government officers (related to the estate); HFS estates and capital team; and stakeholders from the boards, specifically directors with a level of involvement in dealing with the strategic aspects of the estate and senior managers involved in the data collection, reporting and the elaboration of the property asset management strategies. Although the focus was on NHS Scotland, the research also included the case study of NHS Northern Ireland as there was the risk that those responses from NHS Scotland's stakeholders may not reflect their real perceptions or opinions as they can see the research as a criticism of their approaches. This is recognised as one of the challenges of embedded research by Wong (2008) who mentioned the probability of practitioners, as subjects of the research, feeling themselves threatened or intimidated. This engagement with a different set of stakeholders in another region brought up an alternative view with emerging insights to the study.

The emergent nature of this research meant that the sample was not defined at the outset. As the research evolved and concepts started to be discovered, new data sources and collection methods were defined. The review of existing theory and the need for contrasting my assumptions were also a determinant in this process, as new ideas sparked and questions kindled. This was the process until saturation was achieved in the 34th interview. Charmaz (2011) states that a sample of 30-40 interviews, when they are the only source of data, provide a solid foundation for a detailed analysis. However, this is debated by Suddaby (2006, pg. 639) who states that "questions of when saturation is achieved, how coding should be done, or when counting is appropriate can be resolved pragmatically".

The treatment of existing theory in the data study
Bringing theory into the study was conducted during the entire research process. What is important is that the codes and following categories did not emerge directly from the theory but from the analysis of the interviews, documentation and the researcher observations. The significance of the constant review of the literature was the generation of new questions and sparked new avenues of enquiry. For example, in most of the
responses the operational issues come to the fore and less reference was made to the most strategic performance information. This was later discovered to be related to the scarce value the estate still has a strategic function in the organisation. However, it was not until after reviewing the report published by Ware et al., (2017) on behalf of RICS: "Raising the Bar: Enhancing the Strategic Role of Facilities Management" when this connection was discovered and the line of questioning was modified to form a deductive line of enquiry. This gave the researcher additional data and provided greater appreciation of the issues that affect the usefulness of the tool, raising questions about how the fact the estates function is not recognised as much as a strategic resource being secondary and stuck in an operational model, would affect the perceived value of performance measurement from the users at the NHS.

Engagement with the theory was not just significant to generate new questions and spark new ideas; it also became essential to increase the chances for the research to be used in practice and have an impact. This has the potential to become more significant when practitioners may be sceptical of research which seeks to critically appraise processes which they may feel a vested interest in protecting or avoiding criticism over. This is a consideration which with co-production can unwittingly present challenges but especially for embedded researchers. If the embedded researcher is to retain their ability to be critical they need to cross the boundary of being impartial and a neutral observer and to instead work with the practitioners to address these fears and ensure the ability to be critical is not lost. Theory was brought to the study to challenge earlier perceptions promoting understanding along the way and shared with the co-producers with initial theoretical analysis. The attraction of this literature is that it elicited acceptance, doubt and promoted questioning from the co-producers regarding current practice, specifically helping provide recognition that some of the initial perceptions were found in conflict with this understanding.

Dealing with bias through reflexivity and adopting an adductive approach
The research process and outcome ran the risk of being biased from the researcher's assumptions and views for being part of the team; but also from the co-producers feedback and interests when sharing findings of the research during update meetings. In order to privilege data, the researcher adopted adductive reasoning where her assumptions were deductively texted throughout interviewees and contrasted with the literature.

Reflexivity was also used to acknowledge the position the researcher occupies as an individual and as part of the organisational context. Reflexivity was addressed in the interview process, data analysis and the writing up as they were the procedures that were considered to have more impact and relevance to the study.

Data analysis
Data analysis began after the first interview until the production of the substantive Constructivist-GT. The coding process and the identification of core categories was iterative, going back and forward between data collection, coding and memo writing, and evolved alongside the literature review while the researcher's understanding and interpretation developed. This process finalised after theoretical sampling and saturating the categories. The data and codes were constantly compared and some of the initial interpretations were later modified when comparing with data from later interviews and with the literature. This led the researcher to modify the question guide as the research advanced. Figure 1 shows the Constructivist-GT process, while figure 2 illustrates in more detail the steps followed in the research.
The Substantive Grounded Theory

In this study the core category that defines the applicability of performance measurement for the strategic level of management based on the current set of measures is discovered to be at present limited to accountability and control, influenced by the context at which centralised healthcare organisations operate, which include:

1) The size of the NHS board. The value of the tool increases with the size of the estates, becoming more valuable for larger boards. For small operational units the estates comprise of less complex and fewer buildings that allow them to hold a more in-depth understanding of their estate with the ability to identify the problems without the need for undertaking facility performance assessments, or the continuously recording and monitoring of data. On the other hand, performance information was addressed to be important for a few interviewees, mainly from larger NHS boards.

2) The research revealed conflicting interests on the performance needed between the government and the users at the boards. It was found that not all the performance measures were relevant to the boards due to their 'high level', do not take account of local management processes, the limited linked to the service delivery, etc. Based on an institutional theory perspective, Chang (2006) argued that the process of formulating performance is not neutral but subject to the influence of institutional interests imposed by the governments; they have the control of the type, quantity and quality of data that they receive. Therefore, to increase the potential of the tool, it is on the government to make the measures more relevant for the users. It was also significant the discovery that the usefulness of performance information relies highly on the type of performance measured. The current set of performance measures in NHS, as well as it was identified in other healthcare organisations, focus solely on aspects of the estate, serving merely as a description of the state of the estates. In the NHS, as long term decisions are taken around clinical services and not towards the improvement of the estate KPIs, this information is perceived by the research participants from the healthcare bodies became less valuable.

3) In addition, the research revealed that the limited use of the information for strategic managerial purposes goes beyond the value of the tool itself but related to a wider problem: A perceived organisational culture where the estate is perceived as less important as a strategic resource, whose performance is not always seen as the main
prioritisation of the organisation, and where there is lack of communication and engagement across the different departments. Thus, the current role of performance measurement is hindered by the fact that the estates function is still not being recognised as much as a strategic resource, being secondary and stuck in an operational model.

The use of Constructivist-GT gave the researcher additional data and provided greater appreciation of the wider issues the organisation is facing that affect the current role of performance measurement within this context, which otherwise would not have been identified. This research is ongoing and needs to be validated with wider practice, thus generalising the research with other healthcare organisations of the same characteristics.

**LESSONS LEARNED**

The growing trend towards co-production of research between academia and industry necessitates the use of research methods beyond the 'traditional', not simply providing consultancy but establishing research which provides practice based relevance but importantly provides a theoretical contribution (i.e. the theory from the grounded approach). The fact of being embedded limited the use of methodological approaches such as GT due to the difficulty of remaining objective and not being biased by others within the organisation, and more important such as is in the case of this research where the co-producers are also part of the sample studied. In addition, the limited understanding of the subject studied and the ill definition of the research questions forced the researcher to conduct an initial stage to provide the basis for the research focus and a literature review was performed. The C-GT of Charmaz was found to increase the changes for the research to have a higher impact as it is more pragmatic and relates theory with a practical application. Finally, the research benefited from the adoption of C-GT as the methodological approach in that the research evolved on a different direction on how it was and to reflect on wider issues.

Despite the benefits for adopting this approach, being embedded and using GT presented challenges of how the researcher portrayed participant's voices in her written reports due to the analysis being an interpretation with the potential to upset some of those within the organisation. This runs the risk of limiting the ability of the research to be critical as if unmanaged the researcher could refrain from being critical or damage important relations making it difficult to remain embedded. During the three year project there were occasions when resistance was encountered and when the bias of others within the organisation were presented to shape the research, but by working with a core group of co-producers within the organisation it was possible to overcome this. Key was engaging this group in the theoretical reasoning and relevance of the observations to the wider context. Whilst this greatly improved the potential to be critical there were still occasions when the researcher felt rightly or wrongly restricted in what she could explore in a way which she would not have had she been disconnected from the organisation. The authors believe that this paper will support future collaborative-embedded research when needing an emergent approach and the creation of theory that acknowledges the context of the research conditions. There is always the potential of improving of what C-GT can do within this context.
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EXPLORING THE DEVELOPMENT OF, AND INITIAL EXPOSURE TO, A BIM-ENABLED COLLABORATIVE PROJECT INFORMATION MANAGEMENT TOOL

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The coordinated management of construction project information across separate actors within temporary project organisations remains largely unsystematic. Even on small-scale projects, the volume of people, companies, and interfaces that contribute to the project delivery process add to levels of project complexity. To ensure more effective collaborative practice, there is a need for a more structured and consistent approach to project information and process management. The focused use of building information is considered to be beneficial in these regards, however to help better realise such aspirations and the predicted benefits of the use of BIM, a series of supporting standards and tools have been developed for incorporation into industry working practices. One such item, the BIM Toolkit was developed as a possible solution to many of the challenges of facilitating collaborative working and information management practices on a BIM-enabled project. The dual aims of this work are to first document the development of this process innovation, and then explore the first exposure of it to a range of relevant industry practitioners. A series of qualitative interviews were held which yielded concerns around several aspects of the use of the BIM Toolkit in the project delivery process. These revolve around information classification, compatibility of existing working practices and use of communication channels. As such, several anticipated consequences regarding use of the toolkit are revealed, useful for those wishing to use it on their projects.

Keywords: BIM, classification, information, communication channels

INTRODUCTION

Many thousands of information exchanges take place across interdisciplinary teams, throughout the lifecycle of a construction project. Data provided at each exchange is often subject to interpretation, verification, and validation for each unique event. Efficient reuse of information at these exchange events requires the quality of data to be considered in terms of completeness, consistency, and continuity between exchanges. Inefficiencies of traditional information exchange processes within the construction sector are well documented (Tizani, 2007; Emmitt and Ruikar, 2013; Gledson, 2017). Building Information Modelling (BIM) offers a methodology for developing structured information for construction projects. Standards, roadmaps, and manuals provide a framework for collaborative teams to manage the process of developing information requirements and maintaining and validating data (British Standards Institution, 2007, 2013, 2013a, 2014, 2014a, 2015; Building Information Management Task Group, 2013). The benefits of BIM are widely reported (Eastman \textit{et al.}, 2011), but its adoption presents challenges to existing processes, technologies and workflows, which require consideration regarding changes to culture, collaboration, required knowledge and

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training (Arayici et al., 2011). Matthews et al., (2018) argue that process change must be managed through training, education and experience. Similarly, Arayici et al., (2011) consider that changing the attitudes of people and processes is more likely to result in successful BIM adoption. Greater collaboration with other disciplines across project teams and the interoperability and integration of data is required to support BIM adoption across the project (Arayici et al., 2011; Matthews et al., 2018). Structured information flows, open standards and agreed information requirements can support the interoperability and integration of data within and across interdisciplinary collaborative teams. Additionally, the research of Gledson, Hilton and Rogage (2016) has also demonstrated a relationship between recipients of BIM training, education and their levels of BIM understanding, awareness and use, finding that those who have had BIM training or education are more likely to positively engage with the process, and adopt BIM technology.

The BIM Toolkit is a process innovation developed to support industry with BIM adoption (Technology Strategy Board, 2014). The twin aims of this study were to first document the development of the Toolkit; and then explore the first exposure of the Toolkit to industry practitioners. The key objectives of the study were to: capture the purpose of the Toolkit and its development process; establish a base level of BIM knowledge and the Toolkit with practitioners through training; capture industry practitioners’ understanding of BIM and the Toolkit post-training, and then review BIM maturity and level of Toolkit adoption one year after the initial study.

THE BIM TOOLKIT

The ‘BIM Toolkit’ was developed with funding from the ‘Digitising the Construction Sector’ call issued by the Technology Strategy Board (now Innovate UK), in March 2014. The call itself was a response to the Government’s BIM Strategy and the Construction Industry Strategy, both developed to encourage the construction supply chain to adopt BIM. The call was aimed at research and development activities that supported the UK Government’s target for using BIM Level 2 on public sector procured projects. The Toolkit was a collaborative development lead by the National Building Specification (NBS) in association with the BIM Academy, Royal Institution of Chartered Surveyors (RICS), Microsoft, BDP, Mott McDonald, Newcastle University and Laing O’Rourke (NBS, 2017). The initiative sought to develop a tool that allowed users to specify: A) what information they required, b) for particular stages of project delivery, and moreover, c) to then verify whether or not the information requested had in fact been provided.

Three key components were required to enable this: A digital plan of work, a classification system, and a platform that allowed for the integration of different levels of digital object ‘definition’.

The developed Toolkit contains a Digital Plan of Work (DPoW) which enables the definition of responsibilities at each project stage. The DPoW is based on the RIBA’s eight stage plan of work (RIBA, 2013). The deliverables required for each stage can be added to the DPoW and roles assigned to them. Crucially, the Toolkit recognises how object geometry and information are independent of each other in terms of what may be required at any one particular point in time. For example, in early design stages a relatively unimportant object such as a chair, may be geometrically represented as a placeholder cuboid object in a design, but all descriptive information about the chair at that point, such as dimensions, manufacturer and material may be needed more immediately. Later in the design development it may be necessary and important to have more detailed geometry about the object (i.e. the chair) available for purposes of
presenting detailed visualisations about a particular aspect of the design (e.g. furniture arrangements) to the client team. For each deliverable the varying ‘Level of Detail’ (LOD) and ‘Level of Information’ (LOI) required can be independently specified. LOD describes the geometric detail required for the deliverable, while LOI describes the associated descriptive information that is required (Kell and Mordue, 2015). The Toolkit provides a set of predefined deliverables with different LOD and LOI recommendations for different stages within the DPoW. The deliverable data originates from NBS Building and NBS Create tools (NBS, 2017a; 2017b). NBS Building data has evolved over 40 years with industry use, whereas NBS Create expands the core data set from NBS Building to include areas of information such as elemental and performance data. Deliverables within the Toolkit apply Uniclass 2015 as the default classification system, which covers buildings, infrastructure, mechanical, electrical and public health systems (Delaney, 2017). NBS also adopted a classification mapping system to allow the Uniclass 2015 system to be mapped to other classification systems already supported and in use by the industry. As part of this activity, RICS were also commissioned to map their new rules of measurement standards (NRM) to the NBS Create data (NBS, 2018).

At the start of this study the Toolkit had been freely available and accessible online for industry use for a period of 6 months. Users could register for an account then create multiple projects and assign organisations, roles and participants to these. The Toolkit contains a library of data and guidance that recommends the LOD and LOI for assets at each stage within the DPoW, with project coordinators being able to independently select the necessary LOD and LOI most appropriate for each element of their own projects. Figure 1 gives an example of setting the LOD at stage 3 for a window restrictor. The toolkit provides a recommendation for how much detail is required and the purpose of the information.

![Figure 1: Adding LOD for a stage 3 deliverable.](image)

For this same example, Figure 2 provides an example of how it is possible to independently allocate LOI 4, thus requiring more information than detail regarding the windows restrictors at stage 3 of the Project.
Once data is received for a particular stage, it is then possible to validate the data to check if all the deliverables have been supplied. At the time of writing the Toolkit can check to see if data has been supplied but it cannot check the quality of that data, therefore it can assist with ‘verification’, but not ‘validation’ of the data.

METHODOLOGY

The research is positioned in the philosophy of interpretivism, and it uses survey research (mixing initial semi-structured interviews, that are later supplemented with a questionnaire survey) to perform an exploratory study. Whilst the population of interest is UK based project-delivery practitioners, the sampling approach employed meant that a non-probability, convenience sample was used. Research access was requested of practitioners who had undertaken BIM training and education sessions through Northumbria University’s BIM Academy. In total, 17 ‘self-selected’ industry practitioners were interviewed after their first exposure to the NBS BIM Toolkit. These participants came from 9 different organisations representing the architectural and construction engineering professions. Only 1 of the employing organisations was a large contractor (measured by size of more than 250 employees), the remaining organisations employed less than 50 people.

Participants are categorised as Management Professionals, Design Professionals or Technical Specialists. Management Professional job roles are described as those involving the direct management of people or processes, where the management responsibilities may be at multi-project, individual project or individual site-based levels. Design Professional roles are described as those that involve producing design information. Technical Specialist roles are described as involving the management of a process or providing specialist technical advice or output such as a Construction Planner, Design Manager or Quantity Surveyor. Participant roles and organisation size are shown in Table 1.
Semi-structured qualitative interviews were carried out with participants to capture both their current understanding of BIM in practice and their perceptions of using the Toolkit in practice. All participants had been exposed to both BIM training and the Toolkit prior to the interview. 6 of the participants had previous experience of working on BIM enabled projects in practice. Follow up questionnaires were issued 1 year after the initial study to the 6 participants who had given consent to be contacted further about the research. 4 responses were obtained and their experience with the Toolkit post exposure is documented. A Computer Assisted Qualitative Analysis Software (CAQAS) tool was used to both manage data generated via interviews and follow-up questionnaires, and to assist and support the analysis process (King, 2008). From within the CAQAS database, thematic analysis was applied to the data. The data was pre-coded using five key themes relating to the challenges and change processes identified in the background literature (Figure 3).

![Figure 3: Themes arising from literature review.](image)

Qualitative data were assigned to these pre-codes whenever sentence(s) contained relevant wording or phrases. An example of an item coded under the ‘knowledge, training, education and experience’ theme was the statement: “… people think that BIM is Revit and that the two words are interchangeable, and obviously they are not” (P11, Civil Engineer). Figure 4 then documents the research process that was undertaken for the study.
FINDINGS

The findings from the interview and questionnaire data supported the key findings from the literature review, not only in relation to BIM adoption but also in relation to adopting the Toolkit.

Figure 4: Research process

Figure 5 shows the range of items that were coded against the following themes: Changes to processes (CP), project collaboration (COB), using the Toolkit to promote collaboration through communication (TKCOB), knowledge, training, education and experience (KTEE), structured information, open standards and classification (SIOSC) and Technology (TECH).

Figure 5: Data themes

Process and Workflow Change

In agreement with the literature the data revealed that in order to adopt BIM an organisation needed a ‘BIM champion’, with sufficient authority to implement necessary changes within an organisation. All participants could see the benefit of BIM but the demand from clients had not yet been sufficient for all participant organisations to adopt BIM at the time of the study.

Opinions relating to process and workflow change in relation to the Toolkit were mixed. Participants from one organisation using BIM in practice have existing processes and technologies that they use already. P16 described how a lot of time and effort had been taken to develop their own ‘templates’, ‘forms’ and ‘protocols’ using the single Collaborative Data Environment (CDE) 4Projects (Viewpoint Inc., 2017), considered by this participant as a competitor product. The key difference between the Toolkit and 4Projects is that the first allows the information requirements to be defined whilst the latter allows the data to be shared between parties, thus they are effectively complementary. The ability to perform all activities through a single portal such as being able to share data models or publish documents was seen as something the Toolkit lacked that could possibly be done in other platforms.

P8 and P16 had concerns about the duplication of effort required to support the Toolkit alongside existing systems:

You've got your external document saying: ‘what you need by that date’, [and] ‘what level do I want by that date’. So, you’re still working off two documents. So in retrospect you’re
not actually reducing the work you are doing, you are still doing what we would normally
do, so it's just replacing it's not actually beneficial as I see it, yes it's another tool, but that is
all it is at the moment. (P8)

P8 also had concerns about ongoing commitments and possible subscriptions necessary to
operate the Toolkit, stating: “it is another thing to sign up to and keep”, which from an
individual perspective can make the Toolkit seem laborious to engage with.

P14, whose organisation also implemented BIM in practice, stated that they could see the
benefit of running the Toolkit alongside their own processes, as it provided a platform to
keep track of the project deliverables that everyone could access. A benefit highlighted
by P14 was that the Toolkit provides a single repository for information requirements,
whereas the same information within bespoke practice is distributed between excel
spreadsheets and emails making it more time consuming to access. Consistency of
naming conventions was also highlighted as an issue with bespoke practice, this is
resolved in the Toolkit through standard naming conventions through implementation of
Uniclass 2015 and the common data sources provided in the guidance.

**Collaboration**

P2 viewed the Toolkit as useful for managing information processes and as a platform to
guide the dialogue of that process between parties responsible for completing project
deliverables. It was also suggested that the Toolkit made the process transparent because
you could easily see what data was required and when. P6 stated that the Toolkit would
improve communication flows between parties whilst making it easy to keep track of the
project. 8 participants independently stated
that the ability to export roles and
responsibilities for data exchange was a good method for keeping track of projects.

**Knowledge, Training, Education and Experience**

This theme was split into three sub themes: 1) exposure to BIM; 2) jargon and 3)
perceptions of contractor capabilities. Discussions were focussed on adoption of BIM
rather than the adoption of the Toolkit. 11 of the participants had not implemented BIM
on any projects. Exposure to BIM was discussed both in the perspective of exposing the
client to BIM and exposing contractors to BIM. Exposing clients to the benefits of BIM
was seen as a challenge to adopting BIM processes. P5 expressed concern that clients
would not pay for BIM on a project until they had clear evidence of the benefits.

All participants had received prior training around BIM. Methods for BIM exposure were
discussed in detail. Ten participants had received formal BIM training through
Northumbria University’s BIM Academy (BIM Academy, 2018), the remainder were
self-taught. Presentations, videos, BIM standards and roadmaps were all cited as online
materials self-taught participants had used to understand BIM. Out of the ten self-taught
participants, four had implemented BIM on projects, two of these had worked on projects
where there was a client demand for BIM and two had used BIM to develop their
organisation’s experience of innovation.

Eight participants discussed the role of terminology or ‘BIM jargon’ as a challenge to
BIM adoption. P16 described the use of acronyms in BIM as being like “reading a
foreign language” which was seen as a challenge because in order to understand that
language the participant felt that they needed to do a lot of reading before they could
understand the terminology being used. Another challenge was presented around the
meaning of BIM itself. One participant stated that the term BIM means different things to
different organisations depending on what stage in the contract they are and which of the
BIM standards or protocols related to them at that stage. On the subject of understanding
the meaning of BIM, P15 stated that: “understanding [BIM] in the first place is an issue, understanding how it [BIM] applies to you is an issue”. Further to this P16 and P17 stated that they had dropped the term ‘BIM’ from their language altogether, even though they were using BIM on projects, they found it easier to converse with contractors if they dropped the BIM jargon.

The last part of the discussion in this theme touched on the perception of contractor capabilities in delivering BIM on projects, although it was not discussed in great detail with only four items being coded in relation to this topic. The discussion referred again to the understanding of language, P16 described their experience of working with a contractor who stated they weren’t BIM level 2 ready despite P16 observing the contractor delivering project data to a level 2 standard. Contractors were also expected to be skilled enough to access a CDE but P16 and P17’s experiences demonstrated that whilst contractors were able to use the CDE, they were unable to confirm if they could use one as they were unfamiliar with terminology such as ‘CDE’.

**Structured Information, Open Standards and Classification**

Out of the three items coded against classification system within the Toolkit, opinions were mixed. P11 stated that “the only way to get BIM to work is to get people talking the same language, you’ve got to rationalize that with protocol”. P16 was not against the use of classification systems but expressed concerns over Uniclass 2015 being incomplete. P15 stated that “there are too many formats in too many different views and opinions”.

The use of COBie (British Standards Institution, 2014a) for prescribing data requirements was discussed. Those participants who had been exposed to COBie, had negative opinions about it using phrases such as “totally unnecessary…too complicated to comprehend” (P16), “this is too much our clients are just asking for seven items” (P17) and “the information that comes out of the construction phase and goes into the operation phase, is created for one purpose and coming out at another” (P15). Having access to exemplar projects was highlighted as something that could support users in understanding how BIM standards and classification could be applied to structured documents during initial interviews, but was not something that was indicated as being useful in follow up questionnaire responses.

**Technology**

P11 stated that the Toolkit allowed them to get a better understanding of the types of information requirements needed to be BIM compliant. Whilst they had an awareness of BIM and some of the processes involved such as capturing employer’s information requirements, they were not confident in their understanding of what was required of those processes. The participant stated that the Toolkit guided him through those processes, demystifying some of the terminology associated with BIM. Other benefits highlighted were that the Toolkit provided off the shelf questions for the Plain Language Questions required for the deliverables, P3 thought that these would be a useful resource to use for creating their own set of questions with.

The Toolkit received negative feedback in terms of usability. Feedback stated that the Toolkit was difficult to use, and easy to make a mistake with. Many of the participants said they were not aware of anyone using the Toolkit and for some, the training conducted for this study, was the first exposure they’d had. Further to this, two participants, from two separate organisations had attempted to complete a project using the Toolkit, whilst running their in-house BIM processes in parallel. They could not figure out how to apply the Toolkit to the job even after full training and support. P4
suggested that the Toolkit was ‘ungainly’ because it was “trying to encompass everything”. Conversely the Toolkit received positive feedback in relation to it being a good, free, accessible source of guidance and training for organisations new to BIM adoption.

Out of the four follow up surveys conducted one year after the initial study, three of the four participants said they had completed jobs implementing BIM. P16 and P17 found the Toolkit made the process more difficult. P13 advised they could not see the need to change from their current working practice to a new platform as the benefits of the Toolkit were not obvious to their organisational needs. P11 would consider using the Toolkit as a tool for developing their organisation’s understanding of BIM and for working collaboratively with other contractors but to date they had not had the demand to work on a BIM-enabled project.

CONCLUSIONS

The twin aims of this research was to first document the development of the BIM Toolkit, and then explore the first exposure of this process innovation to a range of relevant industry practitioners. The key challenges to BIM adoption revealed during this study served to support the findings from the literature that demonstrate a need to engage people with change management through early engagement, skills and education and collaborative communication. Process innovations such as the Toolkit can be a valuable resource to organisations that are still to adopt BIM on projects. Having a free to use tool that provides guidance and support that outlines the stages of a project and provides a facility for defining information requirements, roles and responsibilities at each stage is of clear benefit. The Toolkit can provide a centralised resource for communicating project requirements that can be viewed by all collaborators with little need for specialist training or knowledge.

Findings from this study outline that whilst the Toolkit can help all organisations, perversely, the Toolkit may actually be of less benefit to organisations with established BIM processes as it brings with it additional practice challenges. As the Toolkit evolves and the industry becomes more open to BIM adoption it is clear to see that the Toolkit does serve a purpose for enabling late BIM adopters to establish collaborative working practices on BIM enabled projects.

REFERENCES


A BIM-Enabled Collaborative Project Information Management Tool


CONTRIBUTORS TO BETTER PRACTICE HEALTH AND SAFETY (H&S) PERFORMANCE

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Contractors are required to pay workers’ compensation insurance. However, depending upon their injury experience, they could be penalised in terms of an increase in the rate, or they could receive a rebate. 65 Clients in the form of contractors of Federated Employers Mutual Assurance (FEM), a mutual workers compensation insurer, that received special awards in the form of a rebate from FEM in terms of recognising their favourable claims ratios, were surveyed using a self-administered questionnaire to determine, inter alia, the extent to which aspects / interventions / stakeholders contributed to their H&S performance. The salient findings include that 92.4% of possible aspects / interventions / stakeholders contributed to respondents’ organisations receiving a rebate from FEM between some extent to a major extent. H&S rules, induction, and awareness predominated, followed by management commitment to and accountability for H&S. Respondents’ organisations generally do not measure H&S performance. Reduced accidents, compensation insurance rebates, enhanced productivity, and enhanced quality predominate in terms of the manifestation of the respondents’ organisations’ H&S performance. Conclusions include that financial and other benefits constitute a motivator in terms of promoting H&S, and a range of aspects / interventions / stakeholders contribute to ‘better practice’ H&S performance. Recommendations include that the Department of Labour, employer associations, FEM, H&S consultants, and unions should motivate addressing H&S based on, inter alia, the financial and other benefits that accrue there from. Contractors should view H&S and other project parameters as a value and afford all project parameters equal status. Contractors should: optimise management commitment to, involvement, and participation in H&S; focus on H&S education and training, risk management, and H&S communication; optimise worker participation, and address H&S during procurement.

Keywords: better practice, Health and safety, performance, H&S

INTRODUCTION

Workers’ compensation (WC) insurance is included in the cost of construction as a labour overhead. Premiums are based upon the sector and sub-sector applicable to the individual organisation, and the performance of the organisation in terms of their claims ratio. The claims ratio is calculated by expressing assessments as a percentage of claims, which is done annually on a triennial basis. Although WC insurance is included as an overhead, depending upon an organisation’s claims ratio, they may either receive a merit rebate, or a loading of their assessment rate. An organisation is entitled to a rebate of between 50% and 2.5% if their claims ratio is between 24% and 62% respectively. However, an organisation can have their assessment rate loaded by between 15% and 50% if their claims ratio is between 75% and 103%. Consequently, depending upon the amount of direct labour employed, there is a substantial incentive to minimise injuries through reduced

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accidents. Furthermore, the claims ratio constitutes a measure of the effectiveness of an H&S programme, and a benchmark.

Given that the receipt of rebate awards is a manifestation of ‘better practice’, the recipients of such awards were surveyed, the objectives being to determine the:

- importance of project parameters to respondents’ organisations;
- extent to which various aspects / interventions / stakeholders contributed to the receiving of a rebate, and the basis for the response;
- extent of H&S measurement, and
- benefits of the positive impact of the aspects / interventions / stakeholders on H&S performance.

**Literature Review**

**Importance of Project Parameters**

Historically, research findings indicate that the traditional project parameters of cost, quality, and time, take precedence over H&S in terms of the importance of project parameters in South African construction (Smallwood, 2010).

**Causes of Poor Health and Safety Performance and Improvement Thereof**

The Construction Industry Development Board (CIDB) (2009) states that management and leadership at all levels are crucial to improve construction H&S in South Africa. The CIDB (2009) states that H&S relevant education and training (or lack thereof), at all levels has a major impact on construction H&S. At the tertiary level, not all construction related programmes in South Africa include H&S within their curricula. At the site level, studies suggest that about 18% of site supervisors and about 33% of site workers have not received any H&S training. Delius and Antuchevičienė (2013) contend that education and training of construction workers is the main area of focus to mitigate the risk of H&S risk occurrence.

Frank Haslam Milan (FHm), a United Kingdom (UK) contractor achieved its target of a zero-accident rate through a training and awareness initiative. Their employees also increasingly contributed their own ideas to improve H&S, as opposed to simply following management’s H&S instructions, which amplifies the value of worker participation in H&S (Pollitt, 2006).

The Olympic Delivery Authority (ODA) managed to achieve an accident frequency rate significantly better than the construction sector, on the Olympic Park site in east London (Shiplee, Waterman, Furniss, Seal and Jones, 2011). There were five key elements to the H&S programme, namely safety, health, wellbeing, competence, and culture. Safety aspects included clear policies, risk assessments, method statements, common standards, visual standards, and daily activity briefings. Competence aspects included induction, training, supervisor academy, briefings, apprenticeships, checks, and records. Culture aspects included leadership, action plans, near-miss reporting, communications, reward and recognition, and a climate tool.

The Health & Safety Executive (HSE) (2002) contends that strong, visible management commitment is crucial for good H&S performance, and that commitment must be expressed in practical terms and thus visible at working level. When directors and senior managers visit sites they should reinforce the H&S messages, as well as listen to workers. A key management task is, therefore, communication. The HSE also refers to risks and states that
some major projects now operate a risk register, where all the risks are set out and quantified along with the steps taken to mitigate them.

**RESEARCH**

Clients of Federated Mutual Assurance (FEM), the licensed mutual workers compensation insurance provider for the South African construction industry constituted the sample stratum. Given the nature of the study, namely ‘contributors to better practice H&S performance’, 65 recipients of FEM special awards constituted the sample. The quantitative study entailed the completion of a self-administered questionnaire, which consisted of 8 questions, 7 being closed-end, and 1 being open-end. The 7 closed-end questions included 123 sub-questions. 22 Recipients responded, which equates to a response rate of 33.9%. The 52 aspects / interventions / stakeholders presented in Table 1, have their origin in a previous study conducted by Smallwood (2002).

A measure of central tendency in the form of a mean score (MS) between 1.00 and 5.00 (five-point), and 0.00 and 5.00 (six-point) was computed based upon the percentage responses to the points on the respective scales, to enable interpretation of the responses and to rank variables where necessary.

In terms of the type of work undertaken / service provided by respondents’ organisations, general contracting (civil engineering) (54.5%) predominates, followed by general contracting (building) (31.8%), and subcontracting (22.7%).

The mean number of people employed by respondents’ organisations is: management (19.2); supervisory (59), and production (317.5).

30.7% of respondents responded to the request to provide the percentage rebates their organisations received for a three-year period. The mean percentage rebates received was 33.4%, the lowest mean was 13.6%, and the highest mean was 56.3%.

Respondents were required to indicate the degree of importance of eleven parameters to respondents’ organisations on a five-point scale of ‘not’ to ‘very’ important. A MS between 1.00 and 5.00 was computed based upon the responses. It is notable that all the MSs are \( > 4.20 \leq 5.00 \), which indicates that the parameters are deemed to be more than important to very important / very important. It is also notable that project H&S (MS = 4.90), and public H&S (MS = 4.85) are ranked first and second respectively. Project quality (MS = 4.85), which complements H&S, is ranked third.

Table 1 indicates the extent to which aspects / interventions / stakeholders contributed to respondents’ organisations receiving a rebate from FEM on a scale of did not and between 1 (minor) to 5 (major), and a MS ranging between 0.00 and 5.00. Given that all the MSs are \( > 2.50 \), all the aspects / interventions / stakeholders can be deemed to have contributed to respondents’ organisations receiving a rebate from FEM. No respondents selected ‘did not’ and hence the column is not included.

It is notable that 24 / 52 (46.2%) of MSs are \( > 4.17 \leq 5.00 \), which indicates the aspects / interventions / stakeholders can be deemed to have contributed to respondents’ organisations receiving a rebate from FEM between a near major extent to a major extent / major extent. H&S rules, H&S induction, and H&S awareness predominate, followed closely by management commitment to H&S and management accountability for H&S. H&S rules are important as the following of procedures and rules is necessary to realize healthy and safe work places. H&S induction is a legal requirement; however, it introduces workers and others to a work place and more specifically, the hazards. H&S awareness ensures that those involved on a project are conscious and mindful of the need for H&S.
Management commitment to H&S is one of the two pillars of an H&S program, the other being worker participation, which is ranked seventeenth. However, it should be noted that management commitment to H&S is a pre-requisite for H&S rules, H&S induction, and H&S awareness. The MS and ranking of management accountability for H&S is notable as invariably management in construction is not held accountable for H&S – that is, measured in terms of their responsibility for H&S. Hazard identification and risk assessment (HIRA) ranked sixth, is a legal requirement and is a critical activity in terms of proactive and reactive H&S management. Seventh ranked H&S inspections in the case of H&S Representatives and other H&S functions are a legal requirement. However, due to the ever-changing nature of construction and the necessity to determine if work is being executed according to plan, H&S inspections are also a critical activity. Furthermore, H&S inspections may result in the identification of hazards. Integration of H&S into all activities / tasks, ranked eighth, is the ideal, as then H&S is addressed when planning and executing work. Ninth ranked H&S Coordinator / Manager is an important function in an organisation as H&S legislation and information needs to be collated and disseminated. Furthermore, strategies, tactics, and operational interventions need to be evolved on an organisation wide basis. Tenth ranked toolbox talks are an ideal forum to address specific H&S subjects, but also to discuss general H&S issues such as incidents, H&S goals, and H&S performance. Safe work procedures (SWPs), ranked eleventh, are a legal requirement in terms of responding to the identification of hazards, and responding to their continued existence. Twelfth ranked H&S training has a substantial impact on H&S performance in that it empowers people to work in a healthy and safe manner, in addition to its being an indirect legal requirement. Thirteenth ranked H&S management system (H&SMS) is notable as H&SMSs are not common. H&SMSs provide a framework for H&S in an organisation. Site management, ranked fourteenth, fulfils a critical role in that it is responsible for managing the construction process and activities, and the related resources. H&S policy ranked fifteenth, should communicate the values, vision, goals, mission, purpose, and assumptions, and thus is the ‘starting point’ for H&S. It is also the first element of an H&SMS. Sixteenth ranked focus on H&S ensures that H&S is considered and addressed throughout the construction process and its activities. Worker participation, ranked seventeenth, along with management commitment, is one of the two ‘pillars’ of an H&S program. Worker participation ensures that the people that undertake the construction activities are empowered to contribute to H&S. Eighteenth ranked incident investigation is important as the outcome of incidents is fortuitous, and therefore all incidents should be investigated regardless of the outcome. Management involvement in H&S, ranked nineteenth, is related to management commitment, but refers to actual involvement such as presenting H&S induction and chairing H&S meetings. Twentieth ranked H&S Officer is notable as the appointment of full time or part time H&S Officers is a requirement in terms of the Construction Regulations. H&S Education, ranked twenty first, is a pre-requisite for management commitment, and ensures that management can manage H&S. H&S consultant, ranked twenty second, is notable, as it falls within the upper range, and therefore the stakeholder contributed. However, ‘in house’ aspects / stakeholders such as management commitment to H&S, management accountability for H&S, H&S Coordinator / Manager, and Site Manager achieved higher MSs and were ranked fourth, fifth, ninth, and fourteenth respectively. Twenty third ranked H&S culture is important as it should include the values, vision, goals, mission, purpose, and assumptions. H&S disciplinary procedure, ranked twenty fourth, is necessary as the OH&S Act requires that contractors ensure that H&S procedures are enforced, and instructions are followed.

A further 24 / 52 (46.2%) of MSs are > 3.33 ≤ 4.17, which indicates the aspects / interventions / stakeholders can be deemed to have contributed to respondents’
organisations receiving a rebate from FEM between some extent to a near major extent / near major extent. H&S plans is ranked twenty fifth, and although it falls marginally outside the upper range, its ranking is notable in that the H&S plan is a key requirement of the Construction Regulations, and is historically a ‘better practice’ H&S intervention. The twenty sixth ranking of H&S legislation (OH&S Act & COID Act) and twenty ninth ranking of Construction Regulations are notable as many researchers contend that legislation is a guide, and that H&S is simply part of doing business. H&S meetings, ranked twenty seventh, are notable, as they are an ideal forum for delegating H&S actions, controlling and coordinating H&S. However, a limitation of H&S meetings is their frequency, even if they are monthly. The twenty eighth ranking of client is notable as in terms of the Construction Regulations, clients have a range of H&S responsibilities. Clearly the respondents’ clients have been contributing to their organisations’ H&S endeavours and performance. H&S goal setting, ranked thirtieth (MS = 4.06), is an integral part of H&S culture, which is ranked twenty-third (MS = 4.24). H&S goals is also an integral part of H&S planning, and should include performance goals such as percentage of workers that have completed a one-day H&S course and outcome goals such as zero incidents. Thirty first ranked allocation of financial resources to H&S is a pre-requisite for H&S performance, as H&S must be resourced, and not just in terms of finance, but also in terms of human resources and their time, management time included. This aspect depends largely on management assuming that investing resources in H&S will result in a return on investment (ROI) – assumptions are part of H&S culture ranked twenty third. The MS of thirty-second ranked medical surveillance is notable, as contractors generally do not conduct medical surveillance. Furthermore, it is notable that a ‘health’ intervention has contributed to the respondents’ H&S performance. First line supervision, ranked thirty-third, is a critical aspect, as such supervision organizes the work place and supervises the physical construction process. Thirty-fourth ranked H&S specification is a requirement in terms of the Construction Regulations. Client originated, it should be project specific and schedule the H&S requirements. It was intended to communicate residual risk and H&S information. Therefore, the contribution is notable as previous research has determined that H&S specifications are not project specific and are a regurgitation of the Construction Regulations. Recognition of H&S performance, ranked thirty-fifth, is important as recognition is critical in terms of managing organisational behaviour and reinforcing positive behaviour. Thirty-sixth ranked H&S measurement is important as it provides an indication of performance. Unfortunately, respondents were not requested to indicate whether they undertook performance and / or outcome measurement. An example of the former being the percentage of workers that have received a one-day H&S training course and the latter, the Disabling Injury Incidence Rate (DIIR). Quality management system (QMS) ranked thirty-seventh, provides an overarching framework within which the construction process and its activities are undertaken and given that such a system is assurance oriented, requires identification of competencies and criteria, which need to be aligned with, and consequently complement H&S. Thirty-eighth ranked H&S message / theme for the month or week entails focus on a generic or H&S issue such as scaffolding. Feedback on H&S performance, ranked thirty-ninth, contributes to maintaining awareness relative to H&S, motivating enhanced performance, reinforcing improved performance and logically follows H&S measurement. Fortieth ranked improvement process e.g. total quality management (TQM), focuses on the processes of H&S, productivity, and quality, and therefore should impact directly on H&S performance. Forty-first ranked H&S Representatives should contribute to H&S performance as they are elected by the workers, are responsible for specific work areas on a project, and are intimately involved with the management of H&S on a project through, inter alia, serving on H&S committees.
Partnering, ranked forty-second, is an informal process subscribed to by the client, project manager, designers, consulting QS, general contractor, specialist contractors, which is focused on evolving common goals and strategies to achieve them, H&S included. Forty-third ranked project manager is notable as project managers should focus on H&S during design, procurement, and construction. Participation in H&S competitions, ranked forty-fourth, has been identified by research as contributing to enhancing H&S performance. Forty-fifth ranked H&S notice board informs regarding H&S issues such as appointments, and raises and maintains H&S awareness through communicating feedback regarding H&S performance in the form of H&S statistics. Participation in H&S star gradings, ranked forty-sixth, as participation in H&S competitions, has also been identified by research as contributing to enhancing H&S performance. The merits of H&S incentives, ranked forty-seventh, have been debated in literature as it is contended that they discourage injury reporting. However, research findings indicate that they do also contribute to enhancing H&S performance. Forty-eighth ranked client appointed H&S Agent, should contribute to improving H&S performance. However, the low ranking is notable.

The remaining four (7.6%) MSs fall within the range $> 2.50 \leq 3.33$, which indicates the aspects / interventions / stakeholders can be deemed to have contributed to respondents’ organisations receiving a rebate from FEM between a near minor extent to some extent /some extent. H&S newsletter, ranked forty-ninth, is notable as clearly respondents distributed such newsletters. The fiftieth ranking achieved by designer is notable due to its low ranking, and underscores research findings that indicate designers do not make a major contribution to construction H&S. However, the MS indicates that they did contribute to respondents’ organisations’ H&S performance. Although H&S suggestion box is ranked fifty-first, it did contribute to respondents’ organisations’ H&S performance. H&S suggestion boxes formalize worker participation. Unions, although ranked fifty-second and last, did contribute, albeit marginally so.

Comments from management (54.5%) and comments from Construction H&S Agents (CHSAs) / H&S Consultants (45.5%) predominate in terms of the basis for the perceived / confirmed contribution (impact), followed by work environment / climate (36.4%). Comments from management, underscores the extent to which management commitment to H&S, and management accountability for H&S contributed to respondents’ organisations receiving a rebate from FEM. The percentage response relative to comments from workers (31.8%), and measurement (31.8%) are notable. Worker participation was ranked seventeenth (MS = 4.30) in terms of the extent to which it contributed to respondents’ organisations receiving a rebate from FEM.

Where respondents identified measurement, they were requested to identify the measure. The Disabling injury incidence rate (DIIR) (36.4%) predominates, albeit by slightly more than a third of those that identified measurement, which was 31.8% of the respondents. In terms of the manifestation of the contribution of the aspects / interventions / stakeholders to respondents’ organisations’ H&S performance, reduced accidents (50%), and compensation insurance rebates (45.5%) predominate, followed by enhanced productivity (40.9%), and enhanced quality (36.4%).

Table 1: Extent to which aspects / interventions / stakeholders contributed to respondents’ organisations receiving a rebate from FEM
<table>
<thead>
<tr>
<th>Aspect / Intervention / Stakeholder</th>
<th>Response (%)</th>
<th>MS</th>
<th>Rank</th>
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Better Practice H&S Performance

This finding indicates and underscores the findings of other research, namely that there are benefits other than H&S that accrue from enhanced or optimum H&S performance.

**DISCUSSION**

Project H&S, and public H&S are ranked first and second respectively, followed by the traditional project parameters of project quality (3rd), project schedule (6th), and project cost (7th). This is notable, as the traditional project parameters are generally viewed more important by H&S conscious contractors.

It is notable that all the aspects / interventions / stakeholders contributed to respondents’ organisations receiving a rebate from FEM. 24 / 52 (46.2%) of MSs are > 4.17 ≤ 5.00, which indicates the aspects / interventions / stakeholders contributed to respondents’ organisations receiving a rebate between a near major extent to a major extent / major extent. However, a further 24 / 52 (46.2%) of MSs are > 3.33 ≤ 4.17, which indicates the aspects / interventions / stakeholders contributed between some extent to a near major extent / near major extent. Only 4 / 52 (7.6%) MSs are > 2.50 ≤ 3.33, which indicates the aspects / interventions / stakeholders contributed to respondents’ organisations receiving a rebate from FEM between a near minor extent to some extent / some extent. The top 25%, which include H&S rules, H&S induction, H&S awareness, management commitment to H&S, and management accountability for H&S predominate, followed closely by HIRA, H&S inspections, integration of H&S into all activities, H&S Coordinator / Manager, toolbox talks, SWPs, H&S training, and H&SMS.

The frequency at which qualitative reasons are cited relative to the receipt of rebate awards by recipients, generally exceeds the frequency attributed to measurement – the top three reasons being comments from management, comments from CHSAs / H&S Consultants, and work environment / climate.
Respondents identified both H&S, and non-H&S manifestations of H&S improvement. Reduced accidents, compensation insurance rebates, enhanced productivity, and enhanced quality, were identified by between the minority and half of the respondents.

CONCLUSIONS

It should be noted that the extent to which aspects / interventions / stakeholders contributed to respondents’ organisations receiving a rebate from FEM are self-reported, and therefore the possibility of bias cannot be excluded.

Based upon the mean percentage rebate received over a period of three years, namely 33.4%, it can be concluded that tangible benefits, in the form of financial benefits, accrue from enhanced H&S performance.

Given that all eleven project parameters are more than important to very important / very important to respondents’ organisations, it can be concluded that the respondents appreciate the synergy between, and the importance of all parameters.

A range of aspects / interventions / stakeholders contributed to respondents’ organisations receiving a rebate from FEM. Therefore, it can be concluded that optimum H&S requires a multi-stakeholder effort and multi-interventions. Furthermore, based upon the aspects / interventions / stakeholders that contributed between a near major extent to a major extent / major extent, the following categories can be concluded to be critical: communication (H&S rules; H&S induction; H&S awareness; toolbox talks; H&S policy; H&S culture); management (management commitment to H&S; management accountability for H&S; inspections; integration of H&S into all activities / tasks; H&S Coordinator / Manager; H&SMS; site management; H&S policy; focus on H&S; H&S Officer; H&S Consultant; H&S culture; H&S disciplinary procedure); risk management (H&S rules; H&S induction; H&S inspections; hazard identification and risk assessment; safe work procedures (SWPs); incident investigations; H&S Officer; H&S culture); education and training (H&S induction; toolbox talks; H&S training, and H&S education), and worker participation. However, a further 24 / 52 (46.2%) of MSs are > 3.33 ≤ 4.17, which indicates the aspects / interventions / stakeholders contributed between some extent to a near major extent / near major extent.

Given that comments from management and comments from CHSAs / H&S Consultants predominate in terms of the basis for the perceived / confirmed contribution (impact), it can be concluded that management is committed to and involved in H&S. Furthermore, the comments from CHSAs underscore the rationale of client responsibility for H&S in terms of the Construction Regulations, and that third-party review enhances H&S. The comments from H&S consultants indicate that management is committed in that they appoint such consultants and that second party review enhances H&S.

Respondents’ organisations generally do not measure H&S performance, which is an indication that measurement is not an integral part of their H&S programmes and or H&SMSs.

Given the range of the manifestation of the contribution of aspects / interventions / stakeholders to respondents’ organisations’ H&S performance, it can be concluded that H&S is the catalyst for the synergy between the various project parameters.

RECOMMENDATIONS

Recommendations are relevant to a range of stakeholders:

- Project managers should include H&S as a project parameter (performance measure):
Better Practice H&S Performance

- Project H&S plans should be prepared for all projects by all stakeholders, both design and construction;
- Procurement systems and related contract documentation should engender H&S;
- Project durations should be deliberated relative to H&S in terms of the compatibility of the nature and scope of the work, with the proposed duration;
- Awareness for H&S should be maintained throughout all phases of a project;
- The Department of Labour, employer associations, FEM, H&S consultants, and unions should motivate addressing H&S based on, inter alia, the financial and other benefits that accrue there from;
- Contractors should view H&S and other project parameters as a value and afford all project parameters equal status;
- All contractors, regardless of size, nature of work undertaken, and annual business volume, should: have a written H&S policy, rules, and programme, even if the programme is elementary;
- A strategy to engender management commitment, involvement, and participation should be evolved, and all levels of management should be held accountable for H&S;
- Contractors should focus on H&S education and training, risk management, and H&S communication;
- HIRAs should be a hallmark on all projects, and precede all construction activities;
- SWPs should be available, and implemented for every activity, and
- Worker participation should be optimised.

REFERENCES


CHALLENGES OF EARLY ESTIMATION OF INFRASTRUCTURE PROJECTS WITHIN THE UK: AN INFORMATION PERSPECTIVE

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This research examines the challenges of early cost estimation of infrastructure projects within the UK with a focus on why cost overruns are such a persistent issue. The research was carried out by an investigation of existing literature surrounding early estimation in construction, characteristics of UK-based infrastructure projects and cost overruns within infrastructure projects. The data were collected through fourteen semi-structured interviews with estimating professionals who work predominantly on infrastructure projects across the UK. The key findings were that the early estimation process consists of an intricate system of hard and soft information exchange from the many involved parties due to the social and political nature of infrastructure projects; this provides many challenges for the estimator. This led to the idea that an estimate is actually a soft input itself and should not be taken as a hard numerical figure but something which requires human interpretation. Moreover, these challenges are heightened by the number of unknowns and uncertainties that are again part of the very nature of large scale infrastructure projects. This is difficult to address as it is the process of converting soft information into hard information and when soft information is hardened it will inevitably lose some of its information or context. Unfortunately, cost estimates have become to be accepted as hard information even when it is known to be soft information that requires interpretation and sense making.

Keywords: cost overruns, early estimation, infrastructure projects, soft information

INTRODUCTION

Siemiatycki (2015) suggests that infrastructure is the fundamental element for successfully accomplishing social equality, economic growth and environmental sustainability. It was estimated that construction work within the UK would rise in both 2017 and 2018, and would reach for the first-time levels equivalent to those before the UK’s 2008 recession. This has been attributed to a recent increase in infrastructure projects across the UK; it has been forecasted that infrastructure will be the leading growth area for the UK’s construction industry for the first time in five years with the work set to increase by 56.9% by 2019 (Plimmer, 2016). Literature highlights that infrastructure projects across the globe persistently experience cost overruns and the UK is no exception to this. The infrastructure cost review (HM Treasury, 2010a) highlights that the average outturns for the UK’s infrastructure projects are much higher than their European counterparts and argues that these greater costs were generally experienced

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early on in projects before construction had commenced. Several researchers point out that those who carry out construction cost estimations are dependent upon either their previous experience or a variety of cost information. This research attempts to explore and present the challenges of early cost estimation of infrastructure projects from an information perspective.

LITERATURE REVIEW

Infrastructure Projects

Frischmann (2012) believes infrastructure is imperative for both social and economic development but cautions that infrastructure assets are no short-term commitment and can come with profound consequences for the public. He further asserts that infrastructure assets fundamentally mould intricate systems of social activity within society, including both economic and political systems. Additionally, governmental funding of infrastructure projects can have a variety of economic benefits as it helps to generate employment within the related industries and it can attract capital investment; hence, they are political.

Although infrastructure is set to increase social and economic development, it is not without its issues. Latham (1994) highlights that there is no such thing as a risk-free construction project and whilst we can manage, reduce, share, transfer, or take risks, it is imperative that we do not ignore it. However, Beckers and Stegemann (2013) contend that it is common for large infrastructure projects to experience poor risk management throughout their project lifecycle due to inadequate planning. This is also reflected in the infrastructure cost review by HM Treasury (2010a) as it described how contingency and risk budgets are often overlooked and as a result are given inadequate budgets. This inadequacy of contingency could be attributed to the fact that a considerable percentage of the risk exposure is affiliated with undefined uncertainties in the conceptual stage and these risks are undetermined at the time of carrying out the early estimates and may not be realised until detailed designs have been produced or even when construction has commenced (HM Treasury, 2015). In theory, the quantity of these undetermined uncertainties should reduce following the use of quantified risk assessments as the design and project maturity progresses but this does not necessarily help the early stage estimates.

Early Cost Advice

Cost advice is provided to the client throughout a project’s life-cycle and is defined as a technical procedure that utilises the full extent of information and materials that are available to generate estimations and predictions of the total cost of completing work in a specific time (Kwakye, 1994). A number of academics such as Serpell (2004) and Trost and Oberlender (2003) agree that the most valuable cost advice for aiding the client in decision-making is provided in the initial project stages when levels of certainty are extremely low. Other academics (Akintoye and Fitzgerald, 2000; Love et al., 2002; Oberlender and Trost, 2001) attribute this to early cost advice being considered the initial step in the practice of cost management; they claim that it provides a thorough insight into the information surrounding a project, highlights the consequences that design choices have on the project cost and determines the client’s likely expenditure. The early cost estimation is required by several parties such as the client, contractor and designers; it serves several purposes including establishing the initial budget for the project, determining the practicability of the project and enabling alternative design options to be evaluated on a financial level (Sonmez, 2004).
Love et al., (2002) argue that an accurate and reliable cost estimate for a project in the early stages can lead to sound financial advice, which is a major factor which determines project success. But historically construction projects have experienced cost overruns at the feasibility stage (Betteridge, 1992). Additionally, Langmaid (2003) argues that in order to reduce the likelihood of inaccuracies occurring within early cost estimation, an in-depth understanding of the client’s requirements is necessary from the very beginning of the project. However, Sonmez (2004) believes that since the level of design information available is minimal and the scope of the project is still unconfirmed, early cost estimates are anticipated to be inaccurate and lacking in precision. Aibinu and Pasco (2008) conducted a more recent study and found no improvements in the accuracy of early stage cost estimates from historical projects. Not surprisingly, many clients feel that the quality of the advice is inadequate (Ellis and Turner, 1986).

**Information Requirements for Early Cost Advice**

The information required at the conceptual stage is client led; an outline brief is required to identify the client’s needs for the project and there should be a specification, design drawings and a list of abnormalities. Abdul-kadir and Price (1995) maintain that in actual fact the outline brief tends to contain a high level of the client’s general requirements and much less of the specific exhaustive requirements. Eldin and Hikle (2003) summarise that the essential goal of the briefing stage is to develop a profound understanding of both the construction project and the client’s prioritised requirements. They argue that this can potentially omit or ease design errors and thus the frequency of change orders once construction has commenced; in turn, this will reduce the likelihood of cost overruns.

Archetypally, cost advice is dependent on a variety of documentation produced by several different parties including: Design information, internal company data, historical data from sources such as the Building Cost Information Service (BCIS), manufacturer and supplier publications, trade magazines, and expert advice (O’Brien, 1994; Love et al., 2002 and Arab, 2011). Traditionally, when offering cost advice, professionals strongly rely upon previous experiences and personal judgement (Akintoye and Fitzgerald, 2000). According to Lees and Fortune (1996), the issue with this practice is that cost consultants within construction inherently make misjudgements.

**Challenges of Early Cost Estimation in Infrastructure Projects**

In a study involving 245 large dams (total cost of USD 353 billion in 2010 prices) that were constructed between 1934 and 2007 across sixty-five different countries, Ansar et al., (2014) found that 75% experienced a cost overrun with the average overrun at 90%, and there have not any improvement in budget accuracy over the seventy-three years that the data spanned. Siemiatycki (2015) claims that there is evidence indicating a positive correlation between project size and both cost and time overruns; infrastructure projects tend to be relatively large which could suggest why they make up a high proportion of the projects that do overrun. He identifies three core reasons for the occurrence of cost and time overruns: Optimism bias, technical obstacles, and tactical falsifications. Siemiatycki (2015) claims that when stakeholders speak about the causes for their project experiencing cost overruns, the technical obstacles tend to be at the forefront of discussion; this is to be expected as it reduces their level of accountability for the overrun. Most of the technical obstacles can be predicted and managed, especially with experienced professionals creating the budgets. Siemiatycki (2015) argues that if cost overruns were unpredictable then a normal distribution would be expected over a large sample. However, it has already been identified from aforementioned studies that the distribution is greatly skewed. In addition to this, large projects are usually delivered by
experienced professionals within the field so if the only causes were technical failures then it would be expected that the volume and magnitude of overruns would decline over time as the industry implements improvements to ensure more accurate forecasting and more efficient methods for project delivery; but this is not the case. However, due to the optimistic human nature, even with experience these professionals tend to underestimate both time and costs, meaning most megaprojects are destined to overrun. In addition to this, tactical falsifications can occur for promotional purposes in order to secure funding and approval for the project. However, some individuals such as Samset (2010) claim that early tactical underestimation rarely affects cost overruns as he argues that overruns are not relative to these early estimates that are used to seek initial approval but the final approved budget.

Muchenagumbo (2015) advises that infrastructure projects are often unique, once in a lifetime projects. As a result, initial estimates may be produced for each project at different stages within the project’s life-cycle and projects that are at the same stage within the cycle can have extreme variance in terms of their uncertainties affecting the project costs (HM Treasury, 2015). However, history highlights that similar types of projects tend to face the same categories of uncertainty; this suggests that the use of appropriate historical data will enable the desired understanding of the cost implications for the project, even within early stage estimating. Unfortunately, this does not completely solve the issue as risk and uncertainties may be inadequately represented because of early cost estimates being susceptible to powerful stakeholder’s desires and demands (HM Treasury, 2015). Furthermore, Williams (2009) identifies that infrastructure projects are susceptible to “scope creep”, where the project, client and even specification and design requirements change during the process of delivery. Accurate estimating becomes even more of a challenge due to this characteristic where the scope is often indeterminate and susceptible to change for a considerable proportion of the project lifecycle. In order to consider this within the cost estimate a contingency is required to facilitate the instigation of such changes (HM Treasury, 2015).

Another challenge that can affect a cost estimate is that many public infrastructure projects are susceptible to optimism bias. Lovallo and Kahneman (2003) suggest that most individuals are greatly optimistic the majority of the time. They further suggest that cognitive research has determined a variety of reasons for this such as an inclination for people to exaggerate their own talents and their degree of control over a situation. People will happily accept recognition for positive results and will even de-emphasise the contribution of luck and chance in achieving the result; whilst attributing any negative occurrences to external factors such as bad weather. Organisations can often intensify these tendencies of over optimism; since there is often strong internal competition employees are encouraged to accentuate the auspicious factors of any proposals they make to improve the chances of their proposal being selected. These early proposals often act as anchors and lay the foundations for any future financial or technical estimates that are produced, meaning the estimates will be plagued with this over-optimism. Some organisations even praise optimistic estimates whilst pessimistic ones are regarded as negativity; this can hinder an organisation’s capacity for critical thinking. In combination, the natural human tendency of optimism along with implicit organisational intimidation for positive outcomes results in a persistent underestimation of costs.

There are many stakeholders within infrastructure projects who will benefit either in terms of status or financially, from the successful delivery of a distinctive public works project; yet these individuals will experience no direct repercussions or accountability if overruns occur. Flyvbjerg et al., (2002) reject technical reasons as a cause for cost
overruns technical faults can be accounted for in appropriate contingency budgets as it is possible to adequately predict the risk based on historical projects and data. But they view tactical falsification and over-optimism as the key facets in causing cost overruns. They classify two causes of cost overruns as “fools” or “liars”. The “fools” are those that are over-optimistic and may overlook the significance of certain risks and uncertainties and the “liars” are the selfish individuals fuelled by greed, seeking to deceive the public to get a project started for their own gain. Their evidence suggested that cost estimates used for project approval decisions are greatly and strategically deceptive and tactically falsified. However, these findings have been questioned by Love and Ahiaga-Dagbui (2018).

RESEARCH METHOD

The goal of the research is to understand what is happening within infrastructure costing at the early stages and to determine what is unique within the infrastructure to be causing the high volume of cost overruns compared with other types of construction. Due to the social and political nature of infrastructure projects within the UK upon which the study is based, the reality of what goes on is intersubjective. Therefore this study adopted an interview method in order to investigate this issue. The data were collected through fourteen semi-structured interviews with estimating professionals who work predominantly on infrastructure projects across the UK. Professionals with more than fifteen years of cost management experience within UK-based infrastructure projects were selected for this purpose. These interviewees had a total of 265 years of experience in estimating within infrastructure projects. Interview method allowed the collection of in-depth experiences of early estimation and its challenges from the selected professionals. Interview with each professional took approximately 40-50 minutes. Within semi structured interviews open-ended questions were also employed to get a wider view of the situation. Interview questions were focused on finding out current industry practices and views on factors affecting estimation and methods used, cost overruns, project scope, information requirements, representation of risk, uncertainties and apportionment of contingencies, optimism-bias and strategic falsification. The collected data were transcribed and coded to establish emerging themes. An information perspective is taken to analyse data emerging from various themes. A rich picture (See Figure 1) was then used to capture these themes and explore the relationship between participants and emerging themes and create new ideas.

Analysis and Findings

A variety of factors that can affect estimation were put forward by interviewees. Interviewee 1 named ground conditions as the most important factor for affecting estimates. Contrarily, interviewee 3 believed that ground conditions are only of concern to engineers. However, there was a common consensus across the interviewees that there is a need for thorough site investigation and ground surveys to be carried out prior to early estimates to reduce uncertainties. Interviewee 11 identified that lack of information is a big issue and it can affect the accuracy of estimates, whilst interviewee 7 feels that the stakeholders need to take a more realistic view of what an estimate actually is. Some of the less senior interviewees from the contractors’ side emphasized that even though they know there are a variety of factors that can influence their estimate, they would not seek to allow for these within their estimates unless they were specified in the client’s brief or design drawings. Interviewee 5 justified this for legal reasons by saying, “in lots of infrastructure projects designers take the lead. From an estimating point of view, you rarely step away from design because if you do, you are embodying yourself in the design.
and you have to be very, very careful [as] if it’s a failure then all of a sudden you’re liable”.

All the interviewees agreed that stakeholders can affect estimates and proposed a variety of reasons for this. Interviewees 3, 5, 8 and 10 attribute it to stakeholder’s change of mind or imposing conditions, whether it be public bodies or end user stakeholders. However, interviewee 7 did not put the entire onus on the client and attributed client led alterations to poor communication. Interviewee 11 even discussed how sometimes if an influential stakeholder has a figure in mind you may be encouraged to go with that figure, but it will not be an accurate estimate of the works. In addition to this, Interviewee 4 discussed other stakeholders who can have influence such as landowners, planning authorities, highways authorities and statutory bodies who can impose conditions and fees. Furthermore, interviewee 2 summarised this power related relationship saying, “you have less control in public sector schemes due to the high number of stakeholders involved, who want their input accepted”.

Most interviewees agreed that they required some form of client led pre-tender information from the design team to start an estimation. This included: A brief, architectural drawings, structural drawings, civils drawings, engineer’s calculations, material specification, location drawings for site access, schedule of works, input from highways, ground investigation details, special requirements, local regulations, site risks, planning permission details, land ownership information and the client’s programme with an idea of the end date. Moreover, interviewee 7 stated that “you want as much as you can from the scheme in order to give an accurate price, the problem is you don’t often get it”. Interviewee 5 echoes this concern for adequate information not being there when it is needed. In addition to this, interviewees agreed that some sort of cost data and knowledge was required from a similar scheme, whether it be from previous experience, and historic data from pricing books or in-house data from their own company or other companies. Interviewee 7 identified that it can also be dependent on what type of contract terms are priced against. Most of the interviewees stated they have in-house records at their current companies with the exception of interviewee 11. Interviewees 4 and 8 believed their in-house information to be dependable as it is actual outturn costs. However, interviewees 1, 2 and 9 stated that they used estimated costs and believed it to be reputable if the final project cost came in within 5 - 10% of the estimated cost.

Whilst most of the interviewees maintained that the current methods for representing risk within the early estimates are inadequate, they feel there is no alternative. Interviewee 4 supported this stating, “…at a stage where you haven’t got full design, I think a percentage on the estimated contract is the best you can do really”. However, interviewees 1 and 9 both offer a potential improvement of risk representation by getting input from professionals who work specifically within each identified risk area.

**Discussion: Hard and Soft Information**

The rich picture in figure 1 presents findings from the data analysis and attempts to depict the information transfer of the early estimation process. Liberti and Petersen (2017) define hard information as quantitative information which can be conveyed easily in a detached manner and the data collection process has no effect on the informational content of the data. Meanwhile, Wiebe (2010) explains that soft information is subjective information that is based on feelings and perception. As can be seen from Figure 1, the estimating process for infrastructure projects is fundamentally built up of a number of hard and soft informational transactions.
Furthermore, Bertomeu and Marinovic (2016) also determine that inaccuracies are more likely when soft and hard information are provided in unison; they argue that the combination of hard and soft information will make all information soft. Due to the nature of infrastructure projects being driven by social demand and biases in the political environment, there is a high volume of stakeholders involved; thus, subjective, soft informational inputs will be coming in from all directions. Therefore, an estimate will always be a soft information output. Moreover, Liberti and Peterson (2017) suggest that if some of the information input is qualitative it cannot all be represented by a single numerical figure; instead, an experienced individual needs to make a judgment call. This indicates that an estimate should not be taken as an absolute figure for project costs but as soft information which requires human interpretation.

An issue with an estimate being largely made up of soft information is that soft information is more susceptible to manipulation (Godbillon-Camus and Godlewski, 2005). This can stem from the stakeholders having different end goals; whilst the client wants to spend as little as possible, the contractor wants to make as much as possible, the politicians want popularity and for their desired scheme to go ahead and the engineers want to produce something practical and picturesque. Subsequently, this can often lead to a non-collaborative and disjointed information exchange process. Since the data can be easily manipulated strategic falsification and optimism-bias can creep in; the findings suggest that contractors seek to price a job as low as possible (while following the standard of estimation) and may misrepresent information. Additionally, clients can be too over-optimistic with timescale and costs and politicians often seem to ignore the risks and accentuate the positives of a scheme.

Additionally, uncertainties and unknowns plague the early stages of an infrastructure project (as depicted in Figure 1) and affect the estimation process. They too are based on soft information which also leaves them open to manipulation from stakeholders. However, the findings support that they can be reduced through appropriate research from clients such as ground surveys and site investigations. Nevertheless, these are not often carried out prior to estimation which could be due to reluctance on the client’s part to spend money. Furthermore, the majority of the participants in the primary research felt that uncertainties and risks were not adequately represented within estimates. This is
difficult to address as it is the process of converting soft information into hard information and when soft information is hardened it will inevitably lose some of its information or context (Liberti and Peterson, 2017).

Thus, embedded within the very foundations of the estimating process for infrastructure projects is a fragmented, soft information exchange that is open to manipulation from many stakeholders involved. Hence infrastructure projects continually experience such a high volume of scope change throughout the project. Due to this very nature of the projects, soft data is a key element of the estimation process. However, budgets produced by estimates has become to be accepted as hard information even when it is known to be soft information that requires interpretation and sense making.

CONCLUSIONS

Cost overruns have become an accepted norm within the UK construction industry’s infrastructure projects for a variety of reasons. Firstly, the early estimation process for infrastructure projects involves numerous data exchanges between various interested parties, which makes the whole process extremely intricate. Furthermore, due to the nature of infrastructure projects, there are a high number of interested parties within this intricate system of data exchange who can have an effect on the estimation process both explicitly or indirectly. This also means there is a high volume of soft information going into the estimation process which is susceptible to manipulation for personal gain. Hence, a cost estimate is essentially a soft informational output, thus it needs to be made sense of to provide meaning; therefore it should be considered as a way of providing advice to the client, not an absolute figure of anticipated project costs. Additionally, there will always be a high volume of uncertainties and unknowns on infrastructure projects and whilst appropriate research can reduce these, they will never be eradicated. These are both factors that you cannot get away from as they are inherent in the nature of the work. Therefore, even though cost overruns come with connotations of poor estimation as the literature review highlighted, it is not necessarily the case and estimators do not deserve to be stigmatised for it.

REFERENCES


THE LINK BETWEEN THE RISE OF SPECIALISED DELAY ANALYSIS AND THE LIMITATIONS OF CURRENT PROJECT PLANNING, MONITORING AND CONTROL PRACTICES

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There has been an increased use of and dependence on expensive outsourced specialist delay analysts and forensic planners to determine the cause and impact of delays and to formulate and present arguments in dispute resolution hearings, often after project completion. This may stem from the lack of guidance and knowledge on the analysis of project delays from project management professionals coupled with a possible misplaced confidence on delay specialists which may have contributed to disagreements on delay entitlements and to an inability of project teams to successfully resolve delay claims as they arise. The research approach adopted in this research was to “test” a sample of thirty (30) experienced international project based planning and controls professionals to determine a contractor’s extension of time (EOT) entitlement based on a relatively straightforward delay scenario on a hypothetical project. The findings showed that a wide variety of non-standard and often unnamed analysis techniques were used by the sample in order to determine an answer, and a wide range of answers were provided. Different answers were also provided even when the same analysis techniques were employed. The lack of participation of project managers in this study may have inferred that they do not appear to have enough knowledge on the subject of delay analysis and are not able to contribute both directly and indirectly. Few would argue that it is actually project management professionals who should be, and generally are, the closest to the project issues with the most knowledge of the delay events and impacts. There appears to be a need for the construction and project management industry to recognise that project management professionals need to enhance their knowledge of delay analysis and need to take more responsibility for analysing delay events and resolving disputes as they arise.

Keywords: delay analysis, extensions of time, forensic planning, project control

INTRODUCTION

Delay analysis is a widely debated construction law subject due to the number of projects that are not completed on time, the financial implications of late completion and the often quite different conclusions that can result depending upon the method of analysis used (Larkin, 2008). The total time for performance of a project is vital to both the project owner and the contractor. For project owners, profits or benefits are lost from being unable to make use of the project at the agreed date, while for the contractor extra cost will be incurred due to a prolonged stay on site (Braimah, 2013). All standard forms of contract have provisions that anticipate delay brought about by the actions and/or inactions of the contractor, the owner, or by events that are outside the control of both.

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parties (Sathe and Bhonde, 2015). The contractor is often excused from the consequences and/or allowed compensation for any costs due to delays resulting from events or circumstances that are beyond its control (Braimah, 2013). There may also be contractual provisions that allow the owner to recover liquidated damages from the contractor when there is no excuse for the failure to deliver the project within the contract performance period. In all circumstances, a detailed schedule analysis is required to investigate the events that have actually caused the project to overrun in order for contracting parties to make correct decisions on potential time and/or cost compensation claims (Braimah, 2013).

Although existing delay analysis techniques have been helpful in support of these decision, they have not succeeded in curbing the high incidence of disputes associated with the resolution of delay claims and the rising number of project delays is forcing companies to rethink delay analysis frameworks (CIOB, 2016). A major source of disputes over delay lies with the limitations of the analysis techniques currently in use, as well as a lack of agreement on best practice (Braimah, 2013). There are also issues with terminology. For instance, “windows” analysis is often misunderstood and means different things to different people. These factors contribute to the ignorance of many project managers and project teams regarding delay analysis. It is not surprising that delay events on projects are often not immediately dealt with leading to disputes to develop later. This aligns with findings that the biggest cause of delay disputes is a failure to properly administer the contract (Arcadis, 2016). It is important that construction organisations develop clear and transparent delay analysis techniques that are fair to all parties and understood by all parties (CIOB, 2016).

DELAY ANALYSIS TECHNIQUES

In the mid-1960s, as the Apollo Moon project advanced, experts working on the Critical Path Method (CPM) schedules developed and implemented “time impact analysis” methods to quantify and forecast time delays that occurred on the project (Livengood, 2016). In the decades that followed there was an explosion of forensic delay CPM methodologies, as a result of it being a new area for construction experts to study and add value. One notable publication was the Society of Construction Law’s “Delay and Disruption Protocol” which was first introduced in 2002. It provided a detailed framework for forensic delay analysis in the UK, and has been widely used in countries that follow UK law. The protocol discussed four main methods of delay analysis but has been criticized for the limited number of techniques described as well as its overt support for a single technique - “time-impact analysis”. Critics argue that the method of analysis should actually be chosen based on a number of factors including the contract requirements, the data available and the completeness of project records, the time available to the analyst, the complexity of the dispute, and the amount of the dispute (Baldwin and Bordoli, 2014). No mention was made of “Windows” analysis in the first edition of the SCL protocol despite this technique being referred to by the judge in Mirant v Ove Arup (2007) as “the most accepted method of critical path analysis.” (Gibson Consulting, 2007: 2). This has subsequently been rectified in the second edition of the protocol. Furthermore, the contemporaneous submission and assessment of EOT (rather than a “wait and see” approach) is elevated to a core principle (SCL, 2017).

In their “Global Construction Disputes Report” for 2016, Arcadis found that the average construction dispute has increased in both value and duration over the last six years (Arcadis, 2016). They report that in 2015 the average value of a construction dispute was US$46m, with an average resolution time of 15.5 months. Arcadis point out that most
construction disputes are settled privately and there is a lack of information available on the exact number of disputes that occur, the causes, or exactly how they are resolved. All the standard forms of contract provide for the assessment of delay and compensation for prolongation, although they do not do so completely or in exactly the same way. They tend not to be prescriptive in the way that delay events are analysed (Baldwin and Bordoli, 2014). They do all stipulate that delay events must be timeously reported and dealt with. In turn, if the Project Manager does not respond to the compensation event notification within certain defined timeframes there are specific sanctions which can eventually result in the contractor’s assessment and quotation being automatically accepted (Evans, 2016). The intention of these clauses is to ensure that where possible disputes are resolved during the course of the project rather than waiting until the works are complete (Glover, 2015).

Attempts to standardise tools and methods is a relatively recent phenomenon, and delay claims remain a major source of conflict in the construction industry and continue to drive considerable effort and output from researchers and industry practitioners (Braimah, 2013). The prohibitive cost of litigation and the corresponding rise of alternative and less expensive dispute resolution options within the construction industry mean that fewer court cases are decided and reported that address fundamental legal questions associated with schedule delays; no legal rulings result in no precedents (Livengood, 2016).

It can be seen that guidance on the subject of delay analysis is limited, sometimes confusing, and still evolving. In this context it is understandable that project based knowledge is not completely up to date regarding the latest thinking and trends. However, there are other potential reasons for a lack of knowledge of best practice delay analysis techniques by project based staff. Project managers and project planners are normally extremely busy dealing with the day to day project work, and it is difficult to find the time to comprehensively analyse a schedule delay at the time of the delay. It is also probable that many project based staff are attached to a particular paradigm involving a technique that they have been taught, or something that worked well on a past project. When both parties are determined to use different analytical techniques, this can exacerbate the traditional entrenched adversarial relations between contractual parties, with both parties unwilling to look for areas of compromise.

Schedules, especially those on major construction programs, are often extremely complex with thousands of activities. Unfortunately, they are also often poorly developed based on assumptions and technical inaccuracies. This represents a failure of project management if a schedule has become so complex and impenetrable that someone with specialist skills outside of the project team is required to “forensically” analyse and interpret it. In a further indictment to project based management and control, one experienced analyst has even gone as far as saying every schedule he has examined in a dispute is not fit for purpose (Baldwin and Bordoli, 2014). It is often the case on major programmes that the schedule becomes a contractual tool to support the positions of the contracted parties, rather than the means of managing and controlling the work. There are instances where schedules have become so complex and are so different from the work that is actually taking place, that they can only be a cause for dispute, rather than a means to resolve them.

**Main Delay Analysis Techniques**

Experienced delay analysts say that it is virtually impossible to use a single technique “out of the box” and that all delay and disruption disputes have their idiosyncrasies that require the analyst to be flexible in their approach and to adapt methodologies to suit the
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circumstances (Baldwin and Bordoli, 2014). Each method of delay analysis falls into one of two categories: either “Prospective” or “Retrospective”. Prospective techniques are those that predict the likely impact on the progress of the works. Retrospective techniques are those that seek to demonstrate the actual impact on the works and can only be used after the works have been completed or after the impact of the delay event has ceased (Larkin, 2008). Prospective analysis can be used both before and after the delay effect has taken place. Analysis methods can also be categorised as either “Simple” or “Sophisticated”. In general, sophisticated analysis methods would be expected to be employed in complex high value disputes. This paper will focus on the most common methods used to analyse delays in the UK and most Commonwealth countries (see Table 1). These techniques are identified within the SCL protocol and as previously stated different results can be obtained for the same delay event depending upon the method of analysis used.

Table 1: Common Delay Analysis Techniques

<table>
<thead>
<tr>
<th>Retrospective Techniques</th>
<th>Prospective Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collapsed As-Built - identifies delays or changes, and then subtracting activities representing these delays from the as-built construction schedule</td>
<td>Impacted As-Planned - activities inserted as a fragnet into the contractor's as-planned (baseline) programme to represent periods of excusable delay linked to appropriate activities in the as-planned programme to determine the impact to the completion date</td>
</tr>
<tr>
<td>As-Planned vs As-Built - all delaying events are depicted on the as-built schedule. The difference between the as-planned and as-built completion dates is used to determine any extension of time.</td>
<td>Time Impact Analysis - determines the impact of delay events on the contractor’s intentions for the remaining works, taking into account the actual progress at the time the delay event occurred</td>
</tr>
<tr>
<td>Windows Analysis - represent the division of the overall construction period into smaller time periods in which progress is recorded delay events analysed.</td>
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Despite considerable industry and academic work relating to forensic planning and delay analysis, contractual parties in many cases are still not able to settle delay claims amicably resulting in costly disputes after project completion (Braimah, 2013). This is the case even though the main contract forms attempt to facilitate the resolution of potential contract disputes as they occur during the course of a project (Evans, 2016). Project schedules are also often deficient and do not support delay analysis. Standards of practice in forensic planning and delay analysis are still being developed, and there is very little consensus on best practice (Braimah, 2013). The suitability of individual analysis methods depends on the circumstances, and different methods provide different answers. Even the same methods can provide different answers due to the numerous factors that can affect schedules (Baldwin and Bordoli, 2014, p278). Current guidance is often confusing and ambiguous. There is also confusion caused by terminology. There are different names for the same methods in different countries, and the term “windows analysis” is used too broadly and often describes different methods (Baldwin and Bordoli, 2014, p325).

Delay analysis is clearly a complex and multi-faceted area, this paper proposes that project based staff from both the project owner and the contractor often do not have enough knowledge or expertise to be able to achieve a resolution at the time of the project delay. This contributes to deferring a resolution to the end of the project when specialist knowledge and help is sought. However, by this time many project staff have moved on much of the detailed project based knowledge is lost. Specialised delay analysis and forensic planning has developed into a distinct discipline with its own tools, techniques and methodology. While specialists within construction and project management are both encouraged and necessary, it is possible that project managers, project planners/schedulers, and other project controls professionals do not currently have
enough knowledge or expertise in this area. It is project based managers and controllers that need to understand, interpret and manage delay events, rather than simply outsourcing these functions to supposed specialists outside of the project team. It arguably represents a failure of project management and control on major construction programmes if someone with specialist forensic skills outside of the project team is required to understand and interpret the impact of events on the planned schedule. If this is the case, then could gaps in the knowledge and expertise of project based teams be identified that help to explain the recent rise in the use of specialist outsourced resources to perform forensic planning and delay analysis tasks?

**RESEARCH AIM**

In order to address this question, the aim of this research is to determine whether a relationship exists between the recent rise in forensic planning and specialised delay analysis with limitations in current project based planning, monitoring and control practices. The research analyses and discusses the latest thinking and practice in delay analysis and forensic planning. It discusses the tools and techniques, the recommended approaches, the standard terminology and the applicable case law. It then determines the extent to which defined best practice in the area of forensic planning and delay analysis is currently used by project based professionals. It further determines whether project based professionals themselves recognise any limitations in their ability and expertise in this area; or if they recognize any limitations in current guidance related to the discipline.

**RESEARCH METHODS**

The research was designed to collect data from two nonprobability purposive samples, one consisting of project based planning and project controls professionals; and one consisting of project managers. Participants in both groups required at least 5 years’ experience working on large scale infrastructure and construction related programmes. Both purposive samples selected experts in a particular field to be the subjects in order to represent the population of experienced international construction project controls and project management professionals. Purposive sampling is also referred to as judgment sampling. It is a deliberate choice of a participant due to the qualities (usually in the form of expertise or experience of a phenomenon) the participant possesses. The researcher decides what needs to be known and sets out to find people who possess the prerequisite qualities and are willing to participate in the research (Bernard, 2002).

Participants in the research comprised mainly of industry contacts established by the researcher while working in planning and project controls on large international construction programmes over the last fifteen (15) years. Social media tools such as Linkedin and Facebook proved invaluable both in maintaining contact with former colleagues, as well as in requesting their participation in the research and in communicating the research exercise. Data was collected through the use of a research instrument comprised of a relatively straightforward delay analysis exercise in which participants were presented with a number of project schedules and delay events on a hypothetical project and requested to determine the contractor’s entitlement to an Extension of Time (EOT). The research instrument was piloted on 2 people from each target group and was designed to ensure reliability of the findings by ensuring that different answers were obtained when using different analysis methods. Participants were required to determine an EOT entitlement (in days) and to answer whether they had used a specific analysis technique and whether this technique could be named.
Obtaining responses to the exercise proved more challenging than expected, especially from the project management group. Although sixty-five (65) project managers were invited to participate in the research, only nine (9) responses were received. The results derived from the project management sample are briefly discussed and a number of characteristics of the wider project management population are inferred. However, the findings related to project managers are caveated and cannot be considered conclusive. This could be considered to a useful area for future research. This research focuses on the results obtained from the planning and project controls sample. Responses from thirty (30) experienced planning and project controls professionals were received. However, given the non-probabilistic nature of the sample, the findings do not make claims of generalisability to the wider population of international project controls professionals. Purposive sampling methods place primary emphasis on saturation by obtaining a comprehensive understanding by continuing to sample until no new substantive information is acquired (Etikan et al., 2016).

Analysis of the answers provided is used to determine measures of central tendency, as well as measures of dispersion and variability. The participants are experienced planning and project controls professionals who were all provided with exactly the same information on a relatively straightforward scenario. Participants were also asked to rate their confidence in their answers, defined as a percentage that represents their confidence in being able to explain and justify their answers. The research was interested in whether the professionals themselves identified and acknowledged any shortcomings in their own knowledge or expertise, or in the current industry guidance in this area. The diversity of answers provided by participants who have high levels of confidence in their answers highlights a further area for discussion. It points to the participants potentially having unfounded confidence in their answers and not being aware of all the complexities of the subject. Agreeing EOT entitlement can often be a contentious subject, and is often the cause for acrimonious disputes between parties to construction contracts. If different parties obtain different answers, and they are certain in their answers, the potential for disagreement is naturally increased.

DATA ANALYSIS

Due to the lack of a strong representative sample of project managers this research concentrates on analysing the results obtained from the planning/ project controls sample. The results obtained from the project management sample are briefly discussed and a number of characteristics of the wider project management population are inferred by the results of this research. However, these findings are caveated and cannot be considered conclusive without a representative sample of project managers.

The planning/ project controls sample has been analysed using quantitative analysis techniques. Descriptive and univariate analysis techniques are predominantly used. Measures of central tendency are determined and discussed. Measures of dispersion and variability are also established. The analysis is particularly interested in determining the extent of dispersion and variability of the answers provided, considering that each participant was provided with the same information on a relatively straightforward scenario. If statistically diverse answers are obtained in these circumstances, it highlights an area of concern for the construction industry.

The research exercise was developed to ensure that different answers would be obtained when using different techniques. The analysis is interested in whether experienced project controls professionals use similar and recognized delay analysis techniques when investigating a simple delay analysis scenario. It is further interested in whether
experienced project controls professionals obtain the same answers when using the same techniques. It is also interested in the level of confidence that project controls professionals have in the answers that they obtain.

Analysis of these issues naturally hold important lessons for the construction industry. Analysing delays and agreeing extension of time (EOT) entitlements is a difficult and controversial subject within construction and project management. If experienced project based professionals are using different techniques and obtaining different answers when faced with a straightforward delay scenario, it points to a lack of understanding and possibly a lack of guidance from the industry professional bodies on what techniques are appropriate. If experienced project based professionals are using the same techniques and obtaining different answers when faced with a straightforward scenario, it points to a lack of expertise and training within the industry. If project professionals are using non-standard or unrecognized techniques to analyse delays it points to both a lack of guidance and a lack of training within the industry.

What if all the above circumstances are found to exist, and what if project based planners and project controllers have a high level of confidence in the EOT entitlement answer that they determine? This points to a situation where project based planners and project controls professionals are actually not aware of the limitations in their knowledge and expertise.

The findings of this research may help to explain why the expertise of specialist forensic planners and delay analysts is increasingly sought within the industry. The research results hold important lessons for project based management and controls staff.

The As-Planned Schedule is shown in Figure 1, with the critical path running through the design activities and subsequently through the construct and final commissioning activity.

**FINDINGS AND DISCUSSION**

The results of the research are revealing. Only seventeen (17) or 57% of the planning and project controls sample used a standard recognized and established delay analysis method. Of these, four (4) used what they described as a “Windows” technique, which is ambiguous and means different things to different people. Eight (8) or 27% of the sample used “other” non-standard techniques. Five (5) or 17% of the sample stated that they did not use any specific or named technique in order to determine their answer. Not surprisingly the answers obtained were statistically diverse, with a range between Zero (0) days EOT entitlement, and fourteen (14) days entitlement.
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Although a mode, median and mean of five (5) days was established and that the answers were distributed in normal bell shaped curve with a platykurtic (flat) kurtosis, it was shown that those who obtained an answer of five (5) days determined it by vastly different means. There was no consistency in the results at all. Even the majority of those who used the same techniques obtained different answers. The standard deviation of 2.4 and the mean absolute deviation (MAD) of 1.5 are significant when considering that the range of potential answers to the question of the EOT entitlement are limited. The possible answers to the research question are generally considered to be in the range between Zero (0) and Seven (7) days - even though one answer of fourteen (14) days was given.

Despite the diverse answers provided, sample participants were extremely confident in their answers, defined in the research as their comfort in being able to explain and justify their assessment to, for example, an independent arbiter. The mean confidence level was 90.3%, with a median confidence of 95% and a mode confidence level of 100%. As previously stated, the attitude of many experienced planning and project controls professionals appears to be encapsulated in an answer provided by the most experienced participant, who has spent 45 years working on large scale infrastructure and construction projects. To the research question on his confidence level in his answer he stated “100%”. The next question asked the name of the technique that he used. He answered: “Have no idea, answer based on experience in dealing with claims.” He worked his entire 45 year career for a large very well-known US based construction and project management company, and was planning manager and project controls manager on some of the largest construction projects in the UK and internationally. His analysis was no doubt comprehensive, well-constructed and logical. Nevertheless, his response points to a fundamental concern.

CONCLUSIONS

Project Management and Project Controls professionals manage and control projects. Management and control of projects should include delay analysis and assessments of Extension of Time (EOT) claims. Project based management and controls professionals have arguably the most useful knowledge in this area about the projects on which they work. They know and understand the issues. They know and understand the causes of delays and the potential impacts. However, the trend in recent years has been to outsource delay analysis and EOT assessments to specialist delay analysis consultants and forensic planners. These consultants do not work directly on the project, and are commonly contracted to resolve EOT entitlement claims following project completion, often when the project based staff that hold detailed knowledge have moved on to other projects.

This research attempts to understand why specialist skills are increasingly sought and used when analyzing delays. The use of a relatively straightforward delay scenario was prepared and participants were asked to determine the EOT due to the contractor on a hypothetical project. The question was formulated to ensure that a variety of recognized and established delay analysis techniques could be used to determine the EOT entitlement, and that different delay analysis methods would result in different answers. Planning and project controls professionals consider themselves to be project based experts in delay analysis and EOT entitlement assessment. You will not find an experienced planning or project controls professional who will not claim to be willing and able to perform an accurate and comprehensive delay analysis or EOT assessment. The
results of the research back up their confidence in this regard. It is therefore strange that project based professionals who have the most knowledge of their projects are not the ones being used to perform delay analyses.

The aim of this research attempts to determine whether a relationship exists between the recent rise in specialised delay analysis with limitations in project based planning, monitoring and control practices. It soon became apparent that not enough project managers were prepared to participate. From direct discussions with a number of project managers it became apparent that many did not know how to perform the analysis, and did not believe that they needed to know how to do it as part of their function. This appears to suggest that there is a strong link with the increase in specialised delay analysis as a result of a lack of delay analysis knowledge of project managers and project based professionals. There is significant scope for educators and training providers to improve the competencies of project managers in delay analysis. This paper concludes that although project managers do not have to be experts in delay analysis, they should know enough to be able to understand and direct the use of specific techniques, as well as understand the results and the advantages and constraints of the analysis method used. Although only tentative inferences may be drawn by this research from the limited participation of experiences project managers, further research is needed to empirically determine the knowledge and attitude of project managers towards the function of delay analysis and assessment.

REFERENCES


This research sought to investigate the nature of current quantity surveying in Scotland, based on a quantitative survey of professional practices. The survey was issued to over 150 Firms to ascertain their size, organizational and legal structures, operational fields and nature of professional services provided. It also explored favoured procurement routes and contracts, professional procedures, awareness of current trends, such as BIM, and preferred dispute resolution processes. Analysis of the results confirmed a fragmented profession divided between a myriad of micro-organizations and a very few substantial Practices, but all operating within the definition of a Small Medium Enterprise (SME, <250 employees). Current practice confirmed a modern approach to the profession in Scotland within the overall context of a devolved Parliament, a different legal system and unique national institutions. Two glaring exceptions, however, showed reluctance to change from the Standard Method of Measurement 7 to New Rules of Measurement 2, and an almost total lack of use of the RICS’s Black Book. Another surprising finding was that only one third of Practices were structured as Sole Practitioners or Partnerships, whilst over half were limited liability companies. The research concluded that, in Scotland, the Quantity Surveying Profession is inherently conservative and even resistant to change.

Keywords: Scotland, professionalism, quantity surveying, current practice

INTRODUCTION

Scotland was at the forefront of the Quantity Surveying profession until the Great War. Modes (Methods) of Measurement were first published in Edinburgh in 1773 and the Glasgow Institute of Measurers published five Modes between 1885 and 1894. The Scottish National Building Code was published in 1915 and brought together for the first time ever Regulations for entering into and carrying out Building Works, Conditions of Contract and Modes of Measurement for all trades. In contrast, the first RIBA Conditions of Contract was published in 1909 and the first edition of the Standard Method of Measurement in 1922 (Trushell 2010).

The UK construction industry is highly fragmented. Although there are 194,000 building firms in the country, only 62 have more than 600 employees. This structure makes it difficult to introduce new initiatives and working practices to increase productivity and efficiency. It is generally only the large organisations that have the time and resources to bring about change (Cartlidge 2013). What is true of the construction industry as a whole is equally true of its professions. The year 1990 was a watershed for the UK construction industry and its associated professions. A ‘heady brew of change’ was being concocted

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on fires fuelled by the recession, client dissatisfaction, fee competition, globalisation, information technology, added value procurement and public private partnerships (Cartlidge 2011).

In addition to death and taxes, a third inevitability of life is change, which is now unstoppable. There is some evidence of innovation in the quantity surveying profession, especially among the larger practices (RICS 2004).

The associations that founded the professions in the United Kingdom were started in the early to mid-19th century by like-minded practitioners who wanted to share their knowledge with others, to improve status by formal qualifications, to lobby governments or to carry out joint projects. There was a ‘wave of association’ between 1840 and 1890 (Carr-Saunders and Wilson 1933). Perkin (1989) asserted that professional society was based on human capital created by education and enhanced by strategies of closure, i.e. the exclusion of the unqualified. He believed that professions lived by persuasion and propaganda, claiming that their particular service was indispensable to the client or employer, and to society and the state. The professions hoped to turn the human capital they acquired into material wealth. Perkin’s concept of the ‘professional ideal’ changed over time, however, and was a continuing process. The ultimate status of a profession was confirmed by the granting of a Royal Charter, e.g. the Royal Incorporation of Architects in Scotland in 1929. Claims that surveying was a profession were endorsed by leading judges who believed that professionalism was concerned with professional confidentiality and judgement; entry standards, training and discipline, duty to the client, services to the community; the maintenance of professional standards of technical competence; the protection of society; and the maintenance of professional integrity (Denning 1971). Modern professionals also have a duty to undertake continuing professional development as defined by the Royal Institution of Chartered Surveyors as, ‘systematic maintenance, improvement and broadening of professional knowledge, understanding and skill …’, i.e. the need to ‘keep up to date’ (RICS 2007).

Although studies and reports on the quantity profession have been produced (RICS 1991 and 1998) and (Page, Pearson and Pryke 2004), this research is truly unique in having surveyed by questionnaire Quantity Surveying Practices in Scotland. No previous study has done this. A Profile of the Quantity Surveying Practice in Malaysia was published (Abdullah and Haron 2006), but there is no intention to compare and contrast their findings with the results of the Scottish survey. Given Scotland’s early, leading role as outlined above, the question raised by this research is, ‘What is the current state of the Quantity Surveying (QS) profession in Scotland and to what extent has it changed.’

Having considered and rejected a qualitative research method because of its lack of precision, a quantitative survey of the entire population of QS Practices was considered to offer the only way fully to answer this question, per Fellows (2015).

**METHODOLOGY**

A database of 169 Quantity Surveying Practices in Scotland was compiled from a number of sources: the last published Directory of Surveyors by the Royal Institution of Chartered Surveyors in Scotland; RICS Find a Surveyor website; British Telecommunications’ Phone Book (business type). Seven Practices were known not to be engaged in Quantity Surveying practice as they were exclusively dispute resolvers and, therefore, excluded from the survey. A letter was sent to each remaining Practice addressed to a Partner/Director describing the purpose of the survey, an invitation to respond via Surveymoniker electronic software and advising that some email addresses were of the,
‘info@...’ variety. Practices were asked to warn the first recipient of such emails not to delete them, but to forward them to a Partner/Director.

Eighteen Practices had no known email addresses and were sent a hard copy of the survey questionnaire enclosing a stamped addressed return envelope. Only three of these Practices returned the questionnaire and these were input manually into Surveymonkey. Royal Mail returned three letters ‘not known at this address’ and 12 ‘gone away’. Corrected addresses for 11 of the 12 were established and re-sent, but none returned the questionnaire.

In total 144 Practices were sent a Surveymonkey questionnaire. Thirty two were opened by the recipient, 106 were unopened, two bounced back, four opted out and 11 completed the survey. Correct email addresses were obtained for the two bounced backs and resent. One completed the survey.

A reminder was issued to the non-responding Practices and a further four responses were received, making a total of 16. The database was then refined to target 33 known individuals within the 113 non-respondents. These were sent another copy of the Surveymonkey questionnaire. Fifteen individuals responded, giving a total response of 31 plus three hard copy returns, making 34 or 21% of 162 Practices invited to participate. Some Practices did not answer all questions.

**ANALYSIS OF RESULTS**

The traditional structure of Quantity Surveying Practices in Scotland was either Sole Practitioner or Partnership. The survey showed that 22.6% of 31 responding Practices were Sole Practitioners, 12.9% were Partnerships, 9.7% were Limited Liability Partnerships and 54.8% were Limited Companies. The high percentage of Limited Companies was unexpected. It may reflect the Date of Founding of the Practices as answered in another question. Of the Practices surveyed, 48.5% were founded between 1961 and 2000 and a further 33.3% after 2001. 81.8% were, therefore, founded after 1961. Directors of these companies clearly sought to limit their personal financial liability in return for full financial disclosure, unlike a Partnership.

**Figure 1: Structure of Practices**

![Figure 1: Structure of Practices](image)

Staffing ratios were examined and of 33 responding Practices, on average there were 3.5 Partners/Directors, 10.0 Qualified Quantity Surveyors, 3.2 Unqualified Surveyors, 3.1 Trainees and 2.6 Administrators. The number of Qualified Quantity Surveyors was thought to be high and interrogating the data revealed three outlier numbers of 65, 63 and 29. Removal of these data reduced the average number to 3.7. There were, on average, about 3.4 members of each technical grade within each Practice and slightly fewer administrators. The Quantity Surveying profession is, therefore, operating at the micro-economic level within the definition of Small Medium Enterprises (SMEs).
The various sectors within which Practices operated were surveyed and 56% of 30 responding Practices worked in Healthcare, 60.0% in Education, 47.8% in Universities, 9.1% in Prisons, 73.9% in Social Housing, 61.5% in Infrastructure, 82.1% in Commercial Offices, 73.1% in Retail, 89.3% in Private Housing and 88.9% in Industrial. The most common sectors were, therefore, Housing, Industrial, Infrastructure, Offices and Retail.

In terms of geographical operations, 25.0% of 32 responding Practices worked locally (within 50 miles), 12.5% within the Region (within 100 miles), 34.4% throughout Scotland, 18.7% in UK and 9.4% internationally. Almost 72% of Practices worked only within Scotland with less than 1 in 10 operating internationally. This probably reflects the small size of the Scottish Practices.

The variety of services offered by QS Practices has expanded in recent times. The survey showed that 93.6% of 33 responding Practices provided Traditional Quantity Surveying services, 26.0% Building Surveying, 78.6% Project Management, 78.6% Employer’s Agent, 53.6% CDM Principal Designers, 12.0% BIM Management, 8.3% Tax Consultancy, 53.9% Dispute Resolution, 55.6% in Contractual Claims and 59.3% as Expert Witnesses. As expected, Traditional Quantity Surveying was the most common service provided. This was followed jointly by Project Management and Employer’s Agent. CDM Principal Designer was unexpectedly high which reflected the diversity of services provided.

Staff employment and location were surveyed and 93.9% of 33 responding Practices had permanent staff, 42.4% used part-time staff and 42.4% sub-contracted. The relatively high use of part-time and sub-contracted staff was unexpected. Some 81.3% of staff in 32 responding Practices worked in the office, 31.3% from home and 25.0% a mixture of office and home. Almost a third worked from home which may reflect the number of Sole Practitioners in the survey.

The changing patterns of procurement routes were examined. Traditional Procurement was the first preference of 75.0% of 32 responding Practices with 18.8% as second choice, 55.2% had Design and Build as second choice and 20.7% as first, 62.5% had Management Contracting as third choice with 6.3% both first and second, 38.9% had Construction Management as fourth choice with 33.3% as second and 27.8% as third, whilst 68.4% had PFI/PPP as fifth choice with 21.1% as third and 10.5% as fourth. The preference of Management Contracting as third choice was somewhat unexpected as this was thought to have fallen out of favour.
**Table 1: Procurement Preferences**

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<tbody>
<tr>
<td>Traditional</td>
<td>75.0</td>
<td>18.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design and Build</td>
<td>20.7</td>
<td>55.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management Contract</td>
<td>6.3</td>
<td>6.3</td>
<td>62.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction Manager</td>
<td>33.3</td>
<td>27.8</td>
<td>38.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PFI/PPP</td>
<td>21.1</td>
<td>10.5</td>
<td>68.4</td>
<td></td>
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</tbody>
</table>

In terms of contracts currently used, 100.0% of 32 responding Practices used JCT/SBCC contracts, 46.9% used NEC3, 12.5% GC/Wks/1, 21.9% ICE, 9.4% I Chem E and 12.5% FIDIC. Almost half the responding practices used NEC3 and the use of ICE was unexpectedly high. Of the JCT/SBCC Contracts used, 71.9% of 32 responding Practices used With Quantities as first choice with 21.9% second and 6.3% third, 40.0% used Without Quantities as second choice with 36.7% as third and 23.3% as first and 50.0% used Approximate Quantities as third choice with 42.3% as second and 7.7% as first. Although over 70% of responding practices used With Quantities as first choice, the high use of Without Quantities reflects a modern trend away from Bills of Quantities.

**Table 2: JCT/SBCC Contracts Used (%)**

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<tr>
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<tbody>
<tr>
<td>With Quantities</td>
<td>71.90</td>
<td>21.90</td>
<td>6.30</td>
</tr>
<tr>
<td>Without Quantities</td>
<td>23.30</td>
<td>40.00</td>
<td>36.70</td>
</tr>
<tr>
<td>Approximate Quantities</td>
<td>7.70</td>
<td>42.30</td>
<td>50.00</td>
</tr>
</tbody>
</table>

**Table 3: NEC3 Contracts Used (%)**

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<tr>
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<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option A</td>
<td>66.7</td>
<td>33.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option B</td>
<td>25.0</td>
<td>62.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option C</td>
<td>41.7</td>
<td>16.7</td>
<td>25.0</td>
<td>16.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option D</td>
<td>42.9</td>
<td>57.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option E</td>
<td>14.3</td>
<td>14.3</td>
<td></td>
<td></td>
<td></td>
<td>71.4</td>
</tr>
<tr>
<td>Option F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16.7</td>
<td>83.3</td>
</tr>
</tbody>
</table>

Of the 13 responding Practices, 66.7% used NEC 3 Option A as first choice with 33.3% as second, 62.5% used Option B as second choice with 25.0% as first, 41.7% used Option C as first choice with 25.0% as third and 16.7% as both second and fourth. Some 57.1% used Option D as fourth choice with 42.9% as third, 71.4% used Option E as fifth choice with 14.3% as both second and third. Some 83.3% used Option F as sixth choice with 16.7% as fourth. The high use of Option B (Priced contract with bills of quantities) was unexpected as was the relatively low use of Option C (Target contract with activity schedule).

The source of data for Cost Planning purposes was surveyed and 90.0% of 31 responding Practices used In-House data as first choice with 6.7% as second, 51.7% used Previous Projects as second choice with 13.8% as third and 17.2% as fourth, 36.0% used BCIS as third choice with 24.0% as fourth, 36.0% used Price Books as third choice with 32.0% as...
fifth, 44.8% used Contractors’ Estimators as fourth choice with 24.1% as third and 52.4% phoned a friend as sixth choice with 14.0% as both fourth and fifth. Only a third of responding practices used both BCIS and Price Books as third choice. Unexpectedly, almost half used Contractors’ Estimators as fourth choice.

Table 4: Cost Planning Data Sources

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<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-House</td>
<td>90.0</td>
<td>6.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous Projects</td>
<td>51.7</td>
<td>13.8</td>
<td>17.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BCIS</td>
<td>36.0</td>
<td>24.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price Books</td>
<td>36.0</td>
<td>32.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contractor's Estimators</td>
<td>24.1</td>
<td>44.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phone a Friend</td>
<td>14.0</td>
<td>14.0</td>
<td>52.4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The preferred methods of Cost Planning were that 66.7% of 31 responding Practices used Approximate Quantities as first choice with 13.3% both second and third, 51.9% used Square Metre Pricing as second choice with 22.2% as third, 29.6% used Elemental Comparison as second choice with 25.9% as third and 22.2% as first and 40.7% used Unit Pricing as fourth choice with 29.6% as third. Two-thirds of responding practices used Approximate Quantities as first choice. Only a quarter used Elemental Comparison as third choice. This possibly revealed too much costing of plans as opposed to cost planning.

Table 5: Cost Planning Methods

<table>
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<tr>
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<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approximate Quantities</td>
<td>66.7</td>
<td>13.3</td>
<td>13.3</td>
<td></td>
</tr>
<tr>
<td>Square Metre Pricing</td>
<td>51.9</td>
<td>22.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elemental Comparison</td>
<td>22.2</td>
<td>29.6</td>
<td>25.9</td>
<td>40.7</td>
</tr>
<tr>
<td>Unit Pricing</td>
<td></td>
<td>29.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Surprising and worrying data was revealed in relation to the use of Methods of Measurement where 90.3% of 31 responding Practices used SMM7, 35.5% used NRM2, 16.1% used CESMM4 and 54.8% used Builders’ Quantities. Nine out of 10 responding practices still used SMM7, despite NRM2 becoming operative on 1 January 2013.

The processes of taking off quantities and compiling Bills of Quantities were examined. Some 55.6% of 27 responding Practices used the Northern Method (separate take-off and writing up), 59.3% used Southern (combined take-off and writing up) and 3.7% used Cut and Shuffle. Slightly more responding Practices used the Southern Method of taking-off than the Northern and hardly any used Cut and Shuffle. In terms of Bill presentation 45.2% of 31 responding Practices used Trade by Trade, 19.4% used Elements, 22.6% used Elements within Trades, 48.4% used SMM7 Work Sections and 19.4% used NRM2 Tabs. Almost half responding Practices presented bills of quantities in SMM7 Work Sections which was unexpected. The more traditional Scottish Trade by Trade presentation was used slightly less often.

Computer Billings Systems were thought to be ubiquitous in current QS Practice and 33.3% of 27 responding Practices used CATO, 11.1% used CostX, 11.1% used Excel, 11.1% used Snape Vector, 7.4% used an in-house system and 26.0% used none. CATO was by far the most popular computer system in use, but just over a fifth of responding Practices did not use computer billing at all.
When sending out Contract Documents for tendering purposes 43.3% of 30 responding Practices used hard copy, 56.7% soft copy and 63.3% used e-tendering. Almost two-thirds of responding Practices used some form of e-tendering, although the method was not defined.

Building Information Modelling (BIM) has been a hot topic within the construction industry in recent times. The survey revealed that 3.2% of 32 responding Practices were Unaware of BIM, 28.0% were Somewhat Aware, 34.4% were Aware and 34.4% were Very Aware. Virtually all responding Practices were aware of BIM and two-thirds were Aware/Very Aware. Some 35.3% of 17 responding Practices operated BIM at Level 1, 64.7% at Level 2 and 0.0% at Level 3. Almost two-thirds of responding Parties had operated at Level 2 BIM, but none had operated at Level 3.

Since the implementation of the Housing Grants, Regeneration and Construction Act in 1998, Adjudication was thought to be the preferred dispute resolution process in the construction industry in preference to traditional Arbitration (GCU 2016). However, the survey showed that 82.8% of 32 responding Practices preferred Mediation as first choice, 60.0% preferred Adjudication as second, 56.0% preferred Expert Determination as third, 50.0% preferred Arbitration as fourth, and 72.7% preferred Litigation as fifth choice. Over 80% of responding Practices preferred Mediation as first choice in resolving disputes which was unexpected. Only 60% preferred Adjudication as second choice. Arbitration was a poor fourth choice behind Expert Determination. Whether the preference for Mediation translates into practice may be a different story, however. It is difficult to believe that there are more construction mediations in Scotland than adjudications as the data for the former are difficult to establish.
Quantity Assurance was once as hot a topic in construction as BIM is today and should still be at the heart of professional practice. The survey showed that 48.3% of 29 responding Practices used ISO 9001, 3.5% used RICS Black Book and 48.3% used in-house Quality Assurance Manuals. Less than 5% of responding Practices used the RICS Black Book as a Quality Assurance system which was unexpected and should be a major cause for concern.

**Figure 5: Quality Assurance**

On average, Partners/Directors were charged-out at £81.91 per hour, Senior Quantity Surveyors at £62.19, Quantity Surveyors at £47.06 and Junior Quantity Surveyors at £35.73. Drilling into the data revealed an outlier of £200 per hour (thought to be an Adjudicator) and removal of this datum reduced the average Partner’s charge-out rate to £76.00 per hour. The range was £35 to £120 per hour. In comparison, a Jaguar Technician is charged out by a Main Dealer at £120 per hour. The profession would appear to be selling itself short.

**CONCLUSIONS**

All conclusions drawn from this unique research must be tempered by the small sample size of 34 Scottish Quantity Surveying Practices. Although in statistical terms this is still regarded as not a small sample (Anderson, Sweeney and Williams 2016), only 21% of the 162 known QS Practices responded to the survey and even then a few did not answer all the questions.

Accepting the foregoing limitation, Scottish QS Practices are characterised as having about 10 technical staff, operating largely as limited companies, except the sole practitioners. They tend to operate locally in many diverse sectors delivering a wide range of professional services. Most of the staff comprises permanent employees who work in an office, although there are exceptions in both categories. There is still a preference for Traditional procurement, with Design and Build as second choice and,
surprisingly, Management Contracting as third. JCT/SBCC contracts are predominately used, particularly With Quantities, although about half the Practices also use the NEC3 contract, particularly Options A and B. Cost Planning is still largely undertaken by Approximate Quantities using In-House data and Previous Projects.

The traditional Scottish practice of taking off quantities and then writing up Bill items, i.e. the Northern Method, has been marginally overtaken by the Southern Method of combining the two operations into one. E-tendering in some form was popular and there was good awareness of Building Information Modelling/Management. The preference for Mediation as a dispute resolution practice was anomalous, given the continuing popularity of Adjudication.

The first significant finding from the survey was the astonishing reluctance to depart from SMM7 as the method of measurement, despite its replacement by NRM2 from 1 January 2013 as recommended by RICS. The rationale of NRM2 was to simplify measurement and to recognise new construction methods. Why practitioners do not avail themselves of a simpler method of measurement is perverse.

The other significant finding was that the much-vaunted and comprehensive RICS Black Book was not used to any great extent as a Quality Assurance standard. The guidance notes to each section of the Black Book states, ‘When an allegation of professional negligence is made against a surveyor, a court or tribunal is likely to take account of the contents of any relevant guidance notes published by RICS in deciding whether or not the member had acted with reasonable competence.’ The RICS suggests that members ignoring such guidance do so at their peril, and that is surely correct.

In the light of the foregoing and notwithstanding the small sample size, it is apparent that the Quantity Surveying profession in Scotland is inherently conservative and even resistant to change. The two most significant changes in the Quantity Surveying profession over the past five years have been the imposition of NRM 2 and The Black Book, neither of which has been taken up by Scottish Practices to any great extent. This is a sad reflection on the profession and must surely be a cause for concern.

The idea that Scottish Quantity Surveying is still at the forefront of professional practice must, therefore, be challenged as this survey has certainly found otherwise.

REFERENCES


THE CONSTITUTION OF CONSTRUCTION SUPPLY CHAIN RELATIONSHIPS: A POST-FAILURE CASE STUDY

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The Bartlett School of Construction and Project Management, University College London, 1-19 Torrington Place, London WC1E 6BT, UK

This study aims to investigate how relationships between main contractors and second-tier subcontractors are constituted, particularly after project experiences that deteriorated relationships. Trust is regarded as a structural property of relationship and the duality of trust provides an analytical perspective of investigating the constitution of relationship. This process-based research used case study method and collected data from semi-structured interviews with actors from both main contractor and subcontractor companies. Findings reveal five processes, learning, relating, collaborating, controlling and routinising, that helped constitute trust and thus supply chain relationships. It reveals that relationship failure had strong impacts on initial trust and practices at the front end. The research also shows that constituting relationship and trust is an intended but also an unintended consequence of project organising enabled and constrained by structures of project ecologies. This study contributes to knowledge in that it 1) provides an analytical approach, from the perspective of structuration theory, and relational approach to understanding construction supply chains, 2) empirically demonstrates the dynamics of trust, in the shadow of the past as well as contemporary lifecycle of the construction project, and 3) links construction project management field with the wider field of social science.

Keywords: project organisation, process study, supply chain relationship, trust.

INTRODUCTION

This study is about constituting inter-organisational relationships (IORs) between main contractors and second-tier subcontractors in construction projects, particularly in the shadow of negative past experiences and demonstrates how such process is both engineered and emergent. Collaboration between project businesses is an organisational reality in the project-based industries and managing relationships are necessary if project businesses are to survive and value levered. IORs were found to be the basis of transferring knowledge, managing structural and dynamic complexity, and mitigating risks (Laeequddin et al., 2012; Brady and Davies, 2014), but they are not in the centre of traditional project management approaches (Sydow and Braun, 2017). In particular construction project management (CPM), supply chain relationships are of value for both project delivery and project businesses (Meng, 2012) and were identified to be worse than client-main contractor relationships (Alderman and Ivory, 2007). Yet most CPM studies have been interested in client and main contractor partnering (Bygballe et al., 2010), with exceptions of Meng (2012) and Manu et al., (2015) recently. Moreover, research effort is focused more on the formal forms of collaboration than the social context and emergent

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Constitution of Construction Supply Chain Relationships

The process of developing collaboration and relationship (Bresnen, 2009). The effects of the past on present interactions and relationship have been under-researched, especially learning from the unsatisfied past experiences that deteriorate relationships. These formal tools and arrangements, however, faced difficulties of translation into practices in the dynamic contexts (Bresnen and Marshall, 2000).

To lever value in the project delivery, CPM research needs to zoom in and understand processes of supply chain collaboration that constitute formal and informal practices as well as the social context in the course of time. Bringing IORs to the centre of analysis and theorising helps bridge distinct projects in time and space and integrate the service contributions to a consistent outcome of value for clients but also main contractors and subcontractors (Sydow and Braun, 2017). In line with the relationship approach to managing project, the present study centres on IORs between main contractors and second-tier subcontractors in construction projects and takes a structurationist view on trust as a structural property of relationship (Sydow, 1998). The paper proceeds with a literature review section on IORs and trust in construction. Research methodology and methods are then specified, followed by a presentation of findings. Finally, the discussion and conclusion link findings back to theories and explicate contributions.

Towards an Understanding of the Process of Constituting Supply Chain Relationships

A considerable body of CPM studies, as well as the broader discipline of project management, has focused on the critical success factors, best practices or design of collaborative mechanisms and tools at the governance level and the front end (Smyth et al., 2010). Nevertheless, having a closer examination of such mechanisms and tools, their effects on IORs and project performance vary (cf. case studies of Cicmil and Marshall, 2005 and Davies et al., 2016). In some cases, partnering was used as a guise by main contractors to reap the profits from second-tier subcontractor (Alderman and Ivory, 2007), which dramatically worsens supply chain relationships. It has been argued that second-tier subcontractors and suppliers have less understanding of collaborative mechanisms and question the benefits they can get through collaborating with main contractors (Mason, 2007), pointing to the need for taking an interpretive view and understanding the process of building supply chain relationships in the social context.

The focus has then been on structures but also practices and behaviour in the context (Bresnen, 2009). Agents and actions are not determined by contracts or any forms of structural arrangements; the latter can only have an enabling and constraining effect on the former. The social context where structures and processes interact also needs attention. Zooming out to a broader picture reveals that projects are embedded in a programme of projects of project-based organisations, which are part of inter-organisational networks. Furthermore, these networks operate in the organisational field constituting the institutional life that enables and constrains actors’ behaviour and actions (Manning, 2008). Multiple levels of project ecologies equip project actors with rules of interpretations and legitimation as well as resources of power and thus involve the interplay between projects and firms. Time matters as well. Despite any projects have an ex-ante defined duration, actors and firms involved in projects have earlier experience and future orientations; most projects have processors, successors as well as simultaneous peers. Therefore, to understand the process of building supply chain relationships, it is necessary to place relationships in the course of time. Extending the process of relationship constitution to the past and future helps reap the benefit from past
experiences, mitigate the negative impacts and prevent path-dependent development (Ebers and Maurer, 2016).

The increasing concern with social and process aspects in construction projects mirrors the criticism of rational approach in general project management and the more general structuralism and individualism in the sociological and organisational studies. The critics have proposed a shift in research orientation from instrumentalism towards approaches that capture the dynamic, emergent and social aspects of projects and a 'becoming' ontology and process perspective (Bresnen, 2009; Bygballe et al., 2016), which requires more open, dynamic, and reflexive management and organisation theories. Structuration theory (Giddens 1984) is among one of the theories able to reconcile the interplay of structures and agency in process studies. The concept of duality of structure provides a dynamic lens of viewing how the process of actors interacting with each other is enabled and constrained by the structural conditions and in return how structures are constituted and reconstituted by actors. The recursive dialectics of structure and agency constrains the unilateral construction of social systems and create unpredictability in social dynamics. According to Giddens' structuration theory, the structure consists of rules of signification and legitimation and resources of domination. In construction projects, interpretative and normative rules are divergent and are from project ecologies such as laws, regulations and organisational policies, and bases of power also disperse. The decentralised project organisations authorise project actor's power at use, but whether and how to use power depends on interests of parent organisations but also power relationships and resources in the projects (Bresnen et al., 2004). Apart from space, rules and resources are diverse in different phases of the project lifecycle, depending on overall and interim goals and performance. As such, construction actors have diverse interpretative schemes, normative practices, and facilities for gaining resources and play an active role in choosing forms of communication, whether and how to use power and ways of sanction. Their choices either reproduce or transform structural rules and resources.

Through the lens of structuration theory, the dynamics of supply chain relationships can be viewed as the consequence of the dialectics of structural properties of relationships and practices enacted by contractors and suppliers in the project. Trust is regarded as one of such structural properties. Seen through structuration theory, generating trust is to raise the perception of trustworthiness, use trust relations to allocate resources and legitimate relational norms that constrain opportunism and encourage trusting and trustworthy behaviour, and, in turn, trust influences actors' interpretative schemes, facilities of resources and norms of conduct, hence project processes and practices (Sydow, 1998). The recursive and dynamic relations between trust and interaction processes and practices provides an analytic approach to understanding the dynamics of supply chain relationships. Based on extant research (Mayer et al., 1995; Rousseau et al., 1998; Smyth et al., 2010; Sydow, 1998), this research uses a working definition of trust as an actor’s current intention to rely on the actions of or to be vulnerable to another party, based on the expectation that the other party can reduce risks and co-create value in a relationship. Particularly, the paper focuses on the main contractor’s trust in the subcontractor. A relationship can be interpersonal. It can also be inter-organisational based upon the sum of the key interactions and individuals.

**RESEARCH METHODOLOGY AND METHODS**

The research took an interpretive and process-based approach and focused on the informants’ view of the topic under research and individuals’ perceptions of events and
Constitution of Construction Supply Chain Relationships

processes. Case study was used to help in-depth study in a local situation, and the aim was to develop analytical generalisations (Yin, 2009). One IOR was selected in the present paper to demonstrate how the supply chain relationship is constituted over time, which involved a piling subcontractor, referred to herein as Found Gamma and a main contractor, referred to herein as Office Plc. The case was in the context of delivering a piling and foundation project for Beta, a building project, in the UK. Table 1 summarised key futures of the case.

Table 1: Case Beta overview

<table>
<thead>
<tr>
<th>Case information</th>
<th>Piling project of an office building in a city development programme and near service tunnels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data collection duration</td>
<td>7 months</td>
</tr>
<tr>
<td>Past experience</td>
<td>- Unsatisfied recent project delivered by a different business stream of Found Gamma and a different team of Office Plc.</td>
</tr>
<tr>
<td></td>
<td>- Competitive procurement</td>
</tr>
<tr>
<td></td>
<td>- Contract: JCT 2011, lump sum, 30-day payment</td>
</tr>
<tr>
<td></td>
<td>- Value: £59 million</td>
</tr>
<tr>
<td>Main procurement and contract</td>
<td>- Limited bid invitation</td>
</tr>
<tr>
<td></td>
<td>- Contract: Design &amp; Build with JCT 2011</td>
</tr>
<tr>
<td></td>
<td>- Lump sum, 45-day payment</td>
</tr>
<tr>
<td></td>
<td>- Value: £1.7 million</td>
</tr>
<tr>
<td>Piling procurement and subcontract</td>
<td></td>
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</tr>
</tbody>
</table>

To investigate the sequence and flow of events and understand processes in the course of time, data collection involved three-round interviews at the procurement, execution and completion stages of the piling project, so to capture both historic and contemporary processes. By doing so, the author gathered data about past experiences that dated back up to five years ago as well as on-going experiences in the project Beta. To capture a more detailed and balanced picture of the phenomenon, the research selected six informants from different functional units and hierarchical levels of Office Plc and Found Gamma, including positions such as bid manager, supply chain manager, project director, project manager, quantity surveyor and site engineer. Bias due to different functional roles and companies were mitigated. To study changes of the relationship and trust, the principal researcher tried to interview the same informants in multiple visits, but due to the handover of the project from the procurement or bid team to the project team, the bid manager of Found Gamma and supply chain manager of Office Plc were substituted by the project directors. At the completion stage, the researcher did not have the last interview with the project manager of Office Plc as the project manager moved to other specialist projects of Beta. In total, 17 semi-structured interviews were conducted. All interviews were recorded, transcribed and analysed by the principal researcher. While the length and focus of interviews varied, they were all guided by a research protocol with interview topics and questions. The unit of analysis was the IORs between Office Plc and Found Gamma. Interview questions were therefore designed to ask informants’ views on own company and the other company, such as practices of own company, interactions between two companies, and attitudes towards the other company. Individual views and attitudes were aggregated to form collective views and attitudes representing their companies.

Data were analysed in three steps. The first step was constructing a description of sequences of events, which was reported in Figure 1 due to space constraints.
Figure 1: The Process and Events of the Project Beta

A framework analysis approach was then used to uncover processes of constituting trust at different stages of the piling project. The development of the framework was illustrated in Figure 2. The framework consisted of themes within which the material can be sifted and sorted. The first version of framework was drawn upon the interview topic guide but also emergent from the first-round analysis (e.g. ‘Internal communication’ in Figure 2). The framework was then applied to the interview data in its textual form, during which new themes emerged and enriched the framework. All interview transcripts were indexed with numbers that linked back to themes (Ritchie and Spencer, 2002).

Figure 2: Development of a Thematic Framework

After indexing individual transcripts, data were lifted from the original context and rearranged in charts. The analyst then began to pull together the data and interpret the data set as a whole. The interpretation was influenced by structuration theory, and the processes of constituting the supply chain relationship and structural conditions for trust generated the interpretation of trustworthiness, use trust relations as facilities of resources or legitimate relational norms (see Figure 3 an extract of charts).

FINDINGS AND DISCUSSION

Interaction Process

Processes that constituted the relationship between Found Gamma and Office Plc at different stages of the project Beta were identified and consolidated into more generic processes. Table 2 illustrated the findings. On the broadest level, this research identified five fundamental processes - learning, relating, collaborating, controlling, and routinising.
Constitution of Construction Supply Chain Relationships

Figure 3: An extract of Charts

From procurement to completion, these processes recursively generated trust by influencing actors' interpretative schemes, encouraging the use of trust relations to allocate resources and legitimating relational norms enabling trusting and trustworthy behaviour.

Table 2: Consolidated Processes

Learning was fundamental to generating trust as a rule of signification. Found Gamma cognitively learnt from the past by accepting own mistakes, identifying problems, and behaviourally learnt by allocating actors having good relationships with Office Plc. The willingness of taking responsibility and familiarity between individuals laid a good foundation for fostering the perception of trustworthiness. On the Office Plc’s side, the internal communication helped reduce suspicion and form the collective perception of trustworthiness in terms of Found Gamma’s capability and expectations on collaborating with Found Gamma. The influences of the shadow of the past were intermediated in the process of learning from the past. On the other hand, the interpretation of trustworthiness could be an unintended consequence of learning about project performance. For instance, the perception of integrity and benevolence emerged experientially and reflexively underneath monitoring project performance and shared learning about problems. For Found Gamma kept consistent service, did extra-mile works and helped solve problems. In other words, the increased knowledge about the other party’s competence and intentions was not necessarily a strategic intention derived from the rational calculation (cf. Williamson, 1993); it might be an unintended consequence of project organising.

Relating provided formal and informal socialisation mechanisms that linked actors and organisations economically and relationally. Office Plc and Found Gamma structured formal mechanisms such as project meetings, report systems and feedbacks. Formal mechanisms provided common knowledge and a sense of security in the project (Olson et al., 2002). Informal mechanisms included individual relationships as well as equivalent knowledge bases between two parties, which reduced perceived risks and facilitated emergent meanings (Lawson et al., 2009). Office Plc and Found Gamma maintained
firm-level communication through scoring and feedbacks. Multiple routes and levels of communication created abundant connections that ameliorates the need for 'safety nets' to prevent communication breakdown (Staber and Sydow, 2002). Office Plc and Found Gamma were also bounded by relationship-specific investment in the form of small and big actions such as excelling goals, prioritising resources and extra help. Different from economic hostages that bound organisations by legal or private orders, such relational investment was driven by and sustained reciprocity and equity between two parties (Swärd, 2016). The dialogic communication, equivalent knowledge from project level to management level and consistent teams throughout the service provision largely facilitated mutual understanding (Ballantyne and Varey, 2006). Collaborating was firstly driven by efficiency gained from early involvement for joint planning and value engineering. The dialogic communication helped sustain collaboration by initiating a sense of equity between two parties. In joint activities, Found Gamma provided consistent service, effective solutions, rigorous H&S procedures and quality design, which, as Office Plc learnt reflexively and experientially, led to the perception of trustworthiness in terms of competence and integrity.

Once during the tendering period, they were with us. When they won the job, they worked with us to make sure that we’ve got a) the right solution, b) understood the problem of the main tunnel...So before and after they won the job, in terms of communication and working with us and solving problems, they’ve been really good' (Project manager, Office Plc).

Shared intentions also emerged in the two-way communication, 'we share that, we talk about it, how we make it work...we all get on, we all want to make it successfully' (Project director, Office Plc.), and both parties expressed 'You are only as good as your last job' (Quantity surveyor, Found Gamma) and 'got pride on what we do' (Project director, Office Plc.). The interpretations of competence and intentions eventually routinised as service processes continuously repeated. Trust as a rule of signification and collaboration form a self-reinforcing cycle in the service process. Competence and intention trust serve as a medium and outcome of collaboration.

When emergent changes occurred and caused uncertainties in interactions, as the case of contract change, the virtuous cycle helped form the faith in Found Gamma’s actions and motivated actors to use trust relations to coordinate communication and resources under uncertainties, instead of using contractual mechanisms opportunistically and profiting from the other party. Collaborating based with shared intentions and reciprocity encouraged value co-creating where actors and organisations were socially-orientated and considered mutual benefits. Further, the repetitive trust-based service exchanges formed relational norms that maintained collaboration through relational control. Actors and organisations refrained from opportunism and maintained relational thinking and social orientations;

…working together, collaboratively, understanding each other’s drivers and trying to help each other...We have to do what we say on the table. If you’ve made a mistake we have to pay, we have to pay them what is due. Who says we are going to do something, we have to do it ...if you are a gentleman, if you have a handshake, you have to stick to. Integrity and honesty…it should go for both companies…work together to make it success' (Project director, Office Plc).

The effectiveness of value co-creating in the service provision and outcomes encouraged the repetition and eventually routinisation of using trust relations as social capital to coordinate service exchanges; the more trust-based service repeated, the more trust gained (Coleman, 1988; Nooteboom, 2002). In turn, trust as an appreciating asset and rule of legitimation supported the continuity of value co-creating.
However, with more knowledge about each other, actors and organisations might find divergent interests, as the early stage of contract negotiation between Office Plc and Found Gamma. Office Plc imposed risk terms on subcontract so to extract safeguards for self-interests. Using power in this way was based on the transactionally-based interpretations of supply chain relationships, which hindered trust (Inkpen and Currall, 2004). Power also offered the ability to structure the project. The adoption of standard procedures and structures helped engender a sense of reliability and initiated collectively accepted norms of conduct, which helped develop trust. As the project proceeded with good performance, Office Plc increased confidence and started to delegate authorities to Found Gamma. In other words, using power to structure the project provided a condition for, rather than an alternative to trust (Poppo and Zenger, 2002). Controlling was found primarily to reduce uncertainties and increase confidence in the service provision and outcomes, instead of detecting opportunism.

Structural Conditions

Apart from interaction processes, structures of different levels of project ecologies created conditions that influenced the supply chain relationship. At the project level, the complexity and uncertainty of the project Beta increased the professional requirements that fewer piling contractors could satisfy. Fewer alternatives equivalent to Found Gamma in the market gave Found Gamma more or less power and increased interdependence in the relationship between Office Plc and Found Gamma. At the organisation level, Office Plc.’s SCM systems gathered, transferred, retained and transformed supplier information between the project and firm levels and across projects. These systems helped fill in the gap of inconsistent personnel across projects. By looking at the information in the systems, key actors who had no prior experience with the other party, such as the quantity surveyor and project manager in the project Beta, were able to know about their suppliers’ trustworthiness before direct interactions. Despite the negative performance in the last project, Found Gamma’s overall performance as retained in systems furnished the initial interpretation that Found Gamma’s technical and financial capabilities satisfied project requirements. That Found Gamma belonged to the major construction company, Gamma UK, supplied a sense of security and increased perceived trustworthiness in terms of Found Gamma’s financial reliability, resource availability and H&S measures. The perception of external risks reduced. Nevertheless, no future project between two companies after the project Beta balanced the self-reinforcing cycle of trust and value co-creating. With no business secured in the near future or a well-structured strategic relationship, most project actors focused on short-term profits that could be gained through delivering the project Beta (Ebers and Maurer, 2016). Furthermore, learning was largely based on project-specific tasks, focusing on ‘whatever…to get the job built quicker and more efficiently’ (Project manager, Found Gamma). In this vein, without the organisational support and structured relationships for future businesses, relationship value and trust might easily lose when individuals were redistributed, and trust relations were not embedded in the firm level (Smyth, 2015).

CONCLUSIONS

This research offers a theoretical lens, the lens of structuration theory (Giddens, 1984), to view construction supply chain relationships and trust. In this manner, this research enlightens a way of building theories in CPM. This is the first contribution of this study. Based on the concept of the duality of trust, the empirical finding illustrates five fundamental processes of constituting construction supply chain relationships and their interplays that form a self-reinforcing cycle of trust and collaboration. This recurrent
relationship between trust and collaboration responds to trust as social capital (Coleman, 1988), whose value increases through its use. Trust as a rule of legitimation emerges in the self-reinforcing cycle where reciprocity and equity formed and sustained collaboration (Swärd, 2016). The role of reciprocity and equity differentiates transactional interactions with relational ones. Whereas the latter is driven by responsibility, the former is for accountability that ties actions with ‘the normative component of the rationalisation of action’ (Giddens 1979: P.85). In this vein, collaborating in construction supply chains is not only about risk mitigation but also risk sharing. The paper also demonstrates how relationship constitution is an engineered but also emergent process by introducing the concept of two-fold learning. Apart from intentional learning from the trust, experiential and reflexive learning also induce the interpretation of competence, integrity and benevolence. In other words, trust can be routinised as a phenomenon that enables and constrains actors’ behaviour (Nooteboom, 2002). The development of trust consists of intuition and tacit knowledge and is not purely calculative or rational (Smyth et al., 2010). The concept of two-fold learning also implies that trust can grow in the structuring of power. Viewing trust and power in this way differs from research that regarded trust and trust in a linear relation (cf. Inkpen and Currall, 2004; Poppo and Zenger, 2002). Finally, by investigating the past and contemporary experiences, this study shows that the shadow of the past has strong influences on the project organising and relationships at the front end and the shadow of the future affects the trust and relationship, particularly by the end of the project (Ebers and Maurer, 2016).

REFERENCES


Constitution of Construction Supply Chain Relationships


LEARNING MECHANISMS AND EVOLUTION OF COMMERCIAL CAPABILITIES FROM THE PROJECT OWNER PERSPECTIVE

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The management of owner-supplier relationships has been widely recognized as vital in the construction management literature. Project owners rely on various suppliers for services and materials and thus need the abilities to deal with the commercial interfaces with them. Such abilities, reflected in collective activities and routines to manage the owner-supplier interfaces, are referred to as commercial capabilities. This research takes as a starting point the critical role of project owners and their commercial capabilities in effective project delivery. Project owners operate within a dynamic construction environment. They thus have to develop, alter, or reconfigure their commercial capabilities to respond to changes and deal with corresponding challenges. The dynamic capability view is introduced to understand the trajectories of how project owners develop commercial capabilities. Following the evolutionary line of thinking on dynamic capabilities and research on organisational routines, capabilities are considered as learned and routinized activities through which organisations could generate and modify their operating routines. Two stages of the capability evolution process are considered: capability establishment and development. Drawing upon the dynamic capability literature and the role of learning, we argue that owner commercial capabilities are shaped by the co-evolution of three learning mechanisms: experience accumulation, knowledge articulation, and knowledge codification. Propositions regarding the role of project-based learning in the different stages of capability evolution are developed. This paper contributes to guiding future empirical studies into how project owners develop and alter their commercial capabilities to address changes.

INTRODUCTION

Project owners rely on a range of suppliers to undertake projects, who provide various project-related services to the projects, forming owner-supplier commercial interfaces (Winch, 2014). Such interfaces reflect different levels of cooperation and collaboration between project owners and suppliers, which are essential elements for effective project delivery outcomes. The nature of these ties between owners and suppliers has been widely acknowledged as central to project success in the construction management literature (e.g. Winch, 2014; Suprapto et al., 2015). Here, the general consensus is that it is important to manage owner-supplier commercial interfaces for effective project delivery.

To manage owner-supplier commercial interfaces, both project owners and suppliers need in-house abilities to make use of their resources, skills, experience, and competences. Such abilities, which are reflected in collective activities, processes, and routines are

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dubbed commercial capabilities (Winch and Leiringer, 2016). Project owners, as relatively permanent organisations, initiate projects, procure the services and materials from suppliers, and ensure the delivery of the projects they have invested in. Considering the central role of project owner organisations, this research takes as its point of departure the importance of project owners and their commercial capabilities in project delivery. At the heart of the research lies the argument that project owners need commercial capabilities to manage the interfaces with suppliers for effective project delivery.

Capabilities evolve over time in changing environments. As relational contracting is becoming more common, e.g. alliancing, framework agreements, integrated project delivery and various forms of public-private partnerships, project owners encounter new contractual and relational challenges and the procurement process has been subject to changes (e.g. Caldwell and Millen, 2009; Hartmann et al., 2010). Yet, most of the professional and academic discussion focuses on the demands put on the project supply side and how suppliers are accommodating and adapting to changes in procurement and delivery methods.

Less attention has been directed to the organisational challenges that client organisations face (here we will henceforth use the term owner as this encompasses a broader responsibility and engagement in the project life-cycle). The ethos of relational procurement will, at least partially, challenge the processes and routines associated with a more conventional approach to procurement. It is, therefore, likely that new capabilities will have to be developed within the owner organisation and the roles and responsibilities of individuals will need to change accordingly. As a consequence, project owners need to build up and initiate new types of commercial capabilities or develop and update their existing capabilities to deal with such challenges. However, questions remain as to how commercial capabilities are established and subsequently developed and how project owners respond to changing situations in the project-based setting.

Following the dynamic capability view (e.g. Teece et al., 1997; Eisenhardt and Martin, 2000; Zollo and Winter, 2002), which considers capabilities as learned and routinized activities, this paper aims to outline the process of how owner commercial capabilities evolve through project-based learning and learning mechanisms. Two stages of capability evolution processes are considered: capability establishment and development. Based on a comprehensive literature review, a theoretical framework along with three primary propositions is put forward, which helps provide an integrated picture of how project owners respond to changes by establishing and developing commercial capabilities. It is argued that addressing the trajectory of how commercial capabilities evolve helps us better understand the two stages of capability evolution i.e., how project owners respond to changing situations, how they respond to changes with new procurement strategies, and how project-based learning mechanisms play critical roles in the process of capability evolution.

**Project Owner Organisation and Project Capabilities**

Whilst both clients and suppliers are relatively permanent organisations, which together make up a temporary organisation, the suppliers are project-based and derive most of their business from projects. The owner’s core operations are, on the other hand, commonly outside the project domain (Winch, 2014). This is especially true in the public sector - where the key concern is the operation and maintenance of the completed infrastructure assets rather than their production. The nature and amount of projects a project owner undertakes quite naturally vary; from routinely undertaking multiple similar projects, through having some routine projects coupled with the odd one-off
project, to only very rarely having to invest in new infrastructure. Regardless of which, investment in infrastructure assets is, for the vast majority, inherently lumpy compared to managing operations, and therefore poses a number of challenges in terms of managing individual projects, programmes and portfolios. These challenges are further amplified by the changes in the environment in which they operate.

Responding to such challenges is impeded by that most project owners are forced to rely on the supply side to undertake project-related tasks and activities, for which they have no permanent in-house capacity. This has long term implications as it affects their ability to engage in learning and development (Winch and Leiringer, 2016). Consultants and suppliers become repositories of knowledge, as well as the direct recipients of experience on a project, with the owner having little to no technical input. Furthermore, even when owner organisations decide to engage in learning, they may find it challenging to value, assimilate and exploit the new knowledge that is brought into the organisation due to a lack of prior related knowledge. Or put somewhat differently, they may lack sufficient absorptive capacity (Harvey et al., 2010) to do so. This is particularly challenging when projects are variable and infrequent.

There is a growing body of literature that seeks to apply the dynamic capability concept to the project-based setting, coupled with an emerging literature on project capabilities (see Davies and Brady, 2016; Winch and Leiringer, 2016). Of importance here is that, as Winter (2003) points out, what constitutes a dynamic capability for a purchasing firm may be an operational capability for a supplying firm. The purchaser firm engages in projects due to a need to acquire infrastructure which allows it to conduct and develop business. Hence, these organisations’ operational capabilities are not normally geared up for projects, and dynamic capabilities are required to meet requirements needed to engage in them. It follows that project capabilities for a supplier firm of productive assets may be operational, but for a purchaser firm they are mostly dynamic. Or put somewhat differently, investment projects are fundamentally about change in the client organisation - either extending in scope operational capabilities or creating new ones to meet new challenges.

The Dynamic Capability View

Rooted in the resource-based view of the firm (RBV) (Penrose, 1959), the capability literature argues the importance of organisational competences and capabilities in organisations' sustained growth (e.g. Zollo and Winter; 2002; Helfat et al., 2007). Subsequent work considering the rapidly changing environments (Teece et al., 1997) put forward the dynamic capability view (DCV) which posits that firms’ competitive advantages stem from dynamic capabilities to adapt, integrate, and reconfigure internal and external organisational skills, resources, competences, and routines in the face of a rapid changing environment. The DCV has received significant scholarly attention and three major research streams have materialised as categorized by Schreyögg and Kliesch-Eberl (2007): the integrative approach, the radical dynamization approach, and the innovation routines approach. The first two follow the RBV and are inspired by Teece et al., (1997) and Eisenhardt and Martin (2000) respectively. The third is influenced by the evolutionary economics view and its focus on organisational routines (Nelson and Winter, 1982; Zollo and Winter, 2002). Though the two perspectives - RBV and evolutionary economics view - originate from different theoretical foundations, both consider dynamic capabilities as learned, patterned, and repetitive activities embedded in strategic processes and routines.
The research presented in this paper follows the evolutionary approach, which offers a theoretical lens on how organisations change in time and space based on the evolution, adaptation, and replication of routinized behaviour (Nelson and Winter, 1982). This line of thinking considers routines as the fundamental ‘building blocks’ of capabilities, with a focus on how they are used to execute and coordinate tasks and activities (e.g. Helfat and Peteraf, 2003; Helfat et al., 2007). Evolutionary scholars distinguish between dynamic capabilities and operational capabilities, from a hierarchy perspective (Zollo and Winter, 2002; Helfat and Peteraf, 2003). Operational capabilities are related to the way organisations regularly function and operate (Winter, 2003; Zahra et al., 2006). They capture the day-to-day, month-by-month abilities of an organisation to deliver on its mission and maintain existing or current products or services (Helfat and Peteraf, 2003; Helfat and Winter, 2011). Dynamic capabilities, on the other hand, are about change and considered as higher-order strategic routines and collective processes that aim to create, integrate, modify, extend or reconfigure lower-order operational capabilities in a changing environment (Zollo and Winter, 2002; Helfat and Peteraf, 2003; Winter, 2003; Helfat and Winter, 2011). They capture the abilities of organisations to change and develop in order to meet new challenges for improved effectiveness (ibid.).

Owner Commercial Capabilities

Anchored in the capability literature, owner commercial capabilities, as a sub-set of owner project capabilities, refer to project owners’ abilities to manage commercial interfaces with suppliers for effective project delivery (Winch and Leiringer, 2016). Reflected in a series of organisational activities, processes, and routines, owner commercial capabilities comprise three main capability sets: packaging, contracting and relational capabilities (ibid.). Packaging capabilities refer to the owner's ability to develop contracting strategies by dividing the project scope into market-friendly clusters of work and coordinating the interfaces among packages, which include the processes such as finalizing the project scope, defining work breakdown structure, identifying resource requirement and refining the sequencing of work.

Contracting capabilities stand for the ability of project owners to identify, select, and motivate potential project suppliers. They are embedded in the organisational routines and procedures to understand the structure of the supply market, ensure the competitive tension through procurement processes, and design appropriate incentives to motivate desirable behaviour of suppliers through pricing options and contract mechanisms. Relational capabilities are considered as applications of socially complex routines, procedures, and policies in inter-organisational relationships, comprising organisational solutions, procedures, and competences (Johnson et al., 2004; Hartmann et al., 2010). They are also needed to perform in and benefit from inter-organisational relationships.

Commercial capabilities are subject to evolution under changing and dynamic environments influenced by both endogenous factors and exogenous stimuli (Adam and Lindahl, 2017). Endogenous factors may include managerial decisions of senior managers or internal organisational problems and feedback; while exogenous triggers could be associated with economic, political, technological, institutional, and social changes, such as adoption of a new technology or changes in government policies (Teece et al., 1997; Zollo and Winter, 2002; Lavie, 2006). Such dynamism may lead to the existing capabilities being outdated (Zollo and Winter, 2002). When responding to changes, project owners face the challenges of either initiating new activities and routines or developing their existing processes and routines so that they better fit the changing context. The first stage is commonly referred to as capability establishment (Helfat and
Peteraf, 2003; Killen et al., 2008), or sometimes capability founding, emergence, or creation (e.g. Keil et al., 2009). This stage often occurs where existing patterns are disrupted, resulting in an initial introduction of a capability or a re-building or replacement of the main elements of existing capabilities (Killen et al., 2008). The subsequent stage to develop existing capabilities is referred to as capability development. It encompasses evaluating, modifying, and adjusting existing capabilities, which enables the organisation to respond to changing situations gradually (Helfat and Peteraf, 2003; Killen et al., 2008). The two stages of capability transformation are illustrated in Figure 1.

![Figure 1: Capability evolution stages: establishment and development](image)

**Project-based Learning and Learning Mechanisms**

Building, developing, and accumulating capabilities is not an automatic process. Dynamic capabilities are acquired in different ways and the process is heavily influenced by historical factors (Teece et al., 1997). This means that some capabilities can be developed rather quickly, e.g. through employing new staff or hiring consultants, but most can only feasibly be developed over time and is underpinned by various forms of learning (e.g. Teece et al., 1997; Zollo and Winter, 2002; Helfat, 2007). In construction, project owners organise their resources and accumulate experience in commercial management through implementation of projects. In this setting activities and learning are project-based.

Project-based learning is thus considered to lay the foundation for capability development and evolution (Scarbrough, 2004) and encompasses both the creation and acquisition of knowledge within projects and the subsequent transfer of such knowledge to other parts of the organisation, including other projects (DeFillippi and Arthur, 1998; Swan et al., 2010). In other words, project-based learning includes both intra-project learning and inter-project learning (Scarbrough, 2004, Swan et al., 2010). Intra-project learning occurs when new knowledge and skills are explored and generated within the projects, while inter-project learning occurs when existing experience and routines are exploited, transferred to other projects, and deployed within the wider organisations.

Project-based learning consists of three primary types of learning mechanisms at individual, project, and organisational levels (Prencipe and Tell, 2001; Swan et al., 2010): experience accumulation, knowledge articulation, and knowledge codification (Zollo and Winter, 2002). Experience accumulation refers to the central learning process by which operating routines have been developed (Zollo and Winter, 2002; Killen et al., 2008). Experience accumulates automatically as organisations perform their tasks and activities and thereby forms and refines organisational routines. Based on accumulated experience and knowledge embedded in individuals, the second process refers to a deliberate process
through which implicit knowledge is articulated by collective learning, reflected in discussions, debriefing sections, and performance evaluation processes among individuals or group members (ibid.). This process occurs when individuals and groups express themselves, share opinions and experience with each other regarding their previous tasks or activities and improve their understanding of links between actions and performance (Prencipe and Tell, 2001; Eriksson and Leiringer, 2015). Based on the articulated knowledge, knowledge codification happens when tacit knowledge becomes explicit, and individuals codify their understanding of performance implications of routines into written or spoken words or procedures, such as manuals, lists, blueprints, guidelines and decision support systems (Zollo and Winter, 2002), which could be kept at the organisational level. These three types of learning mechanisms form the cornerstone of dynamic capability evolution.

THEORETICAL PROPOSITION DEVELOPMENT

Both endogenous enablers and exogenous shocks could bring about commercial pressures for project owners. To deal with such challenges, they need to introduce and acquire new commercial patterns and routines into organisations and subsequently develop these routines and capabilities so that they could maintain commercial capabilities to manage suppliers. Based on the two stages of evolution for commercial capabilities and considering the role of project-based learning, we here put forward three theoretically driven propositions regarding how project owners based on learning processes and mechanisms establish and develop their commercial capabilities. Our intention is for these propositions to form the basis for further work exploring how commercial capabilities are established, developed and maintained.

1) Proposition on Capability Establishment and Intra-Project Learning

The capability establishment stage signifies an initial introduction of new patterns and routines into organisations (Killen et al., 2008). Learning begins with experience, which is an essential element in driving capability evolution trajectories. Experience could be gained from others such as vicarious learning (Huber, 1991), and from own experience such as trial and error learning or learning by doing (Zollo and Winter, 2002). Lavie (2006) also argues that the reconfiguration of existing capabilities involves both learning from internal source of knowledge and experience accumulation and external sources such as industry associations or newly hired employees. On one hand, the acquisition of experience and integration of external knowledge to organisations can be achieved by merging with and acquiring firms, learning from other firms, engaging in joint ventures and inter-firm alliances, or hiring personnel with required knowledge and skills (Lavie, 2006). On the other hand, capabilities could be internally built on the resources, individual skills, knowledge within organisations and collective learning through the path-dependent process of trial and error, feedback, and evaluation (Zollo and Winter, 2002; Lavie, 2006).

For project owners to respond to changes in construction practice, for instance adopting a new procurement strategy, new areas of knowledge, commercial skills and routines are required to obtain or initiate (Killen et al., 2008). Externally speaking, when initiating a new capability, since project owners often do not have access to enough historical experience, they would absorb experience from other firms. For instance, they could learn from other firms with similar experience, hire knowledgeable employees, or depend on third party consultants. Internally, wherever possible, they rely on existing commercial capabilities, but they also have to build up new areas of commercial knowledge, expertise, and routines to meet the changing requirements. During this
process, intra-project learning or learning within projects plays a fundamental role, where the experience gained is held in common by the group involved in the project (Brady and Davies, 2004). Thus, acquiring experience from others and relying on intra-project learning are two major components of commercial capability establishment. Therefore, in light of the above discussion, the following proposition is proposed.

**Proposition 1:** New owner commercial capabilities could be established through a combination of capability acquisition from external environment and capability building within organisations through intra-project learning.

2) **Proposition on Capability Development and Inter-Project Learning**

After a new capability set has been established, the next step towards development is an accumulated process that enables the updating, adaptation and adjustment of existing capabilities. This stage usually takes place under conditions of stable environments with gradual and incremental changes, where individuals refine and modify their existing knowledge, competences and skills (Zollo and Winter, 2002; Killen *et al.*, 2008). Capability development activities are reflected in the refinement and extension of existing knowledge, skills, competences, and technologies and are the results of direct effects of organisational learning, such as experimentation, learning-by-doing, trial-and-error learning, problem-solving learning, and improvisation (e.g. Teece *et al.*, 1997; Zollo and Winter, 2002; Helfat and Peteraf, 2003). The modification of existing routines and capabilities is continuous and path dependent, developed by internal learning through trial and error, feedback, and evaluation (Zollo and Winter, 2002).

For construction project owners, learning-by-doing or experimental learning occurs in the project-based setting. Inter-project learning, including project-to-project and project-to-organisation learning (Swan *et al.*, 2010), is considered as attempts to capture and transfer existing routines and knowledge to subsequent projects. In inter-project learning processes, existing commercial knowledge, processes, and routines are gradually refined, modified and developed when they are transferred to other projects and the owner organisations, which results in project capability development (e.g. Prencipe and Tell, 2001; Brady and Davies, 2004; Davies *et al.*, 2016). Therefore, we assume that inter-project learning forms the basis of subsequent owner commercial capability development.

**Proposition 2:** The subsequent development of existing commercial capabilities in project owner organisations is mainly based on inter-project learning.

3) **Proposition on Capability Evolution and Learning Mechanisms**

For commercial capability establishment and intra-project learning, experience and knowledge may start from a single project (Brady and Davies, 2004) where project team members accomplish commercial tasks and establish new routines. Such experience and knowledge are likely to be shared among project participants through lessons learnt meetings or communications among individuals, and then retained through post-project reviews or databases (Swan *et al.*, 2010). For subsequent capability development and inter-project learning, previous commercial knowledge embedded in individuals could move to new projects through sharing among project members, and then attempts may be made to spread knowledge throughout the owner organisations and consolidate knowledge into codified routines, in forms of manuals and guidelines. The standardized and routinized processes help ensure the commercial management of project owners in the implementation of subsequent projects. Thus, it could be summarized that three learning mechanisms - experience accumulation, knowledge articulation, and knowledge codification (Zollo and Winter, 2002) - play fundamental roles in capability evolution
Learning Mechanisms and Commercial Capabilities

processes. They form the cornerstone of both intra-project and inter-project learning processes in capability evolution. The arguments above suggest the following proposition for future empirical work.

**Proposition 3:** Owner commercial capability evolution, based on intra-project and inter-project learning, is shaped by a conjoint use of learning mechanisms - experience accumulation, knowledge articulation, and knowledge codification.

**CONCLUDING REMARKS**

Project owners, as key players in project organising, need to manage the commercial relationships with their suppliers in order to deliver the projects they have shaped and invested in. This paper takes the owner perspective and focuses on the commercial skills, competences and capabilities needed by project owners. To respond to changing situations, both endogenously and exogenously, project owners are faced with the challenges to establish or develop their commercial routines and capabilities. Owner commercial capability, as a type of project capabilities, evolve based on project-based learning, namely intra-project and inter-project learning. However, to learn from projects and transfer lessons into new routines and practices in subsequent projects is far from trivial. This paper lays bare the importance of developing dynamic capabilities to respond to changes and provides a preliminary understanding of the role of learning in commercial capability evolution.

![Proposed theoretical framework of commercial capability evolution](image)

**Figure 2: Proposed theoretical framework of commercial capability evolution**

In particular, the paper seeks to address how project owners establish and develop commercial capabilities in response to changes derived either from dynamic external environments or endogenous factors. The trajectories of how commercial capabilities in project owner organisations are argued to evolve over time through two stages: capability establishment and capability development. In order to facilitate empirical studies of how such evolution takes place, we put forward three propositions, offering a conceptual framework to understand the roles of inter-project and intra-project learning and three underlying learning mechanisms in the capability evolution processes (see Figure 2). We suggest that commercial capability establishment relies more on intra-project learning, while the subsequent development stage depends more on inter-project learning. Both stages are shaped by the co-evolution of three learning mechanisms, experience accumulation, knowledge articulation, and knowledge codification.

This research theoretically contributes to dynamic capability literature by outlining the concept of commercial capabilities and evolution trajectories of owner commercial capabilities in the project-based organising context. Focusing on the owner perspective, it
also provides a better understanding of how project owners employ dynamic capabilities to deal with changing situations. The three propositions form a starting point for further empirical studies to investigate how project owners establish and develop their commercial capabilities through project-based learning. Future research is also encouraged to focus on what core commercial capabilities are needed, what causes the alternation and modification in commercial capabilities, and how commercial capabilities evolve in different types of project owner organisations, as well as how the capability evolution processes vary in different project-based domains.

REFERENCES


DELAY FACTORS FOR INTERNATIONAL ENGINEER-PROCURE-CONSTRUCT (IEPC) HIGH-SPEED RAIL CONSTRUCTION PROJECTS

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Due to complex projects and diverse risks, schedule delay has always been one of the major problems in high-speed rail construction. Chinese infrastructure companies are the main force of the international market after the Chinese government implemented the One Belt and One Road initiative (OBOR). Currently, more than 10 international engineer-procure-construct high-speed rail (IEPCHSR) projects are being considered or undertaken overseas by Chinese companies. However, delay has severe consequences for the progress of most IEPCHSR projects. The aim of this study is to identify the significant delay factors for IEPCHSR projects. This study was conducted as an exploratory study through literature review and semi-structured interview with seven managers from Chinese IEPCHSR related companies. Result reveals that some delay factors concluded from general international infrastructure projects are also applicable in IEPCHSR projects. In the engineering phase, inappropriate management in design management, inefficient land acquisition, design changes and lack of EPC subsidiary contract management for HSR projects are likely to cause delays. In the procurement phase, improper procurement prepared, under-estimated procurement price, unreliable agency, and inefficient logistics in equipment and labour are leading causes. In the construction phase, the significant delay factors are improper construction task planning, inexperienced site supervision, ineffective technical standard management and ineffective continuous progress payment. Further study will analyse their interrelationships with Chinese construction companies using a questionnaire survey and structural equation modelling (SEM) technique. The result from this study should enable the Chinese HSR practitioners to gain a better understanding of the inter-relationships between the different potential delay factors.

Keywords: delay factors, high-speed rail, International EPC projects, China

INTRODUCTION

High-speed rail (HSR) is currently regarded as one of the most significant technological breakthroughs in passenger transportation development (Campos and De Rus, 2009). Meanwhile, HSR is not only a significant booster of socioeconomic development and the cornerstone of many industries, but also provides a new alternative to flying or driving, reduces national dependence on oil, and fosters urban and rural community development. Due to these features, a growing number of countries regard HSR projects as an important part for promoting economic development. There has been a fast development in the global HSR network over the past two decades, with 34000 km of HSR networks completed and already in service worldwide. As at the end of 2017, the mileage of HSR networks had reached 37300 km, with 15900 km of new line under construction, and

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China account for almost 60% of HSR operation mileage and almost 90% of HSR plan to build mileage respectively. HSR construction are challenging infrastructure projects globally, and countries such as France, Germany, Japan, Spain and China (leaders in the core technology of HSR) are intending to apply their HSR knowledge to other countries, causing fierce competition in international market. In addition, the engineering-procure-construct (EPC) approach has become a favoured delivery system that combines the procurement of construction service in one contract for megaproject. Although early study has drawn a substantial attention about HSR, researches related to features like long distance, complex geographical conditions, complex construction technical and infrastructure projects especially international engineering-procurement-construction high-speed rail (IEPCHSR) projects are still unexplored.

China has been leading the HSR technological development worldwide (Shao et al., 2017). After the Chinese government implemented the One Belt and One Road initiative (OBOR), Chinese HSR is popular in international market because demand for high-speed rail has increased in OBOR countries, and Chinese HSR has low construction cost per km. However, technical incompatibility, inexperience operation management system and unfamiliar with overseas market rules were the huge barriers which restrict Chinese HSR exportation. The Chinese government has implemented international HSR projects in Morocco, Saudi Arabia, California in the US, Indonesia, Iran, and Poland. However, owing to ineffective understanding of the EPC delivery approach and inexperience in dealing with a wide range of risks in working in the challenging international environment, many Chinese companies have suffered from delays in the delivering of EPC projects, for example, the Turkish Ankara to Istanbul HSR project, which was constructed within 8 years by a Chinese and Turkish consortium; the Saudi Arabian Haramain HSR project constructed from 2009 to 2017, expected to be operational in 2018; and the Venezuelan HSR project, which was constructed from 2009 with a project duration of 36 months, but which was shut down immediately. Despite current studies identified and classified delay factors with projects in different field and worldwide area, specific delay factors in IEPCHSR project still need to be conducted.

HIGH-SPEED RAIL RESEARCH AND DEVELOPMENT

High-Speed Rail Project

High-speed rail network has been an explosive growth worldwide; Campos and Rus (2009) found that 23 countries are considering HSR project (UIC, 2017). Many scholars investigated HSR project mostly in Asia and Europe, and they concerned about financial and region impact by HSR project. Cheng et al., (2015) explores the development of HSR as an instrument for promoting economic integration both through enhancing competitiveness and achieving greater economic cohesion in China and the European Union. A limited number of HSR studies have explored HSR projects under international market. After China implemented the OBOR initiative, researchers began to investigate HSR implemented under this initiative. Wang et al., (2018) stated that with the advancement of China’s OBOR policy and subsequent development of HSR projects (i.e. Trans-Siberian Railway, Pan-Asian HSR, Central Asia HSR, Eurasian HSR, China-Russia-Canada-USA HSR) have gradually promoted Chinese HSR transportation projects agenda. Shao et al., (2017) proposed a method for the selection of the most urgent need for transnational HSR construction in the OBOR region. However, they only discussed the HSR project from political strategy, and few studies pay attention on construction management of international HSR project. Meanwhile, Wang and Huang (2017) indicated that China has specific expertise in high-speed trains, communication signals,
traction power supply, public works, system integration, security monitoring, operation and management. The above-mentioned expertise and economic development agenda has led to Chinese worldwide expansion of HSR construction and has become a unique case for international HSR construction research.

**International EPC Project**

International projects adopted various delivery methods such as Build-Operate-Transfer (BOT), Design-Build (DB), Public-Private Partnership (PPP) and EPC. Only a few studies investigated HSR project based on those methods, where Chou *et al.*, (2012) compared the use of PPP policy between HSR projects and general infrastructure projects, and the results reveal that most experience learnt from general infrastructure projects is also applicable in HSR projects after some adjustments. However, we could only find out few researches related to IEPCHSR project. An EPC contract typically covers project management, site management and supervision, engineering, materials and equipment, civil works, foundation and site infrastructure works, transport and installation, and commissioning, as well as scheduling and performance guarantees for the entire solutions (Du *et al.*, 2015). Based on those issues, Galloway (2009) stated the high risks of EPC contract, and the study pointed out that owners shift their risks to contractors through this delivery approach. Meanwhile, international infrastructure construction projects are prone to delays. A common characteristic of infrastructure construction is that they are dynamic and complex with various parties’ agenda which can be conflicting, comprise many stages of work, entail long periods to completion and have high levels of uncertainties and face complex geological ground conditions (Al-Kharashi and Skitmore, 2009). Hence, there is an urgent need to investigate delay factors in IEPCHSR project.

**Construction Delay Management**

Previous studies have been explored the construction delay research from three related fields. Fallahnejad (2013) identified and ranked the cause of delay in long distance project such as pipeline in Iran, which imported materials, unrealistic project duration and client-related materials are the top three factors. Highway and railway are the most similar projects to HSR, and these types of project have a linear character and need long path to be executed. Han *et al.*, (2009) investigated the critical delay causes in Korea Train Express project, and found that lack of owner’s abilities, conflict between public agencies and inappropriate delivery system are the main causes. Public infrastructure project had also been explored. Al-Khalil and Al-Ghafly (2010) determined the most important cause of delay in public utility project in Saudi Arabia, which contractor, owner and consultant are three major parties, with important causes of delay like cash flow problem. Despite some literature on construction delay factors, the IEPCHSR project management is still difficult to be fully addressed due to its unique features.

Identifying delay factors can be studied from different aspects. Yang and Wei (2010) analysed delay problem in planning and design phases, which "changes in client's requirement" are the main causes. However, lack of studies concerned about delay factors in IEPCHSR project implementation phase. Meanwhile, previous studies have conducted researches in different countries and different areas. Different conditions may cause a difference in project environment and its context (e.g. economy, politics, culture, weather) and many other characters of a region or country create a unique environment for its project. Arditi *et al.*, (2017) studied the effect of organizational culture on delays in construction companies located in the U.S and India. From their findings, they indicated that different causes of delay are experienced regardless of the national cultures.
in different geographical regions and higher executives of international companies should be prepared for the different organizational cultures.

Furthermore, construction delays adversely impact on project stakeholders including local government, main contractors, financial investors, and users amongst others (Faridi and El-Sayegh, 2006). Sage and Dainty (2014) stated that across infrastructure construction project, complex geological ground condition involved vary stakeholders even with wild animals. The problems for IEPC project are due to uncertainties in estimating, contracting, design, procurement of equipment and materials, construction, economic and political circumstances, technology issues, and the use of management techniques (Du et al., 2015). When Chinese companies exported IEPCHSR project, they often set up a construction consortium whose typical structure is presented in Figure 1. A comprehensive review of HSR project exportation for Chinese companies and its significant delay factors have not sufficiently investigated. Due to lack of experience in contract management and inefficient construction delay management, almost all the HSR project suffered huge loss and failed delivery.

Thus, above all mentioned in literature reviews, it seems that there is a research gap in IEPCHSR delay factors, and the research objectives in this study can be summarized, 1. To investigate the management status of IEPCHSR construction projects among Chinese companies; 2. To identify critical delay factors in IEPCHSR project from E, P and C stages.

**Figure 1: Structure of IEPCHSR project**

![Figure 1: Structure of IEPCHSR project](image)

**METHOD**

To achieve the research objectives, a qualitative and exploratory semi-structured interview were conducted in Chinese companies which are the main stakeholders in HSR construction consortium. Of the high number of Chinese companies implementing international projects in overseas markets, only a few companies have ability to undertake HSR projects. Thus, seven companies were finally selected. This study selected one respondents from the middle and top management levels with five to fifteen years of experience in IEPCHSR projects from each company. For this qualitative research, seven respondents (see Table 1 for background and experience) were interviewed, selection based on that suggested by Creswell et al., (2004), who recommended that for a phenomenological study the number of interviewees could range between five and twenty-five. All the respondents were contacted by relying on personal contacts to reach IEPCHSR project professionals. Although the number of interviews was relatively small, they were comprehensive and lengthy, and they covered a wide variety of IEPCHSR projects which were processed by those companies. First, this study scrutinizing two railway projects implemented by Chinese companies in Africa, which railway project have a linear character and they share a lot of common problem and challenges (Fallahnejad, 2013). Furthermore, the interview consisted of 10 questions, and all questions were developed based on documents scrutinized and previous studies of delay.
factors in different projects. The respondents were asked to indicate the causes of delay associated with the E, P and C phases of IEPCHSR projects. The author translated all questions from English to Chinese, and interviews were conducted in Chinese. The open-ended interview questions were designed to collect narrative responses, contextualizing the individual perspectives of each respondent, while allowing the expression of individual views. Some of the interviews were conducted face-to-face and others were conducted by telephone, mainly because such respondents could not make time for the interview during the normal working hours. The duration of each interview session was about 40-60 minutes. The interviews were recorded and transcribed and the qualitative data analysed using thematic analysis suggested by Reissman (2008), and this method involves structural analysis and dialogic/performance analysis.

RESULTS AND DISCUSSION

As discussed in former section, respondents in the interviews focus on three themes related to IEPCHSR project: Engineering, Procurement and Construction. Identification as well as what delay factors in these themes critically affecting IEPCHSR project to ensure of the implementation of those projects. The responses from seven interviewees are summarised and presented in the following subsections. Out of seven respondents to answer questions in each stage, only five respondents answered question in Engineering, four respondents answered question in Procurement and Construction, which questions related to their working area.

Table 1: Companies' and Respondents' general background

<table>
<thead>
<tr>
<th>Respondent selected company</th>
<th>Type of Company</th>
<th>Respondents' Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. China Railway International Co., Ltd., (CRIC)</td>
<td>Client</td>
<td>10 years</td>
</tr>
<tr>
<td>2. China Civil Engineering Construction Corporation (CCECC)</td>
<td>Civil-related</td>
<td>12-13 years</td>
</tr>
<tr>
<td>3. China Railway Group Limited (CREC)</td>
<td>Contractor</td>
<td>11 years</td>
</tr>
<tr>
<td>4. SINOHYDRO Corporation Limited (SINOHYDRO)</td>
<td>Electrical-related</td>
<td>8 years</td>
</tr>
<tr>
<td>5. China Railway Design Corporation (CRDC)</td>
<td>Designer</td>
<td>15 years</td>
</tr>
<tr>
<td>6. CRRC Qingdao Sifang Corporation (CRRC)</td>
<td>Vehicle-related</td>
<td>10 years</td>
</tr>
<tr>
<td>7. China Railway Signal and Communication (CRSC)</td>
<td>Signal-related</td>
<td>6 years</td>
</tr>
</tbody>
</table>

Engineering Phase

Although there are many delay factors identified in engineering phase by researches in former studies, engineering is still a critical process in which the owner’s requirement including wishes, desires, and needs are identified and designed to be submitted to the main contractors. Out of the seven respondents, five respondents expressed their ideas in this phase.

Respondent from CRIC stated: “IEPCHSR project is usually constructed by a consortium including main contractors and local companies, and the consortium will be in charge of all the management. International HSR line design first relies on preliminary investigation in the target country, however one of the delay factors is that all the survey tasks will be completed by the design company with local support. It means not all the construction company can participate in the pre-design and location selection.”

As mentioned in second section, IEPCHSR project involved different types of companies in construction consortium. Thus, multiple facets of consortium capability directly
impact the project schedule and cost. According to respondent from CRIC, it proved that poor consortium capability especially improper information management among all participants with a large volume of information due to complexity of IEPCHSR project which lead strong schedule delay

A respondent from CREC stated: “HSR projects involve many technical standards in engineering phase. However, many countries still follow their own standards with local organizations offering the support documents to design team, which in this situation affects the process of design tasks.”

HSR is a high-tech product, which means complex technical interfaces should be considered. Chinese HSR system has its own standard which reduce various interface link issues. However, implementing different construction and technical standard in international infrastructure market lead to schedule delay. The result proved that it is essential to uniform construction standard among organizations, and it allows active exchange knowledge, skills and technologies (Tang et al., 2006).

A respondent from CCECC stated: “Compared to traditional infrastructure project, when constructing HSR line, it will pass through different types of areas such as highway, existed railway, rivers and private area. This greatly increases the difficulty of land acquisition in a country with private ownership of land, and it also increases the proportion of bridge and tunnel. In addition, HSR projects need huge temporary areas for large precast concrete beams and track laying base for storing track resources all along HSR line.”

A respondent from CRDC stated: “IEPCHSR line is quite a long project, mainly with bridges and tunnels, and the construction usually faces challenging engineering geological condition. So, design teams have extensive design works, often face design changes and on top of that have to obtain permits from owners. However, delays in approving design documents often impact the whole construction schedule.”

Subsequently, complexity of stakeholders along the HSR line lead to massive tasks and high cost about land acquisition not only for local government but also for construction consortium. Ahsan and Gunanwan (2010) stated that international development projects can often take longer due to protracted land acquisition problems which occur as a result of local politics, land law and religious issues. Salim and Negara (2016) drew attention to Indonesia’s notoriously lengthy land acquisition process, which argued that the Indonesian government had failed to ensure land provision on time and this what caused the construction delays in Indonesia’s HSR project. Furthermore, the result stated variable geological ground conditions often caused design changes during execution phase, which because extra civil investigation, drawing design documents and approving documents from client cause serious delay.

A respondent from CRSSC stated: “International HSR project has many subsidiary contracts based on the general FIDIC (Fédération Internationale Des Ingénieurs-Conseils, 1999), Chinese IEPCHSR contractors have no experience in application of standardized forms of the EPC contract and this causes delay in contract negotiation period with owners. Hence, the slow progress negotiation with local government and companies under EPC contract is the main delay factor during the whole project.”

In addition, IEPCHSR project engineering phase include investigation, design, land acquisition, procurement, transportation, construction and alignment joint-test. Hence, when such complex projects are being transferred to global markets, the management of
standardised forms of HSR contract mode based on general EPC contract should be particularly restricted by the Chinese government and the associated companies.

**Procurement Phase**

For IEPCHSR project, the procurement phase is an essential phase the financial forecasting can reach 50% of the total contract amount, especially for those with technically sophisticated equipment. Out of the seven respondents, four respondents expressed their ideas in this phase.

A respondent from CRIC stated: “IEPCHSR often faces massive resource transport tasks, which involve kinds of equipment import and export. HSR core technical equipment mainly relies on import from Chinese companies because most of the targeted countries have low technical production level.”

A respondent from SINOHYDRO stated: “Most Chinese HSR construction companies have no overseas subsidiary especially in some developing countries. Hence, a great number of equipment and materials are imported by local agencies. However, unreliable agency and inefficient logistics seriously affected the construction schedule.”

In IEPCHSR project, the construction materials mainly rely on two parts, general materials from local market and special materials from China. Under the strict EPC contract regulation, general materials can only be procured by construction consortium from local markets, which restricts Chinese companies’ independent procurement plans. Furthermore, lack of overseas subsidiary is another delay factor in procurement for Chinese companies, which means special materials like core technical equipment can only be imported by local suppliers. However, local suppliers especially in developing countries are not expert in large-scale and high-tech machinery supply chain tasks. Hence, recognized technical standard perfection is important, which may cause schedule delay because of law issues. Our result support Pal et al., (2017) who stated EPC projects involve complex procurement contract tasks including equipment delivery and installation, maintenance, labour supply, and engineering training. HSR project procurement plan involves more technology patents and intellectual property issues and has a huge volume of equipment demand.

A respondent from CREC stated: “While Chinese companies have an experienced team not only in management but also in construction labour, the local labours are mostly lack of HSR project construction experiences. Improper labour management is one of the delay factors, because many Chinese managers do not arrange technical training between Chinese technician and local labour forces before the construction.”

As we know from the respondent, improper labour management caused lack of IEPCHSR high technicians in overseas project management and equipment operation which restrict the project schedule. Chinese companies should develop an expert team for IEPCHSR project, coping with the increasing demand of IEPCHSR projects.

A respondent from CRRC stated: “HSR projects are unimaginable expensive, and HSR project has a massive advance works before the allowance of construction. However, the strict contract regulation from EPC contract and policy limitation from Chinese government are the main obstacle.”

Improper financial planning like lower than estimated price for procurement of goods, services, and contracts are significant factors affecting project schedule delay and cost underrun (Ahsan and Gunawan, 2010). Thus, based on EPC contract, the main contractors have to gain much support from home country in both politics and finance,
and main contractor and government awareness of the EPC contract about the extent of responsibility and regulation risk they bear is strongly necessary.

**Construction Phase**

IEPCHSR construction throughout project starts from commencement at site to alignment joint-test. While HSR construction has a tremendous success focus on construction in China, it still suffers from various delay issues in international markets. Out of the seven respondents, three respondents expressed their ideas in this phase.

A respondent from CRIC stated: “Project consortium charged all the management tasks in IEPCHSR project. However, consortium had an ineffective construction planning between Chinese companies and local companies, which caused cross construction problem and construction delay.”

Having pointed to the influence of consortium capability, during project execution, schedule is also influenced by improper construction tasks implement. IEPCHSR project has various stakeholders including local companies, and those companies undertake many prepared tasks before construction consortium enter the construction site. However, improper tasks planning and delivering lead to cross construction problem. These views support Wang (2013) who stated the importance for owners to deal with the large volume of information contributed by all project participants.

A respondent from CREC stated: “IEPC contract had a strict financial regulation. In international market, delay in progress payment, exchange rate fluctuations, and improper financial procedure always cause construction delay.”

Our results discussed the importance of financial preparation in both engineering and procurement phase. However, due to a long construction period and EPC contract requests a milestone payment method for HSR project, the respondent also perceived that delay payment in project progress has significant impact. This view supports Ahsan and Gunawan (2010) who found financial crisis and loan disbursement in international environment among the construction period caused delay progress payment. This study proved such impact is growing on HSR and such infrastructure project mostly.

A respondent from CCECC stated: “When Chinese consortium construct the IECPHSR project as the main contractor, construction supervision was always conducted by the Chinese company. However, under strict construction requirements, Chinese companies had not met the requirements of international supervision standards. Inexperience site supervision of the construction process and accessing acceptance of construction results in construction quality, HSR technique, construction information, personnel training often caused construction reworks, which IEPCHSR offer suffered construction delay.”

It is highly relevant to our results that consultant plays an essential role in IEPCHSR consortium, and Chinese companies are always pointed as supervising instead of local or individual authorities. However, high technology and domain knowledge are needed in HSR complex construction procedure like track laying, tunnel holing-through, bridge erection, amongst other things. Thus, they made site supervision requires precision and accuracy to insure the high quality and schedule on time, and this require main contractors establish a cooperative partnership management in quality, schedule and environment. Under this mode, it can make clearly relationship between contractor and supervising unit with international law, regulation and environment.
CONCLUSIONS AND FUTURE RESEARCH DIRECTION

Although construction delay management in international market has drawn much attention by researchers, delays in public infrastructure project like HSR projects implemented by international consortium is hard to identify due to its complexity. Compare to previous research more concerned about general project, our study has presented a comprehensive introductory review about the status of Chinese companies which export IEPCHSR project expertise to overseas markets, in particular regarding delay factors in the international infrastructure construction market. Qualitative research was conducted by interviewing top managers from seven Chinese HSR companies. Seven respondents answered questions related to the causes of delays in IEPCHSR projects associated with EPC projects.

First, our result indicate that some delay factors identified from general international infrastructure projects are also applicable to IEPCHSR projects with proper adjustment. Then, specific delay factors were identified by summarizing the conversation from each interview from E, P and C phases. In engineering phase of the IEPCHSR, our results show that construction consortium capability affect schedule most, broadly, without a uniform construction standard in consortium established by main contract in high-tech project can lead serious construction delay. Inefficient land acquisition and design changes are two significant factors because of long and complex geological ground conditions, and a lack of EPC subsidiary contract management for HSR projects are the main delay factors.

In procurement phase, compare to previous studies concerned procurement contract, respondents focus delay problem in improper procurement planning, especially financial estimation due to unimaginable expensive HSR project. Under strict international market regulation, unreliable agency and inefficient logistics often lead to lack of core equipment and technician labour which those factors cause serious construction delay. Finally, in the construction phase, we also found that improper construction task planning in the construction consortium, inexperenced site supervision ineffective technical standard management by consultant, and ineffective continuous progress payment are the main delay factors. These key findings if properly addressed, should help enable Chinese companies to identify and minimise construction delays during IEPCHSR projects.

In future research, the study will systematically investigate the interrelationships amongst these delay factor groups identified, before proposing a conceptual framework. This will be followed by a quantitative approach using exploratory factor analysis and structural equation modelling (SEM) technique. A typical case study, Indonesia’s Jakarta to Bandung HSR project will be selected to test the theory.

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