The Role of Objects in Decision-Making Processes

The Case of an Energy Renovation

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Martine Buser, Göran Lindahl and Christine Räisänen
(Editors)

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PREFACE

For the 9th Nordic Conference on Construction Economics and Organization we have focused on quality, querying: *What happened to quality? Design, processes and outcomes*. We thought that it was timely for our research community to reflect on the research processes and methods we choose. The resulting papers, presented in this proceedings, have taken up the challenge. They also demonstrate, yet again, how strongly the research is driven by issues and phenomena that confound practice. These proceedings thus present a variety of current research approaches within the field of construction economics and organization in the Nordic countries predominately, as well as elsewhere. We hope that you will find it an interesting read.

The Nordic conference has evolved over the years from a modest exchange of ideas and concepts among Nordic colleagues to grow into an established conference with a publication and all the practices and activities common to such events. The conferences are now organized collaboratively by the Nordic research network CREON and Nordic universities, and will surely develop further. Chalmers University of Technology is the venue for the 9th conference, and we are happy to host it for the third time.

We thank all the authors, reviewers and colleagues that have contributed to an interesting and stimulating 9th Nordic Conference. Well done all of us, and keep up the good work!

We look forward to the 10th conference.

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How task heterogeneity and frequency relates to knowledge codification: Evaluating the Shared Construction Guidelines (SCG) of 24 Swedish Public Client Organizations

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Abstract

Over a sustained period of time, organizational theorists have argued that public sector organizations are more inefficient than their private counterparts. Recent studies have explained these inefficiencies as the result of having to do with capabilities rather than resources thereby calling for an improvement of the capabilities of public organizations. A key mechanism for achieving such improvements is the articulation and codification of knowledge. This study examines an attempt at codifying knowledge in the form of a set of shared construction guidelines (SCG) employed by 24 large public client organizations in the Municipality of Gothenburg, Sweden. Specifically, these guidelines are viewed with respect to the framework of Zollo and Winter (2002) in terms of how organizations with high task heterogeneity and low task frequency can more effectively develop dynamic capabilities through the deliberate learning mechanism of knowledge codification. Preliminary results indicate that task frequency and organizational size are stronger indicators than heterogeneity in deciding whether a public client organization utilizes knowledge codification systems such as the SCG.

Keywords: construction guidelines, public organizations, construction clients, capabilities, knowledge codification

1. Introduction

It has long been argued that public organizations are less efficient than private ones (Brewer, 2011; Barton, 1980; Niskanen, 1971). A common explanation for this is the difference in the level of scrutiny that public organizations face. Services provided by public organizations are, in contrast to private companies, not put through competitive markets, which makes it difficult to evaluate whether these services were provided at an optimal cost. This incentivizes public organizations to overconsume and overproduce (Vining & Wiemer, 1999). Furthermore, unlike private companies, public organizations face stricter constraints on their operating routines. These restrictions govern aspects relating to recruitment, dismissal of employees and differential employee rewards, among others. These types of restrictions imposed on public organizations were introduced with the purpose of minimizing partisan politics, but as a side-effect has made it more difficult to generate incentives for the efficient use of organizational resources (Rainey, 1983; Elling, 1986; Vining & Wiemer, 1999).

A recent development, starting around the 1990's, was the attempt by governmental agencies to separate policy oversight of public service work into smaller more manageable bureaus (Otenyo & Lind, 2006). This development occurred against the backdrop of New Public Management initiatives which put public client organizations in a rather difficult situation: they were expected to do more with less, to increase performance but with fewer resources (Adukpo & Leiringer, 2016). This has led to reframing the challenges faced by public client organizations as having to do with capabilities rather than resources (Adam et al., 2017; Adam and Lindahl, 2017; Davies & Brady, 2016; Winch & Leiringer, 2016). Research on the topic of capabilities, and dynamic capabilities in particular, has been concerned with how organizations achieve competitive advantage by integrating, building, and reconfiguring their internal and external competences (Teece et al., 1997). Writing within the same school of thought as Teece et al. (1997), Zollo and Winter (2002) introduce a framework explaining how organizations can develop dynamic capabilities through the articulation and codification of their knowledge (into guidelines, manuals etc.). This framework stresses the importance of codifying knowledge even in cases where the activity/task being codified occurs on a rare basis. It is the framework of Zollo and Winter (2002) that is used in this study to examine the shared construction guidelines (SCG) developed by the second largest Municipality in Sweden, specifically with respect to how these guidelines conform to the two main hypotheses postulated by Zollo and Winter.

1.1 Overview of the Shared Construction Guidelines (SCG)

The Shared Construction Guidelines (SCG) represents a set of standardized guidelines of the construction process for the Municipality of Gothenburg in its role as a public client. The need for these guidelines was driven in parts due to the lack of conformity that had been identified in the operating routines of public organizations in the Municipality. The procurement and construction processes of the different public client organizations in the Gothenburg region had differed greatly. As a result of this, the city council decided that there was a need for a set of standardized guidelines that ensured transparency and conformity in the way these organizations operated. Transparency in particular had been a contentious issue due to a string of corruption scandals that had been uncovered in the year (2009) foregoing the decision to develop and implement SCG. Shortly thereafter, in 2011, the city council decided that public organizations within the jurisdiction of the Municipality were to develop a joint set of guidelines regarding the construction process. The development of these shared guidelines were to continue for the following two years leading up to an implementation phase beginning from

2013 which was concluded in late 2015/early 2016. At the same time an organizational unit developoing and managing SCG was established in 2011.

Although the corruption scandals created a sense of urgency for creating reform, the initial pretext for developing the guidelines had developed slowly in the years prior. The organization of the construction client function in the municipality had during the 1990-ies been distributed to several municipal organizations and companies. Much in line with NPM initiatives that sought to decentralize public organizations (Otenyo & Lind, 2006), the recession in the 90's lead to client organizations being downsized and split into different units, functioning primarily in an administrative capacity. Around 2005 there was a development starting towards first coordination of investments, leaving maintenance and FM still distributed. The background being an increased volume of investments in public projects. In 2007 a collaboration between a number of organizations related to both housing and civil works developed further as a network between the municipal organizations and companies was initited to manage exchange of knowledge and experiences from projects in order to to handle increased volume effectively. This served as a platform for the subsequent development work with SCG.

1.2 Detailing the SCG

The SCG is supported by a web-based documentation database that serves as a library that allows employees in client organizations to download documentation that regulates and supports how the construction process is implemented. The SCG enables quality-assurance of the building process for the Municipality's building departments that provides support and guidance in the implementation of the construction contract. The system allows for any client organization that operates under the umbrella of the Municipality to gain access to the city's collective knowledge, experience, tools and methods that relate to the construction process. Overall, the SCG sets requirements on the construction contract in the following manner: (1) The project is to be initiated with a purchasing order that clarifies scope, roles and responsibilities. (2) It is to be operated with the support of internal controls consisting of activities for various support and sub-processes. (3) It is concluded with a final report that enables for experience feedback to occur.

Additionally, there are requirements to provide documentation throughout the lifespan of the project. These ordinates are to be considered mandatory for all of the organizations that partake, notwithstanding minor deviations in the shape of customizations that may occur at the request of some of the organizations.

2. Method

This purpose of this paper is to examine the shared construction guidelines (SCG) employed by 24 large public client organizations in the Municipality of Gothenburg, Sweden. Specifically, these guidelines are measured against the two main hypotheses of Zollo and Winter (2002) in their study of how organizations develop dynamic capabilities through deliberate learning mechanisms. The hypotheses are stated as follows:

Hypothesis 1 (H_1)

"The lower the frequency of experiences, the higher the likelihood that explicit articulation and codification mechanisms will exhibit stronger effectiveness in developing dynamic capabilities, as compared with tacit accumulation of past experiences."

Three types of mechanism of building capability is mentioned here: explicit articulation, codification and tacit accumulation of past experiences. It stands to reason that the more frequent the members of the organization experience a certain task/activity, the more capable they become at mastering that task/activity. The opposite could be said about the inverse statement, the less frequent one deals with a particular task/activity, the less capable one will be in handling that task/activity. Given this, Zollo and Winter (2002) then argue that although one is less capable of executing a task that is performed infrequently for all three mechanisms of building capability, the codification of knowledge becomes comparatively more important than knowledge articulation which in turn becomes more important than tacit experience accumulation. The less frequent the organization's members face a specific task, the less able they are on relying on instincts or developing a tacit understanding of how that task could be dealt with. For infrequent activities, relying on codified knowledge becomes increasingly effective relative to other mechanics for developing capabilities. This counterintuitive proposition runs contrary to conventional managerial practice where only frequently reoccurring activities are codified and activities that occur rarely are handled in an ad-hoc manner.

Hypothesis 2 (H_2)

"The higher the heterogeneity of task experiences, the higher the likelihood that explicit articulation and codification mechanisms will exhibit stronger effectiveness in developing dynamic capabilities, as compared with tacit accumulation."

Similar to H_1, this hypothesis states that there are differences in how effective mechanisms for developing capabilities are depending on the nature of the activities. For H_2, Zollo and Winter (2002) postulate that the higher the level of heterogeneity of tasks, the more important knowledge codification as opposed to knowledge articulation and tacit experience accumulation. If the organization only deals with a limited number of activities, it becomes easier to develop capabilities to handle these activities through informal means and tacit accumulation. Conversely, when the task heterogeneity is low, it becomes redundant for the organization to codify their knowledge.

2.1 Documentation

The study draws primarily on reports issued by the Municipality of Gothenburg detailing the use of the SCG as well as the actual SCG database with routines, tool and documentation. The primary data consists of the documentation provided by the Municipality and its SGC management team which highlights the details of the SCG, the reasons for initiating it and its implementation by the Municipality's public client organizations. Included in this documentation are the SCG guidelines, feasibility studies, reports, thesis work, annual reports, and procedural documentation.

Specifically, a report containing an evaluation of the guidelines issued by the Municipality through its SCG management team was used to assess the level of compliance that the 24 organizations that employ

the SCG had with the issued guidelines (GBP, 2016). The level of compliance for each of the organizations were then analyzed in accordance with the framework of Zollo and Winter (2002). The organizations were categorized with respect to their type, size and how heterogeneous their operational activities were and how frequent they dealt with activities relevant to the SCG. The level of heterogeneity of activities and frequency of activities that relate to the SCG was determined by assessing their annual reports in terms of how many different activities the organizations described and how frequent they procured construction projects that needed to comply with the SCG. The result of this assessment is shown in Figure 1.

3. Results and Discussion

An evaluation of the 24 organizations showed great variation in how the organizations were actually adhering to the SCG. The different organizations represented and their level of compliance with the SCG is illustrated below, figures showing turnover and type of organization (area it operates in) has been added.

Table 1: The 24 evaluated organizations: their type, turnover and compliancy with the SCG.

Client organization	Type/Area	Turnover 2015 [MSEK]	Heterogeneity	Frequency	Compliant with SCG
Bostadsbolaget	Public housing	1662	Low	High	Partly
Egnahemsbolaget	Public housing	186	Low	High	Partly
Familjebostäder	Public housing	1298	Low	High	Partly
Fastighetskontoret	Property owner	385*	Low	High	Partly
Framtiden Byggutveckling	Property owner	2	High	High	Partly
Got Event*	**Property owner**	**157**	**Low**	**Low**	**No**
Grefab	Property owner	56	Low	High	Yes
Gryaab	Infrastructure	341	Low	Low	Yes
Gårdstensbostäder	Public housing	195	Low	High	Yes
Göteborg Energi	Energy	6191	High	High	Partly
Göteborgs Hamn	Property owner	715	Low	High	Partly
Göteborgs Spårvägar*	**Infrastructure**	**1106**	**Low**	**Low**	**No**
GöteborgsLokaler	**Property owner**	**209**	**Low**	**Low**	**No**
Higab	Property owner	701	High	High	Partly
Idrotts- och föreningsförvaltningen	Property owner	136	Low	High	Partly
Kretslopp och vatten	Infrastructure	1261	Low	High	Partly

Liseberg	**Property owner**	**1139**	**Low**	**Low**	**No**
Lokalförvaltningen	Property owner	900	High	High	Yes
Park- och naturförvaltning	Property owner	171	Low	Low	Partly
Parkeringsbolaget	Property owner	433	Low	Low	Partly
Poseidon	Public housing	1993	Low	High	Partly
Renova	Energy	1140	High	Low	Yes
Trafikkontoret	Infrastructure	1693	Low	High	Partly
Älvstranden Utveckling	**Infrastructure**	**361**	**Low**	**High**	**No**

* *Data from the year 2014.*

Of the 24 organizations listed, only five stated that they comply with SCG in all matters whereas fourteen stated they complied in most cases. Furthermore, 17 organizations utilized the ability to customize the parts of the SCG that deals with controls, of which eight organizations exclusively used a customized procedure for internal controls (*egenkontroll*). This is however not surprising as there is a clause in the SCG directives that enables for customization. However, what is not acceptable according to the directives of the SCG is to completely disregard internal controls which is what three organizations chose to do. If the customization of a particular clause leads to lessening a requirement or activity, this is referred to as an aberration (*avsteg*) which the SCG allows for only in cases where that particular requirement is not relevant to the organization in question.

The effect of *size* on compliancy

The average (mean) turnover of the selected organizations was 935 million SEK (MSEK), of those organizations that complied fully with the SCG the average turnover was 526 MSEK and 594 MSEK for those organizations that did not comply suggesting that smaller organizations (i.e. with less turnover) would either adopt the new construction guidelines entirely or refrain entirely. The organizations that complied fully and those that did not comply with the SCG had a median turnover lower than those that complied partly (1202 MSEK), it is interesting to note that the relationship is not linear in that those that partly complied with the SCG were bigger than the rest.

The effect of *type of organization* on compliancy

No relationship could be distinguished between the type of the organization and its compliance with SCG. For all four categories mentioned (property owners, infrastructure, public housing companies and energy) the level of compliance varied between the organizations. This suggests that the SCG has been framed in a generalized way that does not seem to favor one type of organizational type over another. It may also suggest that allowing certain customizations of the SCG made it possible for organizations working in different areas to comply with its requirements on an equal footing.

The effect of task *heterogeneity* and *frequency* on compliancy

According to Zollo and Winter (2002), a high level of task heterogeneity and a low level of task frequency means that knowledge codification is more effective as a learning mechanism compared to knowledge articulation and tacit experience accumulation. By excluding the organizations that partly complied with the SCG and instead evaluate only those 10 organizations that either did not comply at all or that complied fully, it then becomes possible to assess if task heterogeneity and frequency affected their choice for complying. The relationship between knowledge codifications (i.e. compliance with the SCG) and task heterogeneity/frequency is illustrated in Figure 1.

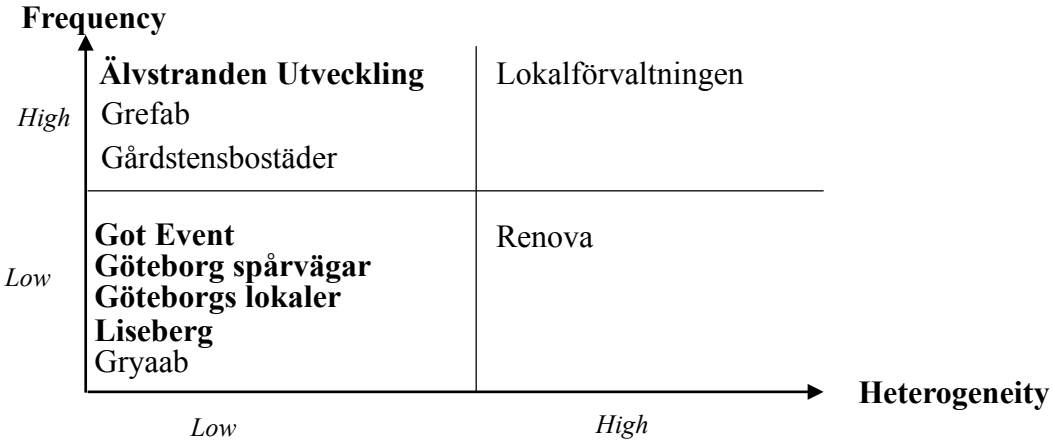

*Figure 1: Showing organizations that did not comply with the SCG (**bold text**) and those that did comply in terms of their level of task heterogeneity and task frequency.*

It would seem that the level of task heterogeneity of an organization is not a strong indicator for whether that organization chooses to work with knowledge codification, in this case the SCG. For the organizations listed above, it would seem that a low task heterogeneity was typically the norm for those organizations that complied with the SCG as well as those that did not. However, task frequency was a much stronger indicator for organizations that did not adopt SCG fully– in that all but one organization had a low level of frequency of tasks that relate to the SCG.

4. Concluding remarks

The relatively small percentage of organizations that complied with the SCG poses a significant challenge that risks undermining the initiative itself. If these guidelines are to be shared as the name implies, they need to be followed uniformly by all of the organizations that purport to adhere to it. A key purpose of the SCG was to provide quality assurance for the way in which public client organizations in the Municipality procured and managed their construction projects and to set a transparent baseline for what is considered acceptable. In order to do so, the initiatives needs to be accepted across the board.

In describing the unsatisfactory results gained when assessing the 24 organizations, the issuer of the report refrained from offering any definitive explanation as to why so many organizations had not

adopted it thoroughly. The report excludes the possibility of this having to do with having insufficient time to adapt to the new guidelines. They support this by citing cases of certain organizations that introduced SCG much later than the other organizations and still managed to do so completely within that shorter time span. We may also exclude that this is due to a perceived lack of usefulness of the SCG seeing as an overwhelming majority (92%) regarded the initiative as useful. If this is the case, why would they then not adopt it? We offer here the possibility that it may have had something to do with the perceived easy of use. Davis (1986) state that in order for a new digitalized solution to be adopted in an organization, two independent conditions need to be fulfilled: a) the members of the organization need to perceive the new solution as useful and b) they need to perceive it as easy to use. In the case of SCG, the results from questionnaire show that they did indeed perceive it as useful but the report says nothing about the perceived ease of use. Knowledge codification is a double-edged sword in that it provides a mechanism for developing organizational capabilities but in doing so it also risks creating organizational inertia especially if the codified guidelines are perceived as complex and difficult (Zollo & Winter, 2002).

Going forward, it would seem that task heterogeneity is not a strong indicator for whether public client organizations pursue knowledge codification as a learning mechanism. It also suggests that the area in which the organization operates is less important than the size of the organizations with respect to the codification of knowledge. Particularly if the routines for codifying knowledge are described in a generalized fashion that allows for customizations to occur. Finally, among organizations that did not comply with the SCG a low level of task frequency seemed to be prevalent. This runs contrary to the recommendations of Zollo and Winter (2002) who argue that organizations that have a low task frequency would benefit more from codifying the knowledge relating to those activities than those organizations that engage in such activities on a frequent basis. The results would seem to agree with the notion that among the public client organizations that were studied, the conventional approach of disregarding knowledge codification for activities that are infrequent seems to be the norm. Due to the small section of organizations studied, it is not possible to emphatically state that the relationship between frequency, heterogeneity and knowledge codification is as it has been described in this paper. Further studies would be needed to determine if for instance the organizations that infrequently engaged in activities relating to the SCG would actually benefit greater by complying with the SCG than those that engage in those activities frequently, as predicted by Zollo and Winter (2002).

From further evaluations in the SCG in 2017 it is stated that the number of organizations complying is increasing, but thet there is a follow up on organization by organization in order to achieve this (ref). Adaptation and complying with rules is a challenge and needs time, especially in organizations whose success is rated by output ratio, budget and time adherenace such as the construction sector.

What can be said, however, is that approaches to knowledge codification, such as the SCG, provide a systematic way for public organizations of various sizes and types to work with similar routines. This marks a significant step forward for making sure that public organizations function in a more efficient and transparent fashion. The remaining challenge is to find a level of balance for the degree to which these organizations follow codified routines. The goal being to share the same systematized way of working and thereby avoid ad-hoc behavior while at the same time making sure the codified routines are not too stringent and overbearing or hinder innovation. The real challenge lies, most likely, in establishing a knowledge based approach where jdugement and decisions are supported by routines and guided by evaluation, documentation and

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Public procurement of railway infrastructure maintenance – a literature review

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Abstract

The maintenance of railway infrastructure has in several instances been changed from government-based to being based on public procurement, with varying degrees of flexibility for the contractor to design their maintenance work. The purpose of-giving contractors a larger freedom of choice of how to perform maintenance is to stimulate them to innovate and develop their maintenance processes. Since the contracts differ in between and there are changes in government policies over time that affects both existing and new contracts, a comparison between different contracts becomes challenging. A literature review has been conducted to understand the change in procurement strategy and how to encourage contractors to innovate. The research questions include: What procurement strategies are there? How is maintenance evaluated? How does procurement affect the innovation opportunities for entrepreneurs?

The literature review focuses on railway maintenance and contract design between client and contractor. In total, 17 articles matched the search criteria and were selected for the review. To have successful maintenance service, five articles suggested partnering as a strategy with common goals in combination with good communication during the entirety of the contract. When selecting incentive plan, four articles mentions that a focus on performance-based incentives in combination with risk management is better rather than actual payment schemes. The reason being that payment is often the main cause of conflicts between client and contractor. The scientific literature suggests that improvement in incentives improves quality of maintenance, decreases delays and technical failures. The conclusion from the literature review is that partnering in railway maintenance is considered successful. With accurate knowledge about railway assets the incentive plan becomes accurate which reduces costs.

The literature review is a part of a research project with an overall goal to develop a model to guide the selection of appropriate type of procurement strategy, contract and control of maintenance for a more sustainable railway system.

Keywords: Procurement, Maintenance, Railway infrastructure, Contract, Payment

1. Introduction

Outsourcing of infrastructure maintenance activities from public to private sector has become popular in Europe. One reason behind the outsourcing is to make maintenance more cost efficient (Österberg, 2003). However, there is an understanding that the public sector fail to keep up with the growing and changing industrial demands (Mattson and Lind, 2009; Vickerman, 2004b). When public organizations outsource their infrastructure maintenance they need to reorganize and handle management of contracts and suppliers instead of performing the maintenance. The design of maintenance contracts is important to preserve high infrastructure quality. One solution is to design long-term performance-based contracts where both construction and maintenance is included (Ng and Wong, 2007; Vickerman, 2004a). However, many maintenance contracts require a separation between construction and maintenance since the majority of assets to be maintained are already built.

Railway maintenance is complex where many factors need consideration, e.g. changes in train traffic, which are critical due to its impact on both the degradation and access to track (Forsgren et al., 2014). The outsourcing of railway infrastructure maintenance has to be performed without jeopardizing the infrastructure manager's task to uphold high safety, quality and availability at a low cost. In fact, the infrastructure managers have to ensure a level of railway safety that is economically sustainable for the society, i.e. balancing quality of service and cost so that the users select the safest mode of transportation. Accordingly, how the procurement process is handled therefore becomes critical. European public procurement strategies are regulated by the public procurement act. This law is sometimes considered as an obstacle that limits changes and renegotiations without a new tender after a contract has been signed (Abdi et al., 2014; Alexandersson and Hultén, 2007; Tadelis, 2012). Accordingly, the difficulty of making ex post changes to signed contract makes its design critical.

The Swedish Transport Administration (STA) has outsourced railway maintenance since 2002. In 2013 STA was obligated to change its railway maintenance procurement with the intent to motivate contractors to innovate and develop their processes. The underlying assumption was that restrictions and specifications of how the maintenance should be performed stifled innovation and process improvement potentials. Hence, the core of the change process involved increasing the contractors' degrees of freedom in performing the maintenance. There is a need for public clients to better understand how procurement strategies work and how they should be designed to maximize the outcome at the lowest cost, which in this case is high quality and availability of the railway system.

This paper aims to review how public railway maintenance procurement has been described in the scientific literature. The paper is organized into six sections, including the introduction in section 1. Section 2 presents the method and describes the literature review process. Section 3 presents the analysis and the result of the review is presented in section 4. The final sections discuss the result and present the conclusions of the study.

2. Method of literature review

A literature review was considered appropriate for condensing the current knowledge of procurement of railway maintenance. The literature review started by selecting databases that were considered appropriate for finding studies on railway maintenance contracting. The database Scopus was chosen due to its coverage of engineering-based publications. On June 3 2016 Scopus was searched using the

search string [Maintenance AND (infrastructure OR Subway OR Metro OR Tram OR Rail) AND (Procurement OR Contract OR Bidding OR Tendering) AND NOT (Sewer OR Water OR Air OR Pavement OR Defense OR Military)] in the subject fields. While this search string generated 209 hits, many of these were out of scope. Limiting the search to journals within the subjects; engineering, business, environmental, decision, economics and multidisciplinary reduced the number of uninteresting search results, leaving 109 articles for further study.

The scope for this study was discussed and defined to exclude road maintenance because of the different management practices and contract designs involved. The first author then reviewed the abstracts of these hits. Many of the articles were discarded since they were outside our scope, such as those focusing on road maintenance. Also no article published before 2001 were found to be within the scope. Finally, 20 articles remained and were selected for the review. The 20 articles were distributed among the authors for a first round of reviews.

Twelve of the initial articles were considered relevant after this first round. The low number of relevant articles was a concern, and therefore a snowballing technique was introduced to find additional interesting references. The snowballing technique involved studying the reference list of the twelve identified articles as well as studying all articles that had cited the relevant articles. An additional five references were found, which based on their abstract were considered interesting. The snowball articles were then reviewed. Of these, four were considered relevant, generating a total of 16 relevant articles.

An additional search was performed to scan other relevant databases, e.g. Web of Science (WoS), EBSCO and Emerald Insight. The same search string generated multiple hits that mostly were out of scope (mostly connected to road maintenance) or duplicates. However, one additional article that was considered relevant for this literature review was found, which brought the overall reviewed articles to 17.

A classification sheet was developed to understand and connect the articles, inspired by Siva el al. (2016). Five articles were chosen to calibrate the classification. The authors all reviewed the articles individually and then met to discuss their review and the classification sheet. The classification sheet was further developed by changing the phrasing of some aspects and new aspects were also added. The calibration showed that the reviewers classified the articles similarly with only minor differences. Table 1 shows the classifications of the review process.

Table 1 - Coding criteria, inspired by Siva et al. (2016)

Coding criteria	Description of coding
Publication year	The year of when the article was published.
Main conclusion	A short description of the main conclusion/contribution from the article.
Type of paper	Conceptual, qualitative, or quantitative.
Methodology	Data collection method (experiment, literature review, database analysis, archival study or interview study).
Empirical data	Client or supplier data, country origin of the data.
Topic	Procurement/contract, contract scope, maintenance, management/strategy or performance
Type of infrastructure	General, railway, subway or high speed rail.
Level of analysis	Contract, organization or policy.

3. Analysis

This section presents the analysis from the data classification and coding that was presented in Table 1. In Figure 1 the distribution of the articles based on the publication year is shown. The figure suggests that publications in the area have been more frequent during two time periods, 2004-2006 and 2010-2012. The relevance criterion was in fact not a dichotomous classification of relevant or not, but a six class ordinal scale between zero and five, where zero represented the non-relevant articles and five represented very relevant articles. Studying the articles that were not classified as irrelevant, three of the five articles published in 2010-2012 were classified as one in relevance but none of the articles published in 2004-2006 had a relevance classification of more than one. The conclusion is that the most significant articles related to public procurement of railway maintenance were published in 2004-2006.

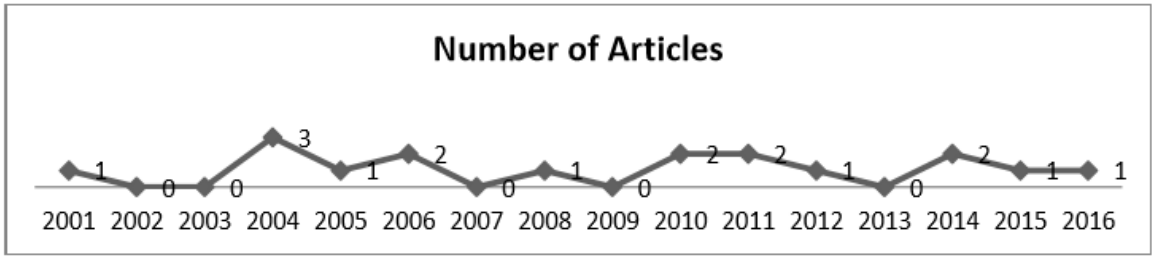

Figure 1 - Timeline of the published articles

Most of the articles were using a qualitative research approach, see Figure 3 and the distribution of methodologies is seen in Figure 2 (note that the number of articles do not always sum to 17, reflecting that articles are often classified in more than one category). Most articles were based on qualitative data based on case study research and/or interview. Of the relevant articles, Sweden stands out as being a common location to base the studies (Figure 5). The three articles that were not connected to a specific country were conceptual articles shown in Figure 3. Two articles collected empirical data from a mix of countries, where they both used interview study as methodology. Amongst the relevant articles Swedish railway is often studied, see Figure 5.

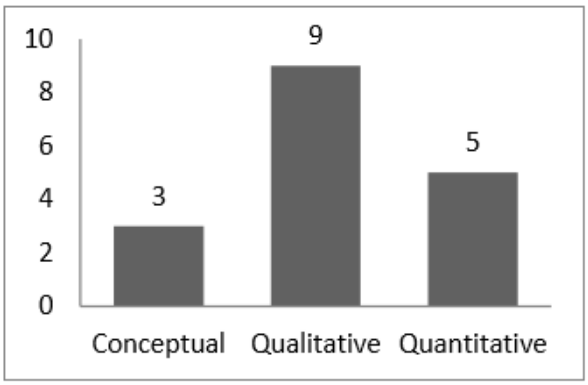

Figure 3 - Description of the type of paper

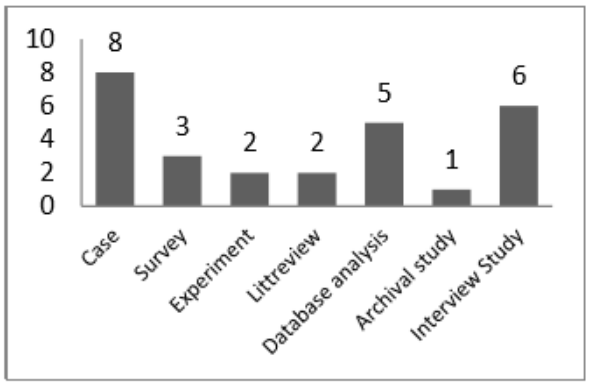

Figure 2 - Classification of the methodology used in the articles

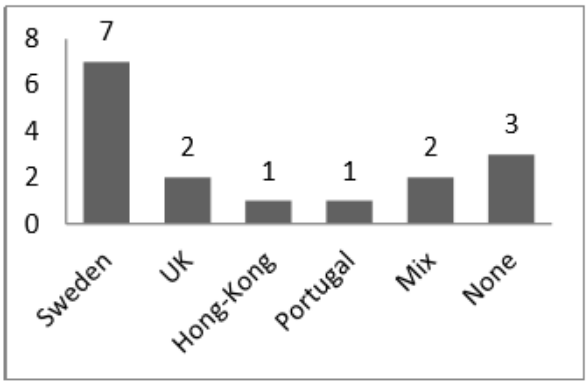

Figure 5 - Classification of where empirical data was collected

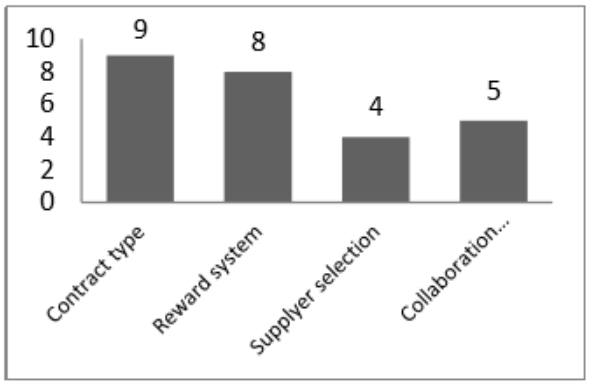

Figure 4 - Classification within the topic of procurement and contract

As seen in Figure 4 many articles focus on the contract type and reward system, whereas supplier selection and collaboration model is less studied. Figure 6 presents the topic of contract scope where the technical aspects are the most studied. Figure 7 shows that the articles focus more on preventive

maintenance than any other type of maintenance, e.g. corrective maintenance. Based on these classifications three articles present findings that contain contract type or reward system, technical scope and preventive maintenance; Kemi (2001), Espling and Olsson (2004) and Olsson and Espling (2004). From the keywords the common denominator for all three articles is partnership.

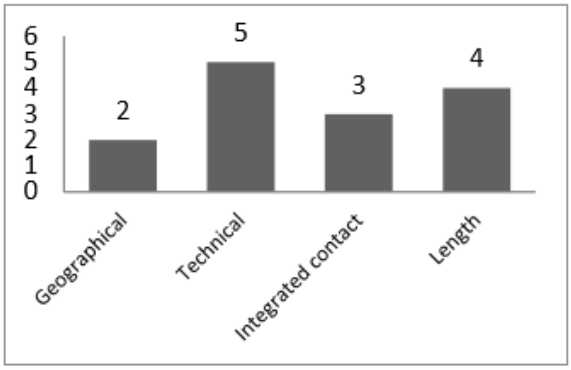

Figure 6 - Classification within the topic of contract scope

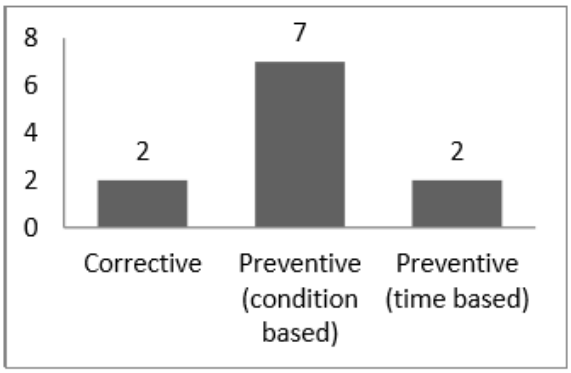

Figure 7 - Classification within the topic of maintenance types

4. Findings

The 17 relevant articles were categorized into four different areas; collaboration model, i.e. partnering (five articles), contract incentives (four articles), financing (three articles) and management (five articles). Thirteen of the articles present conclusions based on empirical evidence, six of these are studies conducted in Sweden. The remaining four base their conclusions on either experiments or archival studies.

4.1 Partnering

The five articles considered most relevant suggest partnering strategy for railway maintenance procurement. However, different authors use different definitions of partnering. Abdi et al. (2014) define partnering as "close cooperation between client and contractor that makes it possible to make adjustment and improvements during the contract period that are to the advantage to both the contractor and the client". Espling and Olsson (2004) describe partnering as "a managerial approach used by two or more organizations to achieve specific business objectives by maximizing the effectiveness of each participant's resources". Kemi (2001) defines partnering as "a process by which organizations develop a more focused collaboration by defining common goals, common collaboration team and common respect for each other's organization". Borg and Lind (2014) and Kemi (2001) emphasize that partnering should not be seen as a specific procurement contract or a new type of contract. Instead partnering could be implemented in any type of procurement contract (ibid.). Based on these definitions we define partnering as close collaboration between partners with common goals and partners working to maximize the resource effectiveness of each organization as well as of the partnership.

Borg and Lind (2014) propose a classification framework for contract type and payment method. Their classification is based on a continuum where of the number of contractors, breakdown of responsibilities and level of construction and/or maintenance are inputs. Borg and Lind (2014) further

conclude that partnering can fit in any type of contract and contracting makes adjustments during the contract period possible.

Cruz et al. (2015) have studied two public-private partnerships in urban light railway system; the contracts were long-term and contained both construction and maintenance. One project was considered problematic and resulted in delays, whereas the other was considered successful, providing lower operating costs (ibid.). The conclusion was that the difference explaining the two outcomes was an innovative maintenance model (Cruz et al., 2015).

Abdi et al. (2014) proposed that contract design should be based on a vision of what the project should achieve for both client and contractor. They further propose that the vision should define common-goals and interests that are included in the maintenance contract. Common goals force parties to consult each other. The necessary adjustments during the contract period are easier with partnering than with other contract designs since partnering offers that flexibility. However, it is argued that the public procurement act needs to be analyzed to see if more flexible contracts are possible without a new tendering process. (Abdi et al., 2014)

Olsson and Espling (2004) present a framework for public sector infrastructure maintenance partnering. Partnering is suggested to improve communication between maintenance contracts parties. Partnering benefits are said to include improved project quality, increased flexibility, improved scheduling and lower maintenance cost. However, partnering is considered to require more management involvement, especially during the startup phase. Their analysis suggests that partnering in railway maintenance may potentially reduce overall cost up to 30 percent. An accurate description of asset condition, clear description of primary objectives and a common action plan to reach the primary objectives are all important railway maintenance factors to consider (Olsson and Espling, 2004).

Kemi (2001) suggests that partnering requires a project team consisting of the contract parties as well as a third party to ensure open and honest communication during meetings, which reduces the total meeting time. At project start and throughout the contract the project team should define common and ranked objectives and a common strategy to meet these objectives (Kemi, 2001).

4.2 Contract incentives

Payment in railway maintenance contracts often leads to conflicts (Abdi et al., 2014). The design and evaluation of payment systems must be considered carefully to handle and minimize conflicts (ibid.). Abdi et al. (2014) and Borg and Lind (2014) both argue the payment schemes distribute risk in large maintenance contracts. The allocation of risk must be carefully considered in railway maintenance since payment is related to both risk and conflicts (Borg and Lind, 2014).

The payment can be used as a tool for balancing risk allocation and risk sharing between client and contractor in their procurement contract framework. Borg and Lind (2014) list three payment systems that affect risk differently; fixed pricing, fixed pricing with general indexing and unit pricing. With fixed pricing, all risk is carried by the contractor and with unit pricing the client carries all the risk. With general indexing all risk except changes in general pricing is carried by the contractor. Both fixed and unit pricing present uncertainties and Borg and Lind (2014) suggest that risk sharing is needed in both extremes. When the contractor carries all the risk, the contract gets less attractive and this can

reduce the number of bidders. The contractor's improvement incentives are, on the other hand, reduced when all risk is allocated to the client. The risk allocation model therefore needs to give incentives to contractors as well as the client. The issue then becomes to properly select and balance incentive parameters. Reduced quality in other dimensions could for instance be an outcome of the contractor only focus on reward bringing incentives (Borg and Lind, 2014).

Tarakci et al. (2006) simulated a method of uptime target and bonus to create a win-win situation when selecting performance based incentives. The contractor gets a bonus if the uptime level exceeds a pre-determined threshold (ibid). Tarakci et al. (2006) have found an optimum threshold and amount of bonus to create the desired win-win condition. Having such performance based incentives was tested by Stenbeck (2008) and the study found that the number of delays and failures related to maintenance contracts could be reduced using this model.

Olsson and Espling (2004) argue that it is difficult to have an accurate and detailed contract design without knowledge of the asset condition. Rahman and Chattopadhyay (2010) have developed a mathematical model for the total cost of ownership for railway infrastructure that is based on previous work. They argue that when outsourcing infrastructure maintenance it is important to have an accurate description of the total cost of ownership for the procurement process. The model they present accounts for the cost of procurement, maintenance, inspection, accidents and disposal of rail. If there is a lack of understanding of total cost it may lead to uncertainties for aspects such as reliability, availability or safety.

4.3 Financing

Financing regulates the relationship between public and private sector in railway maintenance outsourcing. In different public-private partnerships, financial support from private sector has been considered as means to ease the governmental burden. The discussion is then what level of private financing is needed, if any, in outsourcing of railway maintenance (Ng and Wong, 2006).

Maintenance planning is essential to ensure good track availability (Forsgren, et al., 2014). The British railway had major problems with the lack of planning with cost increase of up to 25 % (Vickerman, 2004a). The reason behind the problems was that maintenance needs had not been properly identified and could therefore not be scheduled (ibid.). Vickerman (2004a) argues that there are benefits with maintenance outsourcing, but that outsourcing increases costs for upholding maintenance quality. Vickerman (2004a) argues that infrastructure condition quality indicators need improved definition. Economically it means that there is a need for an adequate asset condition assessment to understand its expected remaining life. Accurate estimates of asset condition provide the possibility to define good quality indicators which provides good incentives to the contractors and good maintenance (Vickerman, 2004a).

4.4 Maintenance management practices

Odolinski and Smith (2016) have evaluated the cost impact of competitive tendering in Sweden. They mention the case in Britain where the entire railway network was exposed at once to competitive tendering, which ultimately caused a drop in quality and the maintenance was brought back in house

(see Kennedy and Smith, 2004). Odolinski and Smith (2016) shows that the gradual exposure of competitive tendering has reduced cost by around 12 per cent.

Bouch and Roberts (2010) considers the logistical part of infrastructure maintenance important and argue that most infrastructure managers aim for that suppliers should plan for just-in-time warehousing to minimize costs. Long-term planning is a solution for most logistical problems within railway maintenance. However, the fluctuating level of government railway maintenance founding is problematic for long-term planning. The track quality variability that requires small and costly work packages is another challenge (Bouch and Roberts, 2010).

Infrastructure managers give higher importance to sustainability issues, and component recycling is increasingly often being used (Bouch and Roberts, 2010). Lundberg (2011) argue for an improvement in environmental follow-up system for railway maintenance. The environmental follow-up activities are defined during the procurement phase (ibid.). Lundberg (2011) further argues that the client and contractor communications needs improvement together with an environmental data memory bank to increase the organizational learning possibilities.

Maintenance planning requires an accurate knowledge of the asset condition (Rahman and Chattopadhyay, 2010; Too, 2012). The use of technological solutions to evaluate the condition of asset and the risk of failure is considered important (Too, 2012). A challenge with maintenance management is the lack of skilled personnel to both assess the asset condition and to perform railway system maintenance (Too, 2012). In Sweden, 30 % of all track related incidents have been attributed to maintenance and of among these, 79 % were related to maintenance work (Holmgren, 2005). Causes include improper communication between maintenance personnel and train dispatcher, lack of experienced maintenance personnel, which may maintain poorly if supplied with poor instructions (Holmgren, 2005).

5. Literature review discussion

Four key areas could be identified in the literature review: *partnering, contract incentives, financing and maintenance management practices.*

Three of the articles involving partnering are based on the same study of two projects that were concluded to be successful (Espling and Olsson, 2004; Kemi, 2001; Olsson and Espling, 2004). However, despite these successes, partnering seems seldom used, as stated by contractors and clients (Abdi et al., 2014). Olsson and Espling (2004) provide a framework for railway maintenance partnering, where they state that common goals, synchronized strategy and honest communication are key success factors. Espling and Olsson (2004) and Kemi (2001) studied partnering within railway maintenance, Espling and Olsson (2004) before outsourcing and Kemi (2001) after. Abdi et al. (2014) provided empirical evidence of the need for partnering from both client and contractor. The conclusion is that there is a need for partnering, there is evidence of partnering being successful in railway maintenance but it is not being used within Swedish railway maintenance.

The complexity and design of railway systems increases managing and control challenges and maintenance outsourcing further increases complexity. Since most railway infrastructure are owned by the state, a government organization sets the system requirements, e.g. availability and quality. Proper

contract incentives connected to the overall objective provide possibilities to reduce overall maintenance cost (Tarakci et al., 2006). However, incentives require an accurate calculation of total cost of ownership to create a detailed specification of maintenance assets (Rahman and Chattopadhyay, 2010).

Abdi et al. (2014) and Alexandersson and Hultén (2007) discusses public procurement laws in relation to railway maintenance and, Abdi et al. (2014) discusses public procurement laws in railway maintenance in relation to partnering. All studies conclude that legal requirements prohibit changes within a contract without renewing the tendering process. Olsson and Espling (2004) consider the ability to change and adapt the contract necessary. More research is needed to explore how the public procurement law affects partnering or can be adapted to allow partnering within railway maintenance.

As for the literature review methodology, the total of 17 articles can be considered few. Initially we discussed databases, search string and the scope of the review. Initial searches in different databases generated only duplicates or zero hits, and we concluded that Scopus provided the broadest number of hits for this review. The conclusion of these discussions was that we wanted a limited scope based on scientific publications, excluding procurement of road maintenance since railway maintenance is more complicated and maintenance contract usually are longer in time. We strongly believe that the findings would be different and ultimately misleading for railway maintenance procurement had road maintenance been included.

6. Conclusion

The purpose of this paper was to review the scientific publications on public procurement of railway maintenance. The review process identified four key areas within the subject: *partnering, contract incentives, financing and maintenance management practices.* Partnering can be a success factor in public procurement of railway maintenance. The Swedish studies often state that Swedish public procurement of railway maintenance is different compared to other countries. Partnering is seen as positive when changes can be made during the contract, something that is difficult due to the law of public procurement. Some evidence in the studied literature suggests that the law forces procurement at lowest price, something that hinders maximizing the service quality. Hence, the possibility of integrating partnering within the laws of public procurement needs more research. Since the public procurement laws usually prohibit change after the contracts have been signed, then perhaps partnering design is neglected even though it shows benefits if it can be adapted within railway maintenance. It is therefore important to improve the knowledge of how a partnering contract can be designed in accordance to the public procurement act to benefit the quality of the railway system.

6.1 Acknowledgment

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UAS-BIM based Real-time Hazard Identification and Safety Monitoring of Construction Projects

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Abstract

The construction site is a dangerous workplace. The risk of fatality, injury, and property damage is significantly higher in construction jobsites compared with workplaces in other industries. Hazardous accidents happen due to traditional safety planning or failure to monitor the construction safety rules during a construction process. Recently, variety of approaches and technologies have been developed to achieve benefits in design-for-safety or safety performance. Unmanned Aerial System (UAS) technologies can easily monitor all over the site by flying around the construction site under a safety manager's control and transmit real-time information for inspecting safety purposes among the project. This paper presents a safety monitoring framework in the construction projects. The framework consists four following processes; BIM based Model, Safety Regulations, UAS-based collection of Safety Inspection Dynamic Data and Analysis of Project Safety. This system has a potential to assist designers, workers, and safety managers to mitigate construction accidents and fatalities. Throughout the design stage, this system with the help of 3D software and BIM is capable of identifying potential hazards. It also will make use of the gathered information to prevent the potential hazards. In control phase, the UAS gives possibility of these rules' monitoring and control. This novel method integrates BIM and UASs, and allows the potential users such as safety managers to obtain and analyse data in construction sites, which in turn can enable safety specialists (supervisors, agents, and inspectors) to identify hazards at different project phases and develop suitable mitigation strategies. The integration of 4D BIM-based models and UAS technology have the potential to improve identification, implementation and monitoring of construction site safety and hence increase the construction projects stakeholders' safety.

Keywords: Construction Safety Management, Building Information Modeling, Visualization, Data Capturing Technologies, Unmanned Aerial Vehicle

1. Introduction

Studies indicate that compared to other industries, the rate of accidents and worker fatalities have reached the highest rank in the construction industry (Mahmoudi et al. 2014; Qi et al. 2011). Construction workers are three times more probable to die and two times more likely to suffer from injuries at work place than the average of the workers in all other activities (Sousa et al. 2014). The role of safety measures is essential in the construction industry if one wants to prevent work-related accidents.

Traditional safety planning still largely relies on paper-based 2D drawings and schedules to understand the needs for safety equipment on a construction site (Chantawit et al. 2005). Also it suffers from a separation between design and implementation phases. Traditional methods depend on safety inspections to detect potential safety hazards and collect them from construction 2D drawings (Zhang et al. 2015). As shown in Figure 1, this type of information is complicated and difficult to implement in real time safety improvement plans. However, these hazards are subject to change based on various conditions such as weather and material delivery, which could lead to change in a safety plan. Traditional method is time-consuming and labour-intensive to update the safety plan every time schedule changes (Zhang et al. 2015). Currently, development of new technologies and software is encouraging designers to consider construction safety in their project. Thus, the awareness of necessity for safety planning is increasing in the design process. Moreover, a powerful safety planning has a vital role in decreasing overhead cost and delays (Bansal 2011). Zhou (2010) suggests that a company adopting a construction safety culture implements a comprehensive range of measures, including leadership and commitment from all levels, safety risk assessment at the design stage, deployment of registered safety personnel at all construction sites, ongoing safety training, and the application of information technology to improve safety performance.

Fall hazardous locations on 2D plan

Figure 1. An example of a traditional fall protection plan

For proper safety planning, identification of safety hazards plays a significant role during all stages of a project, which should be considered at the early stages of a construction-site process. It is also

essential to identify all potential site hazards at each stage of the project on construction site and eliminate or avoid them before accidents happen. To identify site hazards, technology has played an important role in construction industry. It is believed that the availability of technology makes the construction safety reachable (Zhang et al. 2013). Development of innovation technologies has increased safety performance in the workplace but most of them were limited to reflect the site safety management process in the construction stages (Guo et al. 2017).

The applications of BIM in building design and construction planning are growing rapidly (Chan et al. 2016). BIM-based modelling and 4D simulation (3D+ schedule) have brought many benefits to safety and logistics applications. However, only limited automation in modelling and planning safety processes has been exploited so far. The objective of monitoring and control system is to make sure that safety implement based on safety rules and standards during the project. In recent years, using innovation technologies promote safety control with real time feedback to prevent fatalities and injuries. Integration of data capturing technologies and drone help to monitor construction projects from much better prospective. Drone has presented great opportunity for safety improvement on construction sites (Irizarry et al. 2012).

The objective of this study is to improve safety in the pre-construction and construction phases throughout integration of BIM, data capturing technologies, and drone A framework for accurate and proximate real-time construction safety is developed and presented the specific focus on using novel data capturing technologies, BIM in construction safety, and unmanned aerial system for identifying, checking, and eliminating hazards in construction projects.

2. Literature review

As construction sites ever-changing array of tasks that are often hazardous, fatalities and accidents are mainly common parts of the construction industry (Collins et al. 2014). In comparison with different industries in the US, for example, construction keeps on being positioned among the maximum records for work environment fatalities each year (Marks and Teizer 2013). In 2014, 908 workplace fatalities had resulted in US construction industry (BLS, 2013). Accidents that happen on sites resulted from falling, contact with electricity, excavation and heavy equipment accidents and hitting by falling object were recognized as most probable accidents in the construction sites during that time.

2.1 Construction Safety Planning/Implementation

Safety planning is generally considered to be a fundamental necessity in safety rules and regulation. Although no standards for safety were illuminated before 1970, the Occupational Safety and Health Administration (OSHA, 2013) has defined standards for safety and health in the construction site for the last four decades. The safety regulation and standards provided by OSHA has a great influence on improving health and safety on site. In spite of all these improvements, there is still a gap in construction safety. The implementation of safety in construction sites is not completely successful. In many countries, the safety performance in construction industry is left behind most industries (Hon et al. 2011). Clearly, the construction industry is actually far away from the vision of ‘‘zero accidents/injuries’’ espoused through several organizations related to construction (Zhou et al. 2015).

Developing site safety management system is the main issue for construction companies around the world. Studies have shown that owners, designers, constructors, and subcontractors have separately affected construction worker safety and health (Rajendran and Gambatese 2009). The American Society of Civil Engineers (ASCE) states in its strategy on construction-site safety (Policy Statement Number 350) that engineers should have responsibility for "recognizing that safety and constructability are important considerations when preparing construction plans and specifications." (Gambatese et al. 2005). Consequently, providing a safe workplace as a teamwork is a most in this sector. Mitropoulos and Memarian (2012) indicated that team processes influence construction workers' safety. Moreover, the project team can be aware of the safety requirements along with their own tasks when reviewing the project schedule (Benjaoran and Bhokha 2010).

Safety management covers all stages from planning to implementation (Chantawit et al. 2005). Nevertheless, Benjaoran and Bhokha (2010) on their practice of safety management in construction projects in Thailand found that most projects did not systematically implement the safety management on site. Generally, safety management cannot happen without having an efficient safety planning. Traditional safety planning relies on observation, and being aware of all hazard points on construction site all the time for a safety manager was not possible (Zhang et al. 2012). Safety planning itself includes the recognition of all potential hazards and also determining the particular safety measures (Bansal 2011). Besides, it is not acceptable to identify hazardous situations on construction site only after a related accident has previously occurred (Yang et al. 2012). Therefore, predicting potential hazards and probability of accidents is an important step in the design phase during safety planning. Gambatese et al. (2008) after analysing previous studies exposed that there is a link among construction fatalities and the design in the construction safety concept. Zhang et al. (2015) identified and eliminated fall hazards in the planning phase of the construction project. The safety design could be the best solution with the aim of reducing the rate of accidents and injuries in construction sector. Designers can decrease safety hazards in the project by considering worker safety as a one of the main factors in their design decisions (Huang and Hinze 2006).

2.2 Building Information Modelling (BIM) in Construction Safety

BIM is an information-rich design technology; it is a great visualization tool that provides a three dimensional virtual representation of the construction project. Visualization gives a better perspective of what the semi-constructed product may appear during the construction stage. BIM is a new technique to simulate the project and change process of design in construction industry. In other words, it is the process of virtual design and construction throughout its lifecycle. According to Enshass et al. (2016) BIM is the best applicable tool to improve safety performance in the construction industry. 3D BIM model makes integration between structural and mechanical system and design phase. By integrating 3D BIM model with time/scheduling, the 4D model will be developed to connect each part with the related task. 3D/4D BIM can guide designer to enhance quality and sustainability in the project. In addition, by integrating time and cost information, which is known as 5D model, problem of rework can be decreased during the project (not related). Therefore, engineers try to promote the application of BIM science, which could lead to a significant change in construction industry.

In the recent years, there is a growing interest in the use of BIM within construction safety management. It was applied in construction safety as a main tool to help stakeholders. Kasirossafar et al. (2012) after investigating the impact of 3D/4D BIM on occupational safety and health indicated that 75 percent of

respondents felt that accidents and fatalities in the construction industry can be predictable and preventable by utilizing 3D/4D BIM tools in a design phase. The utilization of BIM and other visualization tools can result in improved occupational safety by allowing designers and constructors to visually assess jobsite conditions and recognize dangerous work environment. Qi et al. (2011) also developed a design for construction safety tool that can automatically check fall hazards in 3D model and make an alternative design. Bansal (2011) has found a system with integration of BIM and GIS technology to help labors visualize the construction sequences along with its surrounding, so they better understand task interactions and safety recommendations. Although, Ganah and John (2014) after analysing the usage of BIM pointed out that respondents were to some extent sceptical about using BIM for health and safety, just 2.2% of respondents always utilized BIM. Nearly all fatalities and accidents on work environment are generally avoidable through the integration of an efficient safety plan integrated with BIM during the project (Sulankivi, et al. 2010).

2.3 Innovation Technologies

Variety of approaches and technologies have been developed to achieve benefits in design-forsafety or safety performance. A large number of researchers attempt to integrate innovative technologies with safety as an effective solution to prevent construction accidents and enhance safety performance in construction industry. In the recent years, many articles have been published with a variety of technologies in construction safety. Monitoring the construction site and worker/equipment safety has been executed with the use of various technologies like; Radio Frequency Identification (RFID) technologies, Ultra-wide Band (UWB), different sensors, scanner, and high resolution cameras (Table 1). Also, Global Positioning Systems (GPS) and Sensor technologies can enhance the safety performance of construction workers and equipment by preventing accidents that happen on construction site. Furthermore, Game technology developed the virtual training environment for students and workers.

2.4 Unmanned Aerial System in Construction Safety

Until now, all data capturing technologies in construction safety are not able to gather information from various locations and situations spots to detect hazards. In order to improve site safety, there is growing demand for an innovative technology to collect real time images and videos from different spots of construction site. In recent years, UAS as a real time data capturing technology have been used in construction site in order to promote safety. This technology has the ability to capture data from different locations and blind-spots to cover all different type of hazards. Unmanned Aerial System (UAS) is an aircraft which can fly autonomously or be piloted remotely. The term UAS is used commonly in the geomatics community, but also terms like Remotely Piloted Vehicle (RPV), Remotely Operated Aircraft (ROA), Remote Controlled (RC) Helicopter, Unmanned Vehicle Systems (UVS) and Model Helicopter are often used (Remondino et al. 2011). It is also known as a Drone or Unmanned Aerial System (UAS). These days many of them control by smart phones or tablet and equipped with camera and sensors including a Global Position System (GPS). Safety managers are using UASs with high resolution camera for monitoring safety compliance. UASs are able to gather many safety information from various angles such as; visual inspection for counting hardhats in images under different environmental conditions, create documents for safety, monitoring ongoing operations to prevent hazards locations monitoring situation of workers in the project site, location and orientation of temporary resources such as cranes, monitoring the machinery, and etc. UASs can easily monitor all

part of the site by flying around the construction site under a safety manager's control and transmit real-time high resolution photographs, videos, laser scanners or any other sensors for inspecting safety purpose in the project. It can circulate in different floors and gather information from blind spots. UASs help safety managers to be aware of unsafe situation/locations of the project that exist in construction phase. Also, it can immediately alert accidents and help safety manager to find out the accident location and injured workers. Only in such environments a safety manager would be able to provide immediate feedback and interact with the workers (Gheisari et al. 2014). Irizarry et al. (2012) employed an aerial drone that flies all around the site areas and provides the safety managers with real time image and video about what is happening on the construction jobsite. It has the ability to provide real time safety data during the construction phase for further analysis, if hazard identification performed immediately safety manager is able to react potentially in realtime to an incident. In fact, this technology can cover one of the main task for safety managers which is performing periodical inspections of the whole construction jobsite to control site conditions based on safety standards (Irizarry and Johnson 2014).

UAS has become prevalent at construction job sites, so it is vital that contractors know the current regulations for UAS, as well as their potential risks and best practices for avoiding incidents and claims. Operating an UAS can present risks, which is why National Aviation Administration need to put certain laws in place. These regulations ensure that the UAS operators are experienced and properly trained, while their equipment is certified and adequately insured. UAS operators should demonstrate their ability to fly the vehicle, and each must meet minimum standards set by the National Aviation Administration. The use of UASs for surveillance in civil applications impacts upon privacy and other civil liberties. However current regulatory mechanisms do not adequately address privacy and civil liberties concerns because UASs are complex, multimodal surveillance systems that integrate a range of technologies and capabilities (Finn and Wright, 2012). Table 1 illustrates 13 articles and 6 types of technologies that are used in construction safety management in integration with BIM or UAS. As shown in Table 1, many articles contain more than one technology or approach. It was discovered that, BIM and 3D/4D model have a boundless potential to integrate with technologies in construction health and safety.

Table 1. Technologies and Approaches in the construction safety

Technologies / Tools	Integration with BIM	Unmanned Aerial Vehicle (UAS)	Literature(s)
Radio Frequency Identification (RFID)	-	-	Andoh et al. (2012)
	-	-	Chae and Yoshida (2010)
	-	-	Chen and Zhang (2015)
	-	-	Lee et al. (2012)
	-	-	Kelm et al. (2013)
	-	-	Marks and Teizer (2013)
	X	-	Sattineni (2010)
	X	-	Zhang et al. (2013)
Sensor	-	-	Andoh et al. (2012)
	-	-	Choe et al. (2014)
	X	-	Riaz et al. (2014)
	-	-	Pradhananga and Teizer (2012)
Global Position System (GPS)	-	-	Bansal et al. (2011)
	-	-	Andoh et al. (2012)
	X	-	Sharqi and Kaka (2014)
Image	X	-	Teizer (2016)
	-	X	Gheisari et al. (2014)
	-	X	Irizarry et al. (2014)
	-	-	Andoh et al. (2012)
Geographic Information System (GIS)	-	-	Marks et al. (2013)
Laser Scan	-	-	Wang et al. (2014)
	X	-	Wang et al. (2015)
	-	-	Carbonari et al. (2011)
	-	-	Teizer et al. (2007)

3. Framework and Methodology

The proposed framework for a novel safety management system is demonstrated in 2 parts. As shown in Figure 2, the system includes pre-construction and construction phases. In the preconstruction phase, during the design stage 4D (3D+ Schedule) BIM-base model can be used along with safety standards for identifying potential hazards and eliminating them by using the safety-rule checking system. In the construction phase, the UAS technology is utilized to control safety rules. It can benefit the construction safety-rule checking during the construction process. By following these regulations in the construction stage, any project can improve safety of all stakeholders. This system has the potential to assist designers, workers, safety managers to mitigate construction accidents and fatalities.

By using 4D models and simulations, the project team can communicate more effectively and implement a safety plan. 3D BIM model and schedule together is used to simulate hazards on the site. Identifying dangerous situation and their location in 3D model can be utilized to warn workers of the likely loopholes before construction phase. 4D BIM model is developed to find a prevention method to promote safety in construction. By having an efficient connection of 3D model with the planning and also implementation phase of safety, the goal of giving a great potential to deliver significant benefits to the construction industry can be achievable (Hayne et al. 2014). Safety rules and regulations can be utilized with 4D-BIM model and plan information to detect safety hazards in the safety-rule checking system. In this stage, relevant construction safety standards are extracted from OSHA and linked with the 4D BIM model to identify hazardous situations and eliminate them in pre-construction phase. Safety-rule checking reports will be utilized to assist safety managers to inspect that safety execution follows rules and regulations during the construction phase. The integration of these regulatory rules and technologies makes the hazard occurrence reduction possible

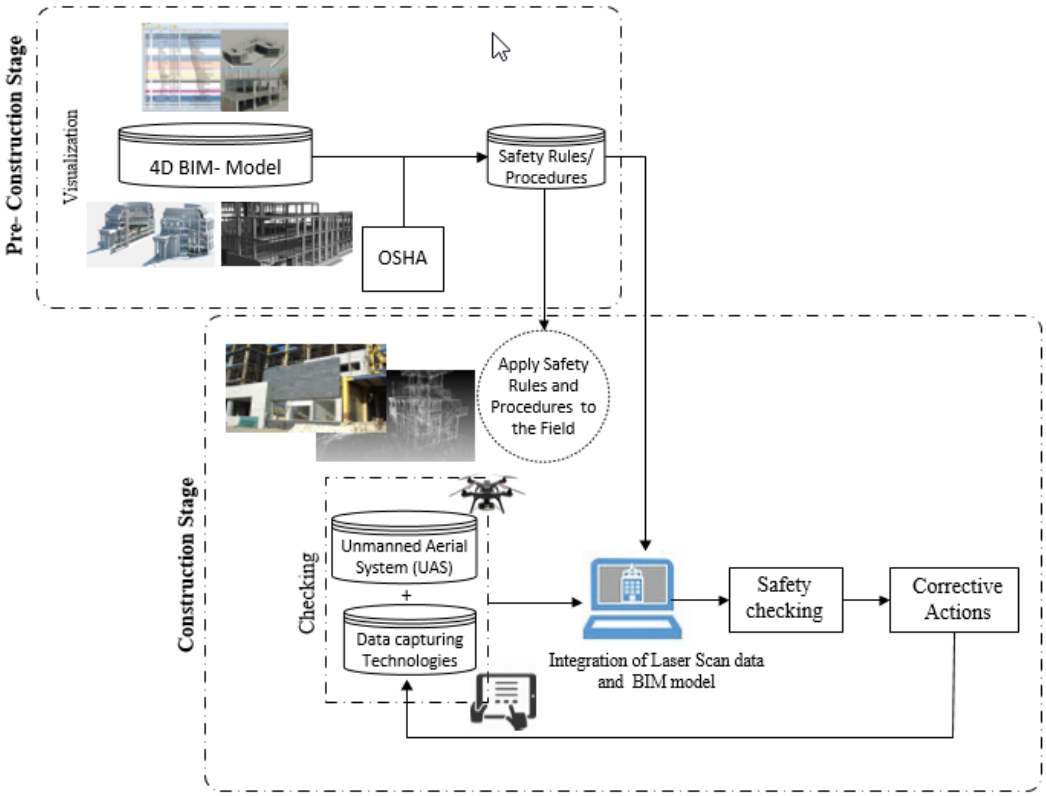

Figure 2. Framework for safety management in pre-construction and construction phases

As shown in Figure 3, during the monitoring process, safety manager use UAS technology to detect hazards situation points and their locations in the work environment. This fresh technology can fly over the construction site and collect real time data from the location of construction personnel and equipment, hazards materials, moving equipment and also more importantly blind spots to eliminate unsafe conditions before accidents happen. The safety specialist is able to compare collected data from construction site and 4D model from pre-construction phase at any required time. This comparison helps safety managers to ensure that the main hazards that may cause harm were identified and prevention methods were taken into account during each stage of the project.

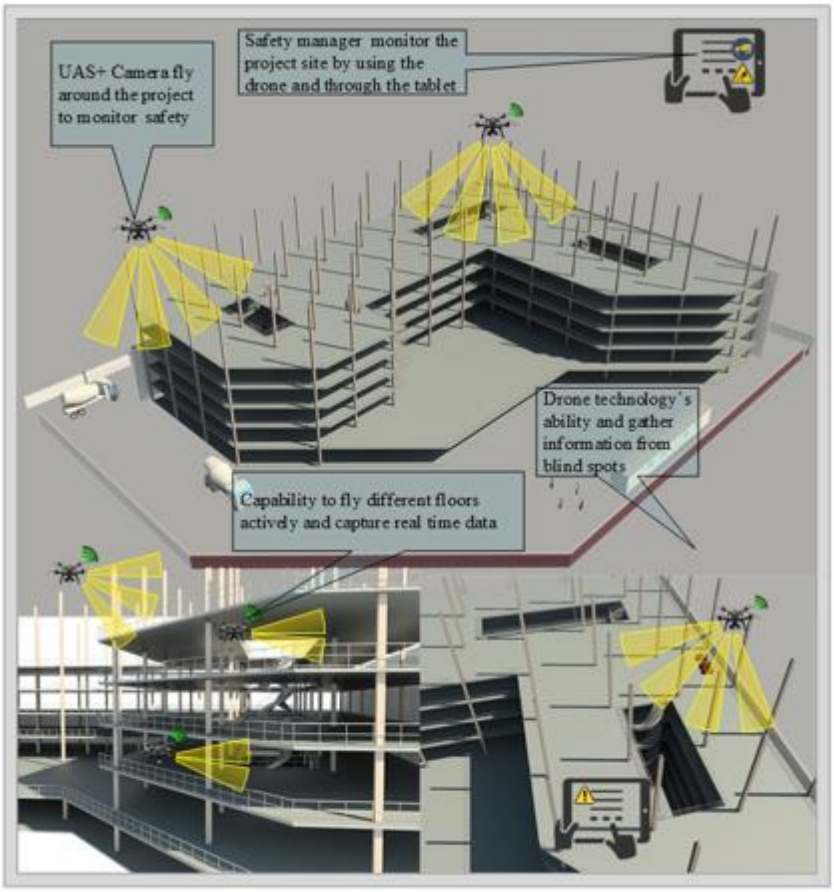

Figure 3. UAS camera based project safety sample

4. Conclusion

This research presented a new methodology in construction safety to detect hazardous locations in order to prevent them in the project. This paper also attempts to improve safety performance of construction-site workers to work more accurate and safer compared with traditional methods. The developed framework can improve safety by integrating BIM and UAS tools to obtain and analyse data in construction sites. BIM has the potential to integrate design into the safety planning and decrease possibility of accidents and reduction of project costs. Moreover, it is believed that BIM is not a useful tool only in the pre-construction of the project but can be included in the construction stages. This study presented a new methodology based on the BIM and UAV technology which will enable safety managers to identify hazards at different steps of the project and develop suitable mitigation strategies.

The developed framework is believed to improve occupational safety by integrating BIM and UAV tools to obtain and analyse data in construction sites. BIM offers many benefits that can improve construction safety. It has the potential to integrate design into the safety planning and decrease the possibility of accidents and reduction of project costs.

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Too complex to standardise? A case study of a socially loaded pier inspection process at the port of Gothenburg

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Abstract

This paper presents a micro-level study of an organisation considering to standardise a facility management process. Standards serve an instrumental purpose in the built environment reducing complexity by promoting similarity across time and space. However, differences in practices and perceptions of involved actors can make standardisation a complex endeavour itself, limiting its effectiveness as a mode of governance. Science and technology studies (STS) approaches are used to study standards in the inspection process. Standardisation is understood in this study as performative and a process of power, understanding, and emerging interests. The empirical material stems from a case study of a pier facility management process at the port of Gothenburg. Ten semi-structured interviews were conducted with actors involved in the inspection process – asset managers, structural engineers, inspectors and a document controller. Additional observations made during pier inspections and project meetings at the port were used to develop the context of the study. The analysis shows the multiple demands and interpretations present among involved actors prior to an attempt to standardise the pier inspection process. Asset managers and structural engineers voice a preference for guidelines that support ideal ways of working implemented using a checklist. Alternatively, inspectors wish to receive a common terminology. More strategically, the symbolic value of an ISO type standard matches a perceived need by the port management for credibility to satisfy customer demands. Simultaneously, a standard is expected to give clear directives to hired consultants, make the process more cost efficient and ensure a stable quality. The variety of interpretations and demands observed in this study underlines the social character of asset and facility management and the uses of standards. It is suggested to reflect on socio-technical conditions in standard design.

Keywords: standard, standardisation, pier inspection, facility management, socio-technical

1. Introduction

This paper discusses standardisation in the built environment as an effective mode of governance. An effective standard builds on a stabilisation of meaning of the object to be standardised. It is through such a stabilisation that complexity is reduced to a more homogenous form that is easier to coordinate. Consequently, a standard may be perceived less effective where it is unable to stabilise meaning. Inability to stabilise meaning can be observed in non-use of standards but also in presence of multiple standards. This happens as the complexity of the world to be standardised gives rise to different interests and understandings which may form seeds of resistance to any imposition of stabilised meaning. The practical relevance of imposing and resisting uniform categories has been vividly described by Bowker and Star (1999) and it returns in Callon's (2007) discussion on performativity as well. Although standards are intended to govern and reduce complexity, resistance to uniform standards appears to be endemic and reduces its effectiveness as mode of governance.

We take up this issue, and follow a process of pier inspection at the Port of Gothenburg as a case of standardisation. This paper builds on an appreciation of the complexity involved in seemingly straightforward activities such as a pier inspection process as part of facility management at a port. It can be argued greater complexity produces a greater variety of interpretations which decreases the credibility of standards as an effective mode of governance. We question whether a rather straightforward process like the inspection of a pier could be too complex to standardise. What is to be standardised? That is the question with which we open this paper to a variety of interpretations and demands of actors involved in the inspection process. What do different stakeholders in the pier inspection process consider valuable to be standardised? What elements in the vast sea of activities and thoughts about a pier inspection process are singled out to be stabilised in a standard? Ultimately, our aim is to better understand the conditions under which standards may be an effective way to govern in the built environment.

This paper is organised in seven sections. After this introduction, section two presents an insight in the theoretical and empirical aspects of the research methodology employed in this paper. Section three further elaborates on a few conceptual and theoretical issues about standardisation as a mode of governance. Section four and five cover the empirical material on which this study is based. Section four provides an overview of organisational arrangements present in the inspection process, a description of the inspection process and perceived challenges. Section five focusses specifically on different perspectives on standardisation. Section six provides a discussion of the results and their implications for standardisation as an effective mode of governance. The paper ends with some conclusive remarks shared in section seven.

2. Research Methodology

Theoretically, the research design follows a STS tradition of critically examining the instrumental rationality attributed to modern technologies such as a standard. The central methodological approach follows Bowker and Star's fourth methodological theme (1999), focussing on the practical politics in standard design. Typically for an STS approach, Bowker and Star's methodological theme allows us to question the neutrality and naturalness of a standard. Callon's (2007) understanding of performativity is used as theoretical frame to operationalise the politics of standard creation.

Empirically, this paper is based on a master thesis of two of the co-authors. It covers a case study of a facility management process at a pier operating crude oil tankers at the Port of Gothenburg (Hallgren & Olsson, 2016). The case study was chosen for its theoretical relevance to standardisation of a process with limited complexity. As such the case is expected to lean towards standardisation as a promising form of governance. The inspection process is followed from start to end over a period of four months in 2016. Ten semi-structured interviews were conducted with actors involved in the inspection process – asset managers, structural engineers, inspectors and a document controller. Selection of the interviewees was based on inclusion of different roles in the inspection process and additional suggestion by the interviewees. The interviews were structured to receive perspectives on the inspection process, its challenges, and opportunities for its standardisation. Additional observations made during pier inspections and project meetings at the port were used to develop the context of the study. Initial results of the case study have been presented at the organisation involved to allow stakeholders the opportunity to scrutinize and provide additional input to the case study. This combination of methods allowed the researchers to aim for a research ideal of closeness to the object (Holme, Solvang and Nilsson 1997). At the same time, a critical distance to the case was maintained since the other authors were only indirectly involved in gathering the empirical material.

The chosen research methodology includes limitations. Bowker and Star encourage us to follow the creation of a standard, a path that quickly exceeds research resources. Whereas the inspection process of the pier has been followed throughout a full cycle, the study of the standardisation process was restricted to the perspectives on standards in the pre-standardisation phase. Here, the study follows the necessary time restrictions of a thesis, limiting empirical observations to four months. At the same time, our approach benefits in empirical urgency by focussing on an ongoing standardisation process, as opposed the historical approach in Bowker and Star (1999). The used research methodology, allows us to produce insights in the variety of meanings that a standard would need to stabilise. This limitation is inevitable for research that aims to be of use for science and technology in the making instead of restricting to an ex-post explanation of already stabilised science and technology dynamics. In other words, because standards tend to become seen as neutral or even natural (Bowker and Star, 1999), it is sensible to study the pre-standardisation phase where the mode of standardisation is still under debate and thus visible and malleable.

3. Standardisation as mode of governing complexity

The built environment has a somewhat mixed history record regarding standardisation. Henry (2000) notes that a history of standardisation in building materials has co-existed for a long time with the absence of quality standards in construction organisation. At the same time, we observe a recurring interest in standardisation in the built environment. Research ranges from pre-fabricated building processes (Gibb 2001) to quality- (Henry 2000) and knowledge management systems (Roy, Low and Waller 2005, Styhre and Gluch 2010).

A classic account of the work that standards do starts from the idea that standards create similarity and homogeneity across time and space. Consistency of form or understanding allows people to coordinate their actions, and subsequently allow for higher complexity in the things people may achieve together (Bowker and Star 1999, Busch 2011, Furusten 2000, Timmermans and Epstein 2010).

Because the human work that goes into developing a standard remains mostly invisible to the large public, standards tend to be perceived as neutral. However, as Bowker and Star show, this is a false neutrality (1999). Instead of a neutral or objective instrument, standards should be viewed as a mode of governing, imbued with value and power based questions and political behaviour. It is for this reason, that we follow Bowker and Star and attempt to uncover "…the practical politics of classifying and standardizing" (1999).

The normative and political nature of standards is relevant because of the power that standards have. Theoretically, the concept of performativity helps to explain the power of standards. It also communicates an understanding that knowledge does not only represent reality but actively helps to shape it (Callon, 2007). Callon's work allows to address the socio-technical nature of standardization, the work by actors in socio-technical assemblages that goes into making ideas real, and the struggles that are involved in doing so. Interpreted this way, we may expect to see different assemblages of actors and statements attempt to collaborate and compete in a struggle for survival (Callon 2007). The gains and losses of imposing reality also explains why a reduction of complexity through standards is both sought after and resisted.

Regarding standardisation in a pier inspection process, it may be expected that different understandings and interests give rise to identification with different perspectives on standardisation. Standards are neither neutral nor powerless instruments.

4. Standardising a pier inspection process

4.1 Organisational arrangements underlying the inspection process

The Port of Gothenburg is responsible to maintain the pier structures from a safety perspective and a business perspective. According to an asset manager, the major reason on retaining the piers in a good standard is to keep them attractive for their customers, e.g. the oil companies operating the piers. The customers do not want to risk that the accessibility and operation of the piers is disturbed due to maintenance work or bad conditions, which could make them choose another port for their operations. Further, it is of high importance to keep the piers in a good shape to prevent high costs due to neglected maintenance.

The structural organisation of the inspection process is as follows (c.f. Figure 1). At the port, the general asset manager appoints an asset manager to oversee the main inspection, here a consultant. The consulting asset manager procures a structural engineer and inspectors to perform the main inspection. After the main inspection is finished, the findings are handed over to the asset manager who will decide how to proceed. If any repairs on the pier are necessary, the asset manager should appoint a project manager for that specific task.

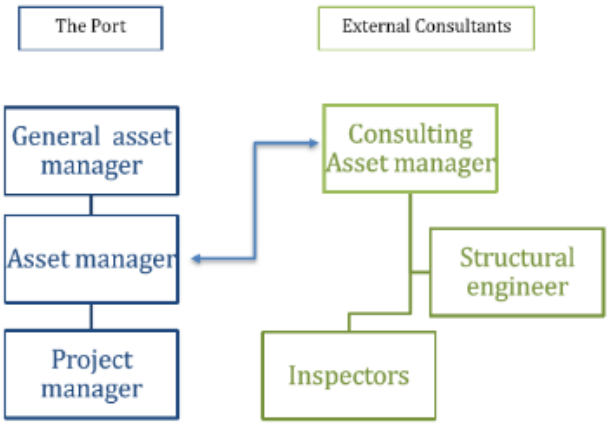

Figure 1: Organisation of the pier inspection process at the Port of Gothenburg (Hallgren & Olsson, 2016)

A second organising arrangement consists of the framework of the Swedish Transport Administration (STA) regarding the maintenance system for Bridge and Tunnel Management (BaTMan). As piers are relatively similar to bridges in terms of structure and design, it has been decided by the asset management to align the inspection process with the maintenance system. The system includes both inspection guidelines and a documentation system. The STA guidelines prescribe a main inspection to be made on each pier within an interval of six years. The inspection should aim to assess defects that can impact the functioning and safety of the construction within the next ten years. This includes defects that within three years can lead to structural malfunctions but also defects that may increase future maintenance costs. All elements of the construction should be inspected at an 'arm's length' distance or equivalent (Rutgerson 2014). The documentation system is used to compile the information collected about the pier after the main inspection. This includes data on damages, which can be classified according to type, location, and with options for input on the methods and extend to which a damage has been repaired. The port uses a limited licence for the maintenance system, limiting documentation to mark or unmark damages found on the piers but not to include details regarding reparation methods or partials reparations.

4.2 Description of the inspection process

The main inspection process can be divided into three parts: preparations, execution and closure. Preparations for the main inspection process are started by the general asset manager who decides that a main inspection should be done and then appoints an asset manager. The main inspection process is then initiated by the asset manager in cooperation with a structural engineer, evaluating the current pier with the latest executed main inspection as starting point, to investigate what was done during the last main inspection. Based on what is found there, documentation for the main inspection is set up. This documents includes specifications on range, budget and time amongst others and is used as a base for the procurement of consultants. The studied main inspection of Torshamnen span over about four months, but there have been main inspections that have taken almost a year.

When the material from previous inspections is collected, it is compiled to a compendium, which constitutes the basis for the quantity description used when procuring inspectors. The quantity

description describes which parts of the structure should be inspected using which technologies. Areas that need extra inspection are marked on the blueprints handed out to the inspectors, so are the areas where samples will be collected. The blueprints also give the inspectors a hint of the extent of the inspection. After the procurement, a more in depth description of the scope is written out, giving the inspectors some background information on the pier and the conditions of the project. Furthermore, the inspectors usually receive one or two reports from previous inspections.

When the procurement is made, the inspectors, asset manager and sometimes also the structural engineer, undertake a site visit at the pier. This site visit is intended to get an overview of the project aside from the blueprints, and ask questions. Next, the questions are collected and discussed during a question meeting. Finally, before the execution phase starts access permissions for the inspectors to the site are arranged. Additionally, a risk meeting is conducted, involving all participating parties.

Execution of the inspection consists of an underwater- and an above water inspection. The underwater inspection is conducted by a diving inspection team consisting of one captain, one diver and one diver attendant, serving the diver with oxygen cables, tools, and keeping the contact underwater. To undertake a main inspection, the responsible diver must complete a course on the BaTMan maintenance system and be practically trained by an experienced diver. It is also preferred that the diver has been hired for several years to conduct inspections for the port, including previous main inspections. In addition, there is an above-water inspection team, consisting of two inspectors.

Closure of the inspection occurs when the inspectors transfer the results of the inspection into the maintenance system. This enables the structural engineer to assess the status of the pier and make suggestions on maintenance measures. The assessment from the structural engineer are sent over to the asset manager who decides upon a maintenance plan and formulates maintenance projects for the pier.

4.3 Challenges – demands for improved coordination

Several challenges were identified by the interviewees when discussing the inspection process. These challenges are arena's in which the struggles between socio-technical assembles can be expected to take place in a later stage of the standardisation process. For clarity reason ns, the challenges have been grouped by the authors in three categories: documentation of information, practical arrangements and decisions on the inspection process, and misunderstandings between actors involved.

First, access to the relevant information and subsequent documentation of inspection findings has been viewed as problematic by different actors in all stages of the inspection process. During the preparation phase, access to materials from previous inspection is viewed as problematic because the maintenance system does not contain all information needed for the inspection process. Additional information can be found using reports stored on an internal server at the port which is characterised by a lacking structure and accessibility. It is telling that even employees of the port itself consider it challenging and time-consuming to find the right information on the internal server. During the closure phase of the inspection the systematic documentation of information is limited to the basic damages that can be reported into the maintenance system. Additional information like the time, place and methods used for the reparations are not compiled and stored systematically. Consequently, there is a dependence on personal expertise and experience as source for relevant information. This leaves the inspection process vulnerable to personnel changes and limits overall efficiency.

An example of an unsuccessful reparation of a connected pier can be used to illustrate this vulnerability. In the example, an earlier attempt to repair the pier had failed because the concrete at the repaired area had cracked. Eager to avoid a repetition of the mistake it was attempted to find out which methods were used in the original repair. This was much harder than expected as the person conducting the failed reparation had left to another company, taking along the knowledge about which method had failed. Frustration about these types of inefficiencies due to insufficient documentation is expressed by an asset manager when urging that "we have to stop reinventing the wheel!"

Second, insufficiently structured coordination of working practices is identified by several interviewees as a common challenge during the inspection process. A number of examples were brought up during the interviews that support a perceived weakness in coordinating working practices. The selection of poles and areas to be inspected was identified as poorly structured. Instead of a systematic sampling of the poles inspected, time constraints may lead to a deselection of poles that are difficult to reach. Once the poles are selected, access to site itself can be problematic for the diving team. A recurrent example is the absence of a single person in the diving crew, which requires a stand-in diver to perform the inspection. This simple change leads frequently to delays as the stand-in first needs to get the right permissions to work at the port's premises. At other times, working practices was inefficient because necessary tools and materials required for specific parts of the inspection were not available at the port. Depending on criticality of the working practice and the lack of coordination, some of these problems simply result in delays and inefficiencies. Others, such as the selection of the poles may risk more serious quality problems.

A third coordination challenge in the inspection process results from plain misunderstandings between the professionals involved. For example, in a meeting at the port a misunderstanding between a structural engineer and an inspector was observed. Attempting to come to a common understanding on the seriousness of a delay, the structural engineers assumed that the inspector was referring to a single day delay for the entire pier. Instead, the inspector meant a single day per pole to be inspected, adding a few weeks to the delay. It can be said that the organisation of the inspection process, including a necessary outsourcing of the underwater inspection to specialists, adds to the complexity of the communication. Even where the importance of good communication is recognised, it may still be difficult to avoid misunderstandings as different professional groups speak different professional languages.

This sub-section discussed three challenges that were identified to contribute to inefficiencies and potential quality issues in the inspection processes. These include challenges about structured documentation, working practices and communication between professionals. The general asset manager judges the execution of the main inspection to be of high quality despite the challenges witnessed. For the future, the general asset manager expressed concerns as to maintaining quality while professionals involved may change employer and take their competences with them, away from the inspection process. In response to these challenges, the general asset manager views a more standardised way of working to be beneficial for safeguarding the quality and efficiency of the inspection process.

5. Perspectives on standardisation

When the interviewees were asked to express their views on a standardisation of the inspection process, a variety of different perspectives were retrieved. These perspectives represent different preferred solution types and related to different stakeholders and aspects of the inspection process. In this section, we discuss the following views on standards: guidelines, nomenclature, symbolic standards, and the current BaTMan maintenance system.

5.1 Guidelines

Asset managers and structural engineers voiced a preference for guidelines that support ideal ways of working. The general asset manager approaches guidelines as a way to prevent the procedure to start from scratch every year. This is expected to improve the efficiency and quality of the inspection process. Different ideas were voiced on what such guidelines should look like.

Most concrete, a process chart is under development intended to structure the access of the asset manager to documentation during the inspection process. The process chart is intended to be coupled to an internally used software system allowing instant access to ongoing activities and aid in future planning. Alternatively, a check-list can be prepared to give guidance on the type of activities to be done, permissions needed, meetings conducted, and goals to be achieved. For example:

"A standard should set up several minimum levels and requirements, for example that one should inspect ten or twenty percent of the poles"
- a structural engineer

According to the general asset manager, a standard should assure that the main inspection is performed correctly and efficiently. Although clear guidance is key, the general asset manager does not want a guideline to be overly prescriptive. A risk with relying on guidelines is that you take away professional authority from the inspectors by prescribing not only what to do but also how to do an inspection. The development of a check-list could lead professionals to blindly follow their checklist and stop relying on own knowledge and experience.

5.2 Terminology

Inspectors appear to be quite satisfied with the organisation of the inspection process at the port.

"The expectations from the port are clear, thanks to the usage of the BaTMan methodology." – an inspector

"The cooperation with the port is working very well, (...) we prefer the down-up type of governance that is currently used." – an inspector

When asked about their ideas on standardisation, the inspectors voiced a demand for terminological principles to enable a common nomenclature. The lack of a common nomenclature between the different professionals has been identified to lead to misunderstandings at the port. Different types of professionals speak different languages and a more detailed agreement on terminology would help a great deal.

5.3 Symbolic value

More strategically, the general asset manager brought up the possibility of implementing an internationally renowned standard - ISO 55000. The implementation of the ISO standard was identified to be guided less by intentions to improve coordination of the inspection process, and more by the symbolic value of the internationally recognised standard. In branding of the port to shipping companies, ISO 55000 was perceived to be able to strengthen the brand of the port. Although not actual yet, the general asset manager could envision a future where this would become more relevant.

5.4 BaTMan

Next to a satisfaction with the organisation of the inspection process, the inspectors voiced an appreciation of the guidelines and documentation provided for by BaTMan. Two inspectors described the maintenance system to be their standard. Interestingly, other interviewees did not do so. The maintenance system is perceived to organise for a more a uniform inspection process and outcome. At the same time, the system's guidelines are interpreted flexibly in practice to account for difference between the application in pier inspection compared to the original focus on bridges and tunnels. Instead of developing an own guideline, the inspectors seem to prefer an extended use of the current maintenance system by the port.

In short, a variety of perspectives on standardisation of the inspection process have been described in this section. In the next section, implications of such a variety for standards as a mode of governance will be discussed.

6. Discussion

Standards imply a common way of working. But what does this mean? In the previous sections, different challenges to the coordination of the inspection process were identified which reflect in different ideas on standardisation.

Operationally, a standard could make it possible for a less experienced person to run the main inspection process and maintain quality and efficiency of the inspection process. A standard should improve communication within the inspection process and provide for structuring of the documentation to store knowledge and experience. Some refer to the need of just establishing a set of common terminological principles, others rather refer to it as a set of guidelines and rules which describes the ideal way of working. Strategically, a standard should fulfil a symbolic value and provide credibility to satisfy customer demands. What are we to make of this variety in viewpoints?

Firstly, there appears to be a tendency for parties that are involved in the whole inspection process to ask for guidelines or checklists on what the process should include. The desire to have a checklist can be linked to the concern of forgetting something, as well as making individuals easier replaceable. The asset management is worried that the quality of the inspection process is not consistent and request a standardisation of the process flow. Through standardising the process, the expectation is to streamline the process and by that identify waste, making the process more cost efficient.

Secondly, engineers and inspectors tend to be only involved in parts of the inspection process and do not value process thinking to the same extent. Instead, they focus on the quality and completion of their individual tasks. It is not unsurprising that such professionals are more receptive to an agreed nomenclature to avoid misunderstanding. The consultants further desire clear directives in the form of properly structured documentation stipulating what is expected, and a proper organisation of work task related aspects such as pole selection, regulation and access to working sites.

Thirdly, the general asset manager's concern with the symbolic value of standards adds a more strategic level to discussions of standardisation. Here, the introduction of ISO is not desired because of operational quality benefits it may bring, but because of a concern with customer perceptions of quality. This distinction reflects a tension between the role of standards in organising markets (Brunsson, Rasche and Seidl 2012) and organising an inspection process. Whereas BaTMan may have a symbolic value within Sweden, the international nature of shipping may make such a system less valuable from a symbolic perspective.

Returning to the research questions, there is no unambiguous answer to the question what is to be standardised. Differences in ideas about standardisation appear to follow different understandings and interests in the inspection process. The case study presents us with examples of task oriented, process oriented and symbolic understanding of standardising the inspection process.

Callon's (2007) discussion of performativity teaches us that the interaction between these different understandings may not go smoothly. Instead, different actors and ideas may form alliances in a struggle for survival or for maintaining their turf and benefits. Here, one can see the potential for an alliance between an extension of the current maintenance system and use of a common nomenclature. The symbolic understanding of an ISO standard seems relatively better aligned to ideas of process standards. Obviously, alternative modes of interaction between these assemblages can be thought of.

Ultimately, the conditions under which standards may be an effective mode of governing complexity include a necessary appreciation of plurality in understandings, interests, and standard options. Even a relatively straightforward inspection process between a limited number of actors shows a variety of perspectives on standardisation. Instead of neglecting such differences, we propose standards to be reflective of the different challenges and perspectives of actors involved in the process to be standardised.

7. Conclusion

This paper set out to study perspectives on standardisation of a pier inspection process at the port of Gothenburg. The analysis showed multiple demands and interpretations present among involved actors prior to an attempt to standardise the port inspection process. Examples of task oriented, process oriented and symbolic understanding of standardising the inspection process show that even a relatively straightforward object can be expected to be complex to standardise. Does this mean that the facility management process at the port is too complex to standardise? We would not want to go this far. Standardisation can be understood as an outcome between actors and understandings, struggling for maintaining their interests. A more reflective understanding of the socio-technical context could smoothen such process, and benefit the use of standards as an effective mode of governance.

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Bridging strategic quality assurance (QA) regime with operational initiatives for better project decisions

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Abstract

Norwegian State Project Model (the QA regime) forms a potential framework for measuring quality of projects. The regime has been used at strategic level and it mostly deals with financial aspects of projects. In parallel, unlike QA regime, there are other operational initiatives that focus on non-financial aspects and could possibly enhance quality requirements of construction projects, such as the safety charter and BREEAM-NOR (Building Research Establishment's Environmental Assessment Method in Norway).

The researchers wanted to test a proposition of bridging the strategic QA regime (financial) and two operational initiatives (non-financial) introduced in Norwegian construction industry. Combining the three initiatives will potentially help to make better strategic choice of right project and at the same time strengthen operational choice of the right method for project execution. We studied the attributes of QA regime and operational initiatives and use their attributes as input for newly introduced sense and response method to identify the critical ones, so that the QA regime can be expanded to cover more non-financial aspects. Identifying the relationship and the critical level of the attributes could help to link the strategic attributes to the operational ones that in turn helps project stakeholders to make a quality and sustainable project choices.

The paper introduces a sense and response method called scaled critical factor index (SCFI). This method helps to identify the critical attributes from the initiatives considered. This method uses both qualitative and quantitative analysis. The paper briefly discusses how the survey is organized, the question formulated, and how the responses are analysed to determine the critical level of the attributes considered. Desk test carried out as an example to clarify the concept of sense and response method.

As a primary source, the researchers consider the three initiatives, investigates the historical records of the initiatives using available secondary data (manuals and reports). However, the current stage is limited to the on desk test analysis.

Keywords: Project selection, quality assurance (QA) regime, safety charter, BREEAM-NOR, strategic, operations, sense and respond

1. Introduction

Successful project governance is a key for economic and societal (welfare) development. Therefore, having good project governance with strong tie between the strategic and operational initiatives is crucial. The strong link between the strategic initiatives (choosing the right project) and the operational initiatives (doing the project right) improves all rounded performance of the project. However, creating such link requires well-structured operational efforts synchronized with strategic efforts. One component of such efforts is having good and updated project appraisal system so that the right projects can be selected and consistently governed to achieve their intended goals. This can be done and assessed from bottom-up or top-down (Chen and Volden, 2013), in case, there is a gap between various initiatives and the strategic goals. However, this needs good understanding on the requirements and contents of strategic and operational initiative efforts that can be reflected using some attributes.

Following the first strategic initiative by the Norwegian government to review the systems for planning, implementing, appraisal, and following up public investment projects in the 90's, the first generation quality assurance scheme was introduced in 2000 (Klakegg et al. 2016; Odeck et al. 2015, Samset and Volden 2013; Samset et al. 2006). The Ministry of finance introduced the QA regime second generation through a frame agreement covering QA1 and QA2 in 2005. QA1is quality assurance focusing the choice of concepts) and QA2 is quality assurance focusing cost estimates and readiness for execution. The framework agreement is known as QA regime, later called the Norwegian State Project Model (Samset and Volden 2013). This regime has been implemented in public investment projects and has served to make better project choices with better use of resources. The attributes in the strategic QA regime are mainly used for making strategic choice of right projects.

Unlike the aforementioned strategic initiative (QA regime), the operational initiatives are used to help doing the project right e.g. safety charter for safe construction and BREEAM-NOR for sustainable construction. BREEAM-NOR seems to partly cover both strategic and operational level when we look at some of its attributes. For example, project owners/investors select projects with high score of being environmentally friendly because it would reward them to have better price while selling the building. This generally emanates from fulfilling BREEAM-NOR objective to raise the awareness of stakeholders (owners, occupants, designers and operators) of the benefits of buildings with a reduced impact on the environment. Another initiative is 'safety charter', which mostly considered as operational level and helps to do the project right. Obviously, safety is one attribute required to do the project right. This is because accidents and loss of lives are unacceptable by any operational standards. Reducing the probability of accidents and keeping the safety and wellbeing of human lives also has a strategic dimension, as there should be a possibility to choose the project with the least probability of having safety issues. BREEAM-NOR and Safety Charter is chosen because these initiatives are introduced relatively recently and has become very influential over a short time in Norwegian construction industry.

The bottom line here is to look at both the strategic initiative attributes (choosing the right project) and the operational initiative (doing the project right), study all attributes under each initiative, and investigate the possibility of obtaining better investment projects. Our assumption is that better projects can be obtained by continuously evaluating and considering bi-directional reinforcement of strategic and operational attributes (see Figure 1 that shows the conceptual relationships of initiatives attributes towards the strategic and operational decisions). The thickness of the connecting lines shows the level

of involvement of the attributes. Indeed, all initiatives have their own attributes to be pledged on achieving better results on choosing the right project and making the project right. However, some of the attributes seems considered in at least two of initiatives, e.g. safety, environmental friendly. Therefore, incorporating some critical operational attributes, creating synergy at early project selection stage could help improve the future project choices.

To create such synergy between the strategic and operational initiatives, it requires good understanding on the attributes, identify the most critical ones and look for the way to incorporate operational attributes to the strategic QA regime. This will help in a way to identify missing ingredients, unique to one initiative and common attributes that are found in the strategic and/or operational project activities. This can be considered a part of continuous improvement (Deming Plan-Do-Check-Act cycle), and an endeavour to make better, quality and sustainable project by bridging the strategic and operational initiatives.

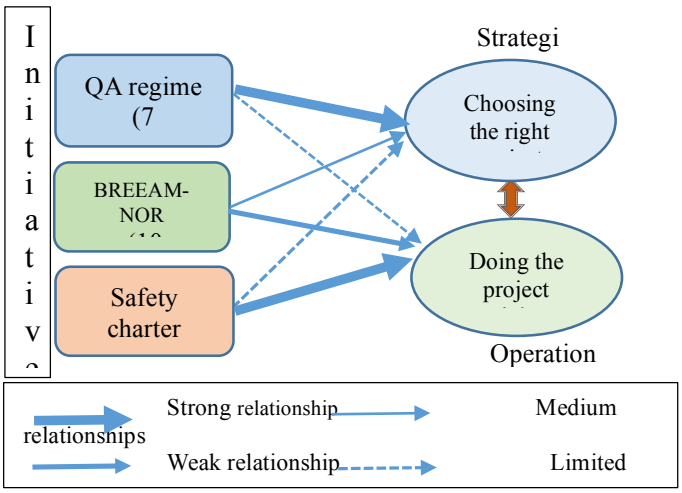

Figure.1 the conceptual involvement of initiatives attributes to the strategic and operational decisions.

To investigate the relationships and involvement of the initiatives we introduce "sense and respond method" that can help to identify the critical attributes. The purpose is to sense the situation (by studying various attributes of the initiatives), and respond by incorporating the critical attributes that could create positive synergy both in project choices and while doing the project right.

To achieve this goal, the researchers investigate three initiatives and identify attributes that are missing, common for both initiatives, and unique to one of the initiatives. This can be done using sense and respond method (Ranta and Takala 2007) by looking at the experience of using attributes in project selection, expected results from the selection, compare with best practices (other initiatives) and finally look at the direction of improvement by comparing the gap between using the attributes from not using them. Although the strategic and operational initiatives seems intuitively linked (related) to one another as indicated in Figure 1, this relationship and gap between the strategic and operational initiatives have not been systematically studied. Therefore, this sense response study can serve to fill this gap and considered as one systemic endeavour of creating a link between operational and strategic initiatives.

2. Literature review

Selecting the right projects depends on availability of well-structured framework that constitutes both financial and non-financial attributes. However, many of project selection processes focus more on financial attributes. However, according to Moutinho and Lopes (2011) the decision-making and selection of investments projects is complex and it goes beyond the financial aspects. In this connection, Mohamed and McCowan (2001) stated "*non-financial project aspects need careful analysis and understanding so that they can be managed. In extreme cases, neglect of these aspects can cause the failure of a project despite very favourable financial component*". However, there are evidences that show the challenges of incorporating financial and non-financial attributes on project evaluation process (Kishk, 2002).

In the process of successful project selection, according to a balanced scorecard collaborative white paper (2005), a strategic project success requires not only the achievement of financial goals but also interim improvements in skills, organizations, processes, and relationships that enable financial performance better. However, for such evaluation process to work, both the strategic outcomes and the interim strategic actions must have direct success measures and specific targets (Kaplan and Norton 2008). In this regard, it is relevant to consider both the strategic and operational initiatives and evaluate project overall performance using multi-attributes.

Literature showed that there are two approaches of handling (managing) those initiatives and overcome the challenges of incorporating financial and non-financial attributes. The first approach is to put all efforts towards to aligning the strategic initiatives with the operational ones (Kaplan and Norton, 2008). Typically, Wolf and Muratcehajic (2016) showed in their white paper that the value added of a strategy depends on the consistency of operationalizing it and this require close links between strategic initiatives and strategic resources management on one hand and management and operational methods on the other. The second approach claims that strategic initiatives should be managed separately from routine operations (Kaplan and Norton 2015). These two approaches seem contradicting in the way that they approach the challenges. However, the overall goal is to achieve better project performance.

The challenge seems to be lack of understanding the influence of attributes found in each initiative and how to bridge them, starting from the first step of project selection. This selection process includes identifying the right criterions and methods to evaluate the project impact on strategic goals and operational objectives. According to Kaplan and Norton (2008), one of the necessary conditions for project success is appropriately design and links the selection criteria to the strategy using financial and nonfinancial attributes. This helps evaluators at strategic initiative to determine their project priorities. For example, Salehi and Ghorbani (2011) considered one premise of the balanced scorecard approach, which is the financial accounting metrics that companies use to monitor their strategic goals. The result from their research showed that the strategic financial metrics were not well understood by operational evaluators. Furthermore, they concluded there were challenges on reporting and delivering all the financial and non-financial attributes together.

3. Recent frameworks introduced in Norway

After having gone through project selection literature and considering thematic Norwegian project governance initiatives, we chose three initiatives with justification for their selection as shown in Table 1. Three initiatives are briefly described; one strategic (QA regime) and two operational initiatives (BREEAM-NOR and Safety charter).

Table 1. Three selected initiatives

Initiatives	Justification for selecting the initiatives	Level of initiative
QA REGIME	-The one state project model for quality project selection. - Has systematically designed two overarching decision points, including the concept choices and cost frames (QA1 and QA2) and it needs the highest decision-making level. -it articulates what project success mean by considering operational, tactical and strategic achievements. This gives a room for improvement by linking operations with strategic goals.	Strategic
BREEAM-NOR	-BREEAM is global and integrated assessment system for construction and real estate, which documents differences in effects on the environment and human health, and which makes it easier to make the correct choices. -BREEAM-NOR is a Norwegian adaptation and is connected with relevant standards & rules in the environmental & energy areas. -It can serve as benchmarking because BREEAM is the global leading and most widely used assessment method for buildings, with over 115,000 buildings certified and nearly 700,000 registered. -*Technical Credibility:* BREEAM tested in terms of both its robust technical standards and its commercial delivery, and expert advice (based on scientific evidence).	Operational
SAFTEY CHARTER	-It is a branch initiative that involves several stakeholders in the Norwegian building and construction industry, such as Norwegian contractors association (NCA), the large Norwegian public project owners in Construction (NPRA (Norwegian Public Roads Administration), Statsbygg, Association of consulting engineers, The charter was established with the aim to work for zero accidents in the Norwegian construction industry. The different actors have developed their own action plan for how they will work to continuously improve safety.	Operational

Each initiative has its own attributes to achieve the intended objectives. All initiatives have a common ambition of securing better quality projects. Some of the attributes under these initiatives seems similar, some looks peculiar and dedicated to each individual initiative, and some looks common in more than one initiative but use different terminologies. Therefore, by elaborating more attributes, detailed statements of the attributes, the researchers identified the gap to pinpoint the critical attributes towards creating better synergy between the strategic and operational initiatives. The research framework is shown in Figure 2. It shows the link between the strategic and operational initiatives using top-down and bottom-up approach as a continuous improvement process in project selection and specific goals of identifying attributes that could help better project selection.

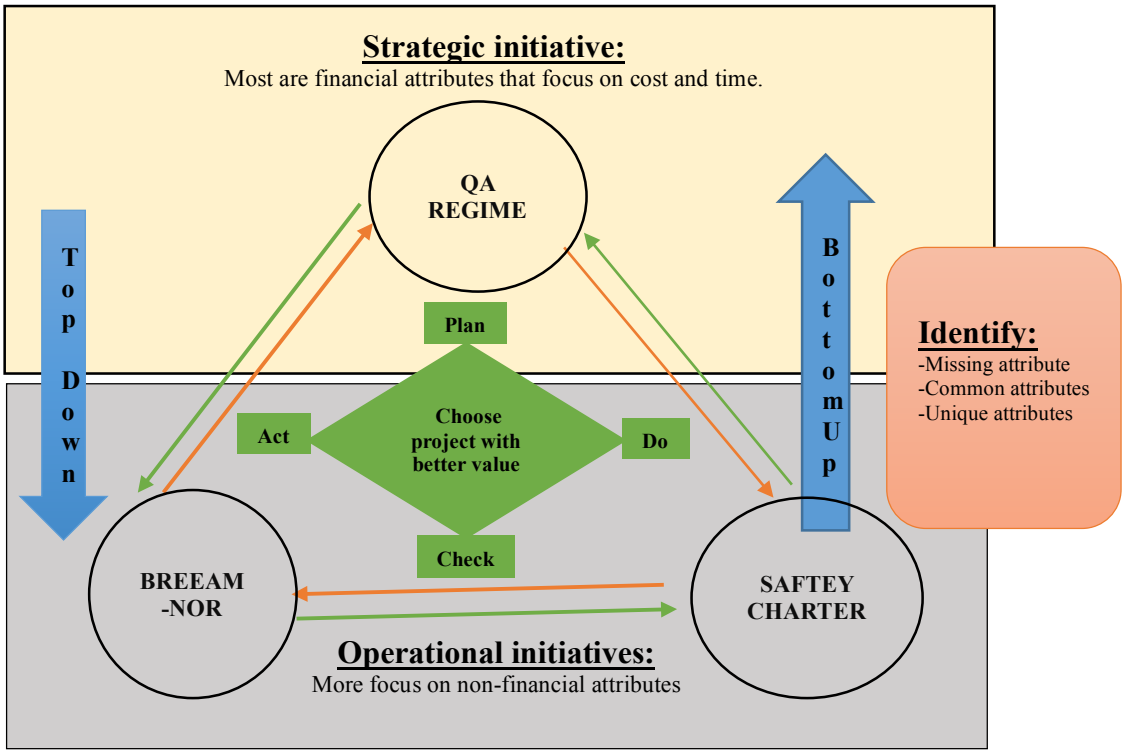

Figure 2 Research framework.

4. Methodology

In all endeavors to close the gap between the strategy and operational executions attributes, firms should consider strategy as an iterative loop with four steps: making sense of a situation, making choices, making things happen and making revisions (Sull, 2007). Inline to this, the first step to obtain better performance or filling the gap is identifying the critical attributes by sensing the actual situation.

4.1 Method description

In connection with sensing the actual situation (Sull, 2007), the research is approached to improve quality project choices and doing the right project by systemic study of attributes using a sense and respond (S&R) method. In this regard, critical factor index (CFI), which is one S&R method, is considered to serve for a useful purpose. CFI helps to identify the crucial attributes using various indices. CFI is robust and has been used in several application and validated in many industrial sectors other than construction (Belay et al. 2013; Takala and Uusitalo 2012; Ranta and Takala 2007). In this connection, this research would like to employ the improved (scaled) CFI, which is represented as SCFI after incorporating the sample correction error (Belay et al. 2013). The inputs for the SCFI equations below are derived from the response of the survey and CFI will be calculated. Different standard deviations from experiences and expectation, gap index, direction of performance improvements are calculated as follows.

The critical factor index (CFI) was represented as follows**:**

$$\text{CFI}=\frac{\text{Standard deviation of expectations}*\text{Standard devation of experiences}}{\text{Importance index}*\text{Gap index}*\text{Direction of development index}}$$

$$\text{Gap index}=\left|\frac{\text{Average of the experiences}-\text{Average of expectations}}{10}-1\right|$$

$$\text{Direction of development index}=\left|\frac{\text{Dir. of devt. (better)}-\text{Dir. of devt. (worse)}}{10}-1\right|$$

$$\text{Importance index}=\frac{\text{Average of expectations}}{10},$$

Where, Dir. of devt. stands for direction of development (improvement) either better or worse that indicate the subjective ratings of the specified attribute as compared to best practices and the change on performance with and without using the attributes.

By extending CFI to SCFI (incorporating sample error correction), it is possible to avoid a non-zero standard deviation that makes the decision difficult. Therefore, SCFI is can be calculated as:

$$\text{SCFI} = \text{CFI} + \frac{s-1}{2\ln(2)n},$$

Where s is the minimum number of samples required and n is the number of total samples (responses) actually analysed, CFI is a critical factor index without sample error correction,

$$\text{SCFI}=\frac{\text{Standard deviation of expectations}*\text{Standard devation of experiences}}{\text{Importance index}*\text{Gap index}*\text{Direction of development index}}+\frac{s-1}{2*\ln(2)*n}$$

4.2 Survey Organization

The first step to do a systematic sense and response survey is to select the right attributes. The paper uses a retrospective project selection attributes from the strategic initiative and refer important documents (manuals and reports) from operational initiatives. The study organized the survey in two steps: first, it defines the proposition (context) and then formulate the questions that are thematic to project selection.

Defining survey proposition (context): The purpose of this research is to bridge selected strategic and operational initiatives for better projects in Norway. The initiatives are the QA regime (Finansdepartementets ordning med ekstern kvalitetssikring av store statlige investeringsprosjekt), BREEAM NOR (miljøsertifiseringsordningen) and the Safety Charter (HMS charter for en skadefri bygge- og anleggsnæring). The research wants to find out if and how they support and/or complement each other.

The intention is to make use of this knowledge to propose improvements to project governance and to increase the value of projects for the society. The respondent was intentionally chosen that have experiences from various projects and expertise concerning at least one of the initiatives mentioned above.

The assumption is the respondents are in a situation to select investment projects by considering several attributes listed below (the attributes all refer to one of the initiatives). The study wanted them to give their subjective rating as answer to four thematic questions. In addition to rating, the survey provides the opportunity to give their remarks/comments if relevant.

Formulating questions: Because sense and response method (CFI) is adopted from other industrial sectors, it was required to formulate the questions in to the project selection context. All thematic questions arranged in a single survey format as presented in table 1.

QUESTION 1. Expectation: Rate the ideal importance of attribute 'i' in selecting projects (1 = not important, 10 = very important)"

QUESTION 2. Experience: In your actual experience from using, 'i' as a selection criterion, how influential is it? (1 = not influential, 10 = very influential)

QUESTION 3. Effect (Direction of improvement): How will the use of attribute 'i' in selecting projects influence the outcome? i.e. the effect on the outcome while using "i" versus not using it. Choose one of the three. (Worse – Same – Better).

QUESTION 4. Benchmark: Compared with other best practices and initiatives you know (assuming the best way to go - indicate which best practice reference under remarks), what could be the impact of attribute 'i' in project selection? Choose only one of the three choices below. (Worse – Same – Better).

Table 2. Survey format

Purpose: Proposition/context:		QUESTION 1 (Expectation)	QUESSTION 2 (Experience)	QUESTION 3 Effect (Direction of development/improvement)			QUESTION 4 Compared to best practices		
Initiatives	**Attribute i**	**(1-10)**	**(1-10)**	**Worse**	**Same**	**Better**	**Worse**	**Same**	**Better**
QA REGIME	Attribute 1 Attribute 2 •								
BREEAM-NOR	Attribute 7 Attribute 8 •								
SAFETY CHARTER	Attribute 7 Attribute 8 •								

Data collection: The study gets no enough responses except few feedbacks. This makes challenging to put some summarized details of the respondents. The target groups from the first trial were experienced project managers that are involved in project selection from the three initiatives. However, at the current stage, it is preferred to discuss only the challenges raised by the respondents in section 4.

5. Result and discussion

The first task in this research was to identify the attributes from the three initiatives (see appendix A). After selecting and defining the context, the researchers formulated thematic questions and prepared a survey using the attributes identified. Although the survey was sent out to potential respondents who have vast experiences on project selection, it got only few responses. Few comments were in line with

literature that argue operational initiatives are barely linked with strategic project choices. However, other literature (Moutinho and Lopes 2011, Sull 2007) claim the gap between the strategic and operational efforts and the involvement of non-financial attribute plays a great role. However, he challenges for the survey seem to stem both from technical and technical concerns. For example, based on the respondents' feedback, some of the technical challenges of the survey were: complexity of the survey, do not understand the terminology, hard to read, do not understand why it was asked, etc. However, beyond the technical issues, there are tactical concerns to connect the strategic and operational attributes. For example, one of the concerns (perspective) was that the three initiatives do not support the same purpose. On the other hand, some literature showed the relevance of operational initiatives to the strategic decisions.

This is one research motivation to fill the gap between the strategic and operational initiatives. A very good practical case is quality assurance (QA) regime follow up investigations carried out by Samset and Volden (2013) and presented on the concept research program report 36 (figure 3).

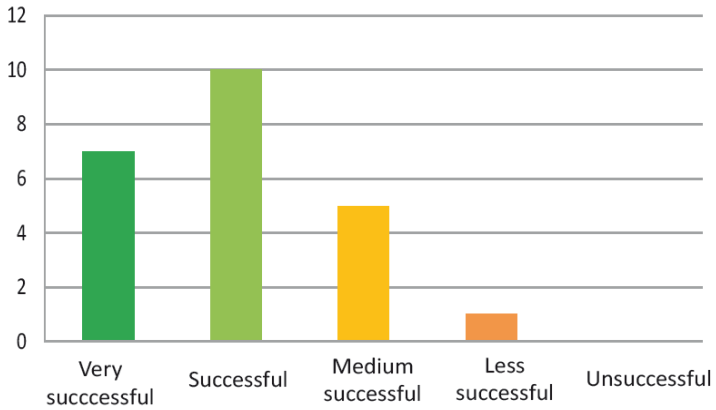

Figure 3. Operational success, the researchers' assessment. N=23 (Samset & Volden, 2013)

However, the question that the research wants to address and make pose to project management community is how managers can obtain quality project governance from the dyadic relationship of attributes from strategic and operational initiatives. This could help to overcome or resolve the causes the challenges faced by previous less successful/unsuccessful projects (figure 3) In addition to that, to invite further discussion if managers have other ways of creating synergy or bridging strategic and operational initiatives.

Obviously, it is difficult to have a concrete conclusion to answer the question on how to link strategic and operational initiatives at current stage (without having complete responses from the survey). However, this study attempted to intervene sense and response approach and use SCFI method to identify the most critical attributes in each initiative. Identifying key attributes systematically from past project selection experiences and considering the influence of selection attributes would help to improve the future quality projects selections.

The result from SCFI that is identifying the critical attributes is not the final goal but it would insight to which attribute the project manager should give emphasis in the future selection. However, in line with some of respondent concerns, some attributes could not serve the three initiatives, some might be found in more than initiatives (common), and other could be unique to only one initiative (example is presented in table 2 and figure 3).

Table 2. Identification of attributes based on the initiative type and level

Designation	Initiatve/s	Attributes found	Initiative level	Attributes charcter
A	Unique to QA regime	e.g. 1, 2,3, 4,5,6,7	Strategic	Unique only to one initiative
B	Unique to BREEAM-NOR	9,11,12,13,15,16,17	Operational	
C	Unique to Safety charter	18, 20,21,24,25,26	Operational	
D	Mixed (common to QA regime and Saftey charter)	1	(strategic & operational)	Mixed with two initiatives
E	Mixed (common to QA regime and BREEAM-NOR)	8,14,17	(strategic & operational)	
F	Mixed (common to BREEAM-NOR & Saftey charter)	10,11	Operational & operational	
G	Common to all initiatives	10, 19, 23,22	Common to all	Common

The purposes of identifying and categorizing project selection attributes is twofold. Firstly, it would provide opportunity to improve project selection by creating synergy and minimizing the gap between the strategic and operational initiatives. Secondly, it helps to avoid compliances on projects performance for not being successful. Further, it helps to easily visualize missing attributes (could be new or found in one of the initiatives) that could be useful in future projects selection. The conceptual representation and relationship of strategic and operational attributes are presented in figure 4.

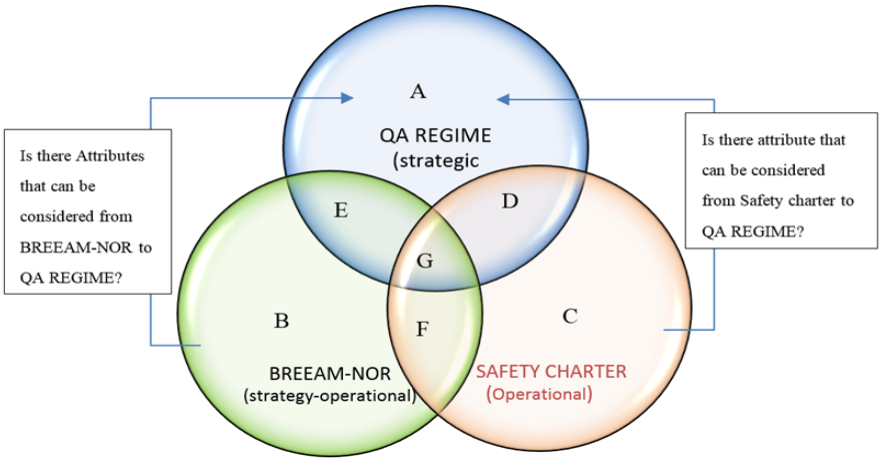

Figure 4 Relationship of strategic and operational initiatives' attributes.

5.1 The result from desk test survey

Regardless of the complexity and challenges to get response from the survey, the sense and response method seems has potential to identify systematically the critical attributes from the three initiatives considered (figure 5). For example, attributes from operational initiatives (early identification of problems, design for safety construction) can be considered in project selection. Similarly, from BREEAM-NOR, project governance and transport related attribute can be incorporated in project selection. However, some of the attributes in the strategic level (QA regime) itself can also be re-evaluated and improved for better future project choices (e.g. impact, affordability and good timing). Other attributes that showed lower indexes are important within their own initiatives to improve performance. However, not all these attributes may necessarily be incorporated in the strategic choices or vice versa.

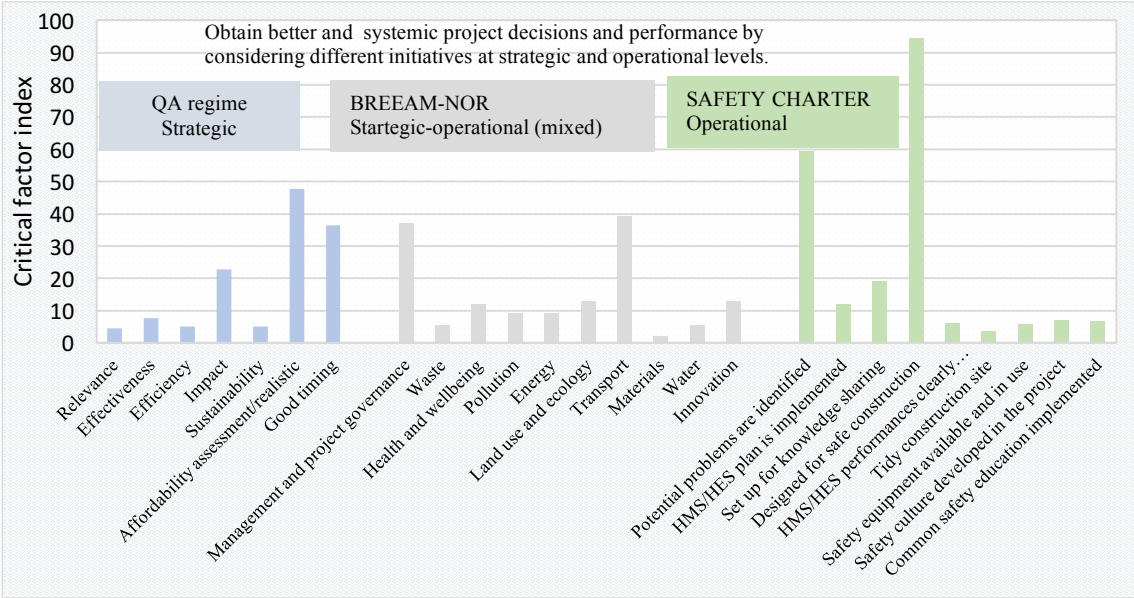

Figure 5 Identified Critical factors from the three initiatives using sense and response method.

6. Conclusions

The research attempted to approach systematically the strategic and operational initiatives that would help to make quality project choices and better project performance. It investigates attributes that could create better synergy between initiatives while selecting quality investment projects.

The research discussed on how to identify attributes that needs immediate attention from the three initiatives. In addition to that, it suggests incorporating them or provide some improvement so that the future project decisions would be better. In this regard, it introduces sense and respond method to categorize attributes that are relevant to the quality project selection and doing the project right. In the meantime, the research attempted to develop conceptual framework that could help to understand the strategic and operational attribute relationships. Knowing these relationships would help to identify missing attributes (unique to the specific initiatives) and common between two initiatives and those which are common in all three initiatives. The research can be considered as a systematic effort that lay a foundation on how to identify the critical attributes in all initiatives so that project managers can use them for future project choices or incorporate on their efforts to do the project right.

The result from the desk test showed that there are some attributes in BREEAM-NOR and safety charter that could be included in strategic QA regime for project right project choices.

Irrespective of the aforementioned contributions, the research faces practical challenges from the respondents. The future work will be to combine Delphi (iterative) method to get a significant number of responses. We iterative approach would help the respondents to understand better about the attributes and key term definitions.

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Appendix A: list of attributes from the strategic and operational initiatives.

Initiatives	Attributes (i)
QA REGIME	**1. Relevance:** Are we doing the right thing? How important is the relevance or significance of the intervention regarding users' needs, local and national requirements and priorities?
	2. Effectiveness: Are the objectives of the development interventions being achieved? How big is the effectiveness or impact of the project compared to the objectives planned (Comparison: result –planning)?
	3. Efficiency: Are the objectives being achieved economically by the development intervention? How big is the efficiency or utilization ratio of the resources used (Comparison: resources applied –results)?
	4. Impact: Does the development intervention contribute to reaching higher-level development objectives (preferably, overall objective)? What is the impact or effect of the intervention in proportion to the overall situation of the target group or those effected?
	5. Sustainability: Are the positive effects or impacts sustainable? How is the sustainability or permanence of the intervention and its effects to be assessed?
	6. Affordability assessment/realistic: Careful analysis of the expected costs of the project, cash flow required to repay the loans and provide a return to the investors. Specified in measuearable terms.
	7. Good timing: Considering if this is the right time to make a decision. Alternatively, will there be relevant new information in the near future that may influence the decision? What is the urgency - is this the right time to invest?
BREEAM-NOR	**8. Management (project governance):** Commissioning, construction site impacts, building user guide
	9. Waste: Construction waste, recycled aggregates, Recycling facilities
	10. Health and wellbeing: Daylight, Occupant thermal comfort, Acoustics, Indoor air and water quality, Lighting
	11. Pollution: Refrigerant use and leakage, Flood risk, NOx emissions, Watercourse pollution, External light and noise pollution
	12. Energy: CO_2 emissions, Low or zero carbon technologies, Energy sub metering, Energy efficient building systems
	13. Land use and ecology: Site selection, Protection of ecological features, Mitigation/enhancement of ecological value
	14. Transport: Public transport network connectivity, Pedestrian and Cyclist facilities, Access to amenities, Travel plans and information
	15. Materials: Embodied life cycle impact of materials, Materials re-use, Responsible sourcing, Robustness
	16. Water: Water consumption, Leak detection, Water re-use and recycling
	17. Innovation: Exemplary performance levels, use of BREEAM-NOR accredited professionals
SAFETY CHARTER	**18**. Potential problems are identified
	19. HMS/HES plan is implemented
	20. Set up for knowledge sharing
	21. Designed for safe construction
	22. HMS/HES performances clearly described
	23. Tidy construction site
	24. Safety equipment available and in use
	25. Safety culture developed in the project
	26. Common safety education implemented

“A Knot” – breaking the inertia in construction?

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Abstract

The aim of this paper is to contribute to new collaborative processes in construction practice, which are challenged by a traditional understanding of teams in construction project management. A dynamic innovative and open-ended expansive process is requested and badly needed. The development and implementation of new technology require a parallel process of developing the use of technology and the social processes of its use. Knotworking represents a distributed collaborative expertise in pursuit of a task that is organised among designers from different design disciplines and other players in a construction process. In Finland and Denmark experiments with Knotworking is being developed and tested: Experiments with Knots, how can it change or create new objects and solutions in construction?

The method of the study is action research and applied ethnography that is a practice-oriented approach to contribute to change processes. The degree of authors’ participation varied from being a facilitator, consultant or observer in the Danish case and from being a facilitator and observant in the Finnish case. The data collection was a participant observation in a Finish and Danish case. The participants of the experiments were architects, contractors, energy specialists, HVAC design engineers, structural engineers, a cost calculator, representatives of property owners and researchers. The data was saved in digital format using several video cameras. We also gathered BIM documents, process charts, advisors’ reports and photographs.

Experiments with Knots have the potential to break inertia in construction, multiple solutions will persist and it implies learning by experimenting with the new practice. The Knots are organised to solve specific problems or tasks requiring multidisciplinary expertise. Working with Knots as a successful process requires intensive collaboration across organizational boundaries and hierarchies through object-oriented actions, i.e. objects of activities that include both material and cognitive constructions which lead to entail directionality, purpose, and meaning to collective activities.

Keywords: construction project, Knotworking, BIM, activity theory, collaboration,

7. Experiments with Knotworking

This research paper defines and investigates "A Knot" as a construct and concept for change in Construction. From our research, we present two experiments with Knotworking from a Finish and Danish context. Our aim is to provide critical reflections on the current situation of facilitating construction projects with new technology – BIM – and a new way of collaboration – Knotworking. Our normative proclamation is that Knots can be drivers for implementing the potentials of BIM, and as an opportunity to break with the inertia in construction, which leads us to the research question: *Experiments with Knots, how can it change or create new objects and solutions in construction?* As practise-based researchers, we have created experiments with Knotworking in our eager to understand and find solutions the construction industry and the build environment.

There has been an expectation about that BIM as a tool can be a central vehicle to increase productivity and efficiency in the building industry. This assumption covers elimination of design errors and quality of design, management of processes in construction, collaboration and communication between partners in the construction process and new forms of collaboration with clients. Miettinen and Paavola (2014), describe the inertia of construction with an activity-theoretical approach and socio-technical perspectives on BIM implementation. Starting with a critique of the traditional rational (normative) approaches continuing to technology implementation, the definition of BIM, and future vision, from the BIM Handbook (Eastman, Teicholz, Sacks and Linston, 2011); including the "new-won" understanding of collaborative cooperation - Integrated Project Delivery (IPD). IPD is an American framework for construction processes, it requires a high degree of cooperation, coordination and knowledge sharing among participants, with the purpose of generating a common understanding of the project and using the available knowledge. IPD is the supported by BIM tools for building modelling together with calculation and simulation tools (AIA National, 2007). Lahdenperä (2012) describe with reference to Cohen (2010). IPD as a project delivery method and which is a contractual agreement between a minimum of the owner, design professional and the builder, where risk and reward are shared and stakeholder success is dependent on project success (Cohen, 2010). By the use of BIM, the AEC facility management industry learns how to use the technology to support integrated teams (Eastman, Teicholz, Sacks and Linston, 2011).

Miettinen and Paavola describe four key elements (promises within the BIM rhetoric): "These four elements are 1) all relevant data needed in the design and construction of a building will be included in a single BIM model or is easily available with BIM tools, through common repositories or distributed database systems. 2) In allowing interoperability between data (shared with open standards like IFC) from several native design models, BIM becomes a tool of collaboration allowing new integrated ways of working. 3) BIM will be maintained and used throughout the lifecycle of the building. 4) BIM is expected to increase considerably the efficiency and productivity of the building industry" (Miettinen and Paavola, 2014, p.85.).

The disappointing news is even though potentials for implementing BIM seem obvious, these promises seems to be a utopian vision, which means it is impossible to achieve or at least fulfill only to some degree. BIM enables sharing of information and communication across 'silos' even now to some extent, new forms of collaborating, are emerging. The development and implementation of BIM is studied as a long-term historical process, and the various conditions must be investigated. Miettinen and Paavola claim that there is a need to study the specific uses of BIM in different phases of the construction

process and the different actors in the construction process (stakeholders) that can gain value by using BIM. They also suggest a way out of the locked situation, based on their activity theoretical background, three principles on BIM development and implementation are proposed: 1) BIM development and implementation is an open-ended expansive process; 2) Multiple solutions will persist: the development is a differentiation-integration process; 3) Implementation of BIM implies learning by experimenting and invention of novel uses in which process the practitioners and users play a key role (Miettinen and Paavola, 2014).

We are following these principles in our research. The purpose of our research is to study the development of new collaborative practices in BIM-based building projects. We use the theory of expansive learning to enable a creative process that entails experimentation of new kind of collaboration such as Knotworking. The creation of new practices inevitably involves working with processes that persist the new. However, experimentation makes it possible to explicate and reflect the prevailing processes and to develop new ways of working (Engeström, 2008).

Our paper starts with the introduction of the theory of expansive learning and the main concepts of Knotworking based on cultural-historical activity theory; followed by a historical projection from teams to Knots in the construction projects and industry. This theoretical and historical explanation is followed by methodological reflections about doing experiments with Knotworking. Two experiments from Finland and Denmark open new perspectives and alternative frameworks on collaborative process of cooperation. Both cases have a focus on common understanding and BIM development and its implementation, solving tasks through IT model-based and simulations tools as well as local experiments and solutions. However, the cases complete each other in terms of the research context (development program/client-driven building project), client and end-user participation and instrument development. The concluding section is reflecting upon whether Knots can break with inertia in construction.

8. The theory of expansive learning and activity-theoretical concepts of Knotworking

The theory of expansive learning and activity-theoretical concepts of Knotworking Engeström (2015/1987) introduced the theory of expansive learning as a form of learning that can support change processes in human activity. The theory of expansive learning is often visualized as a cyclic process that starts in the emergence of needs for changing collective activity (figure 1). Actors experience the need to change the activity as tensions and contradictions such as errors, disturbances, and incongruences in current activity. In successful processes, reflection and analysis of the tensions and contradictions lead to envisioning a new model of an activity. The new model contains a working hypothesis of new instruments, rules, and division of responsibilities. The working hypothesis is experimented (i.e., examined and tested) in practice. During experimentation the new model is improved and for instance instruments are adjusted and enriched in the activity. The phase of experimentation may require several cases until the model has reached the maturity level required for implementation. After the implementation the entire process of expansive learning is reflected before it is consolidated. In figure 1, the ideal model of expansive learning is depicted as learning action through which the process of expansive learning takes place. In real life, all phases of the process are completed or reported in one study (see for instance Engeström & Sannino, 2010). In this study, we examine only the experimentation phase of expansive learning in both cases.

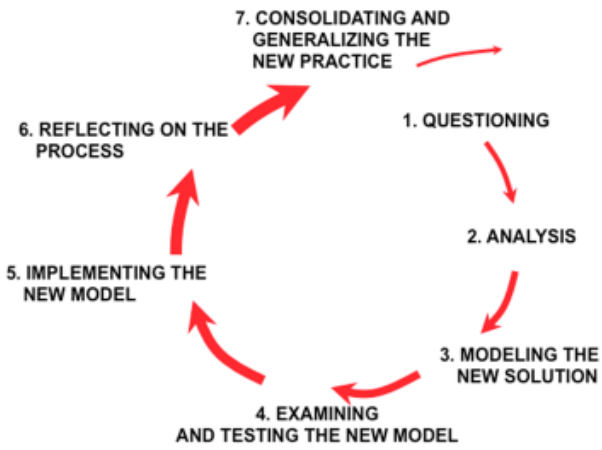

Figure 1. The model of expansive learning actions (adopted from Engeström & Sannino 2010, 8)

Expansive learning based on the cultural-historical activity theory (CHAT) originating from the work of cultural psychology in 1920s (Vygotsky, 1978; Leont'ev, 1978). The object-orientation of a human activity is the *first* characteristic of Knotworking. Objects of activity are both material and cognitive constructions that entail directionality, purpose, and meaning to collective activity (Engeström 2008, 204). Human activity is often depicted as an activity system that entails the relations between subjects, objects and instruments involved in production as well as the social aspects of an activity such as rules, division of labor and community (figure 2).

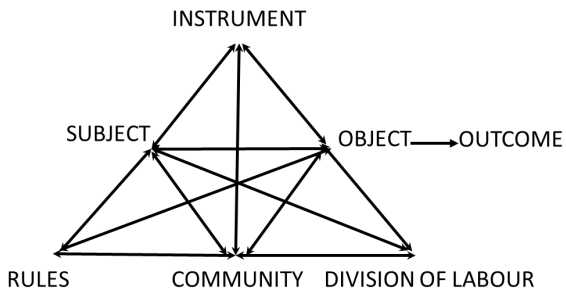

Figure 2. The model of an activity system (adopted from Engeström 2015/1987)

A material object of collective activity entails the basic motive and sense of the activity (Leont'ev 1978, 52). From the activity-theoretical perspective, to have groups of people or professional groups working on a shared object is important in the creation of novelty and innovation (Miettinen, 2006). Different experts constitute the overall object of activity through inter-connected tasks in building projects. Poor integration of tasks may prevent the effective performance of the activity in project teams. At the same time, different actors may not know how their contribution is connected to the overall object of a building project.

The mediated nature of human activity is the *second* characteristic of Knotworking. According to CHAT, the elements of an activity system mediate human activity. For instance, various instruments

such as manual and software tools, building plans, building schedules, and meeting procedures, mediate a building project.

The *third* characteristic of Knotworking concerns the concept of activity. An activity is realized by human goal-oriented actions and their components 'automated operations' (Leont'ev, 1978). The levels of activity and actions/operations are often examined as separated in previous studies (see for instance Bakker, 2010). However, the activity and its realization in actions and operations cannot be distinct from each other but need to be analysed in dynamic relations (Engeström, 2001). The analytical distinction between levels of activity, actions and operations is important in order to examine the embeddedness of actions (or operations) in an activity. For instance, actions related to previous activity may prevent the creation of new actions and operations during the change of activity (Engeström, 2008). For instance, actions related to the use of CAD may cause problems in the use of BIM if not made explicit during the change process.

Examining contradictions as sources of change is the *fourth* characteristic of Knotworking. Contradictions are historically accumulated tensions between and within different activities that manifest in disturbances, gaps as well as innovative solutions (Engeström, 2008, 205). For instance, a contradiction may emerge between the adoptions of new digital technologies such as BIM and organizational structures developed during a prior technological paradigm (Kerosuo et al., 2015).

The historicity of human activity is the *fifth* characteristic of Knotworking. Engeström connects Knotworking to the emerging historical type of work called co-configuration. Building on activity-theoretical research tradition Knotworking is connected to an emerging historical type of work called co-configuration. The features of co-configuration involve:

- Integrated product and/or service combinations
- Continuous relationships and mutual exchanges between customers
- Producers and products and/or service combinations
- The customization of products and/or services over a lengthy period of time
- Multiple collaborative producers operating in networks within and between organizations (Engeström, 2008 p. 195-196).

Engeström (2008) describes Knots as an elusive and improvised phenomenon in the context of distributed expertise. A movement of tying, untying, and retying together characterizes seemingly separate threads of Knotworking. The tying of a Knot is not reducible to any specific individual or fixed organizational entity as the center of control.

9. From temporary teams to Knots in construction projects

In general, the construction industry differs from many other industries by being project-oriented as temporary teams with a significant share of unique production, an organizational form which who implies, that clients, advisers, the production team, and suppliers are composed anew for each project. Thus the cooperation process in the construction industry is challenged by a vast number of different stakeholders and professions (Winch, 2010), which must cooperate with each other on project-based contracts during the individual project lifecycle. The process being made more complex by projects which are uncertain endeavors. Projects do not consist of a decision at a single point in time; rather

they are, in many ways, an ever deepening and broadening sequence of decisions through time (Winch, 2010/2015).

Karrbom Gustavsson and Gohary (2012) describe (with reference to Chan et al, 2003; Dainty et al, 2006; and Winch, 2010) the traditional building practices as being based on rigid and impenetrable border between the different phases of the process, e.g. design and production and professions such as architects, engineers and the contractors, making the processes of communication, cooperation and integration of projects in practice difficult. The process of cooperation becomes difficult when the advisers, users, and client, and later contractors, are located at different locations, have different working methods, technologies, tools, structures, and cultures. Knowledge sharing becomes inefficient and is often more disclaimer and personal positioning than true sharing of expertise.

Fragmentation of the construction industry links to project organizing in temporary teams with a significant share of unique production, different working methods, technologies, tools, structures and cultures between the participants, and a process of continuous sequences of decisions, etc. Fragmentation in the construction process and the resulting adversarial relationships between involved participants have been an ongoing topic of critical writing (Lahdenperä, 2011). In parallel, there is a vision of integrated trust based practices also developing. Collaborative approaches are one way of dealing with the fragmentation and the lack of integration that has complicated previous attempts to improve project performance in construction projects (Bresnen and Marshall, 2000).

In the previous literature, the challenges of temporary organization and temporary teams were concerned with the effects of the limited time of their existence, the team processes, and the nature of their tasks and the characteristics of contexts under which they are operating (Bakker, 2010). Temporary teams are oriented to the demands of a situation and they do not anticipate future interaction with each other beyond the imminent deadline (Saunder and Ahuda, 2006). Construction projects are typically composed of temporary teams from several companies for one particular purpose. In general, such a working process entails negotiation among trades, different ownership interests and architectural and engineering design. This implies that the participants of the construction industry are influenced by an internal conflict of interest between the project and the company. For instance, subcontractor companies' obligations to the company goals influence the decisions about the marketplace allocation of personal and time across different projects. The company prioritizes the values of optimizing profits with respect to time across multiple projects (Dossick and Neff, 2012).

Temporary teams function under constraints of high uncertainty and interdependence during a limited time, if the functionality is dependent on their members´ sets of diverse skills and knowledge (Kerosuo, 2015). This creates very often communication challenges, which reinforced the obligations to individual scope, at the expense of commitment to the building project. The various participants are following their scripted roles, each concentrating on the successful performance of the assigned actions or "presentation of the self" (Engeström, 2008).

Knotworking, in co-located "Knots", is organised on a temporary basis to solve a specific task, a problem or an open question requiring multi-disciplinary expertise in a building project, and last typical one or two days. Several Knots can be organized during the project (Kerosuo, 2015). Through workshops, opportunities for participants to work concentrated on practical solutions of specific themes are established. These themes are pre-defined, for instance demands /wishes to design, construction,

cost, construction time, environmental impact and energy consumption, etc. In practice, these thematizations develop as a Knot(s) in combinations of plenary discussions, frequencies where the individual subject specialists are working separately on the problem in each Knot, for then subsequently in plenum being presented as different scenarios solutions. In order to identify the most advantageous choice in the process, various disciplines through modelling and simulation tools are participating. The process provides a visible picture of the consequences of the different scenarios, which are discussed and gives the participants opportunity to take joint qualified decisions, including visibility of some new Knots/challenges. Plenary discussions and scenarios create a merge of process and technology where participants can continuously make informed choices and thus is a common create a practiced understanding, grounded in perspectives of different occupational groups. Next sections give Knotworking examples from Finland and Denmark.

10. Methods and data of the study

The method of the study is applied ethnography that is a practice-oriented approach to contribute to change processes (Chambers, 2000). Applied ethnography is often applied in action research projects that serve public good and/or decision-making. It emphasizes collaboration with the participants of the change projects and those involved as subjects in fieldwork. Applied ethnography resembles developmental approaches drawing from the methodology of expansive learning with regard to its orientation to practice and participation in change processes. The focus of developmental approaches on tensions and disturbances is also similar to applied ethnography. The idea of both these methods is that researchers make the tensions and disturbances of the work practice visible (Kerosuo, 2006).

The method of the data collection was participant observation in both studies (Hammersley & Atkinson, 1983). The first and the second author of this paper did the fieldwork in the Danish study and the third author conducted it in the Finnish study. The degree of authors' participation varied from being a facilitator, consultant or observer in the Danish case and from being a facilitator and observant in the Finnish case. Besides the authors here students were observing and making field notes in the workshops of the Danish case. The data was saved in digital format using several video cameras. We also gathered BIM documents, process charts (Finnish case), advisors' reports (Danish case) and photographs. For the analysis, we have selected only those parts of the data in which object of activity, mediating instruments and the tensions, as well as contradictions are dealt with in the data.

11. Finnish Knotworking experiment: Initiating and experimenting in a research and development program

The idea of Knotworking emerged during an intensive seminar organized in a Finnish research and development program during 2012-2014. Members of the steering group in Model Nova work package participated the seminar. The program in question was called Built Environment Process Re-engineering Programme (http://rym.fi/program/pre/). In the seminar, the purpose was to create a new method of collaboration based on sharing ideas and fluent communication between different players in a building process. The participants the seminar represented various expertise and specialized knowledge such as contracting, facility management, project and knowledge consultancy, architecture, structural and HVAC-E design, contracting and academic research from the technological university and social sciences.

Some members of the steering group had visited Big Rooms in San Francisco area hospital projects and had in mind to have something similar in Finland. However, the problem of Big Room was that designers and other experts are usually hired to various projects at the same time (as in many Nordic countries). The group adopted the idea of Knotworking from the activity-theoretical research group at the University of Helsinki. The concept of Knotworking had been created in the development of health care organizations and adopted in many other activities (Kerosuo, Mäki and Korpela, 2015).

The adoption of the idea of Knotworking was an open-ended expansive process in the seminar. The process of development Knotworking involved many of the ideal typical epistemic learning actions described by Engeström (2008) such as questioning and criticizing of prevailing design-meeting practices. The participants had used a considerable amount of time in the development of collaboration in BIM-based building process but no good solutions had been created. The idea of Knots raised enthusiasm and the group decided to test the idea in a concrete building project.

The idea of a Knot was to invite all relevant parties and experts to work one to two days in early design issues of a building project. The concrete case was a school and daycare building that also hosted evening and weekend activity. The aim was to provide alternative designs solutions to the client and end-users. The object of activity was to model several architectural scenarios and to calculate energy solutions and their costs in the project. BIM would be used in such a way that the results would immediately be available after each design phase "that you don't need to go to your own office to count and some results come out after a week or two."

The group engaged the authorities responsible for the school premises and the teachers as well as the community members. The goals and procedures of the Knotworking workshop were set in three planning meetings during spring 2012. The contents and the acquisition of the initial information were planned, the division of labour between the designers and specialists was decided, and the means of client and user involvement negotiated in the meetings. The members of the group used considerable time for the creation of key performance indicators (KPI) and their measuring units to be used in the comparison of energy solutions. They also ensured the integrated use of the several software used by the architect and design experts in the workshop and created tools for the presentation of the alternatives to the client and end-users of the building.

The two-day Knotworking workshop was organized on May 21 and 22, 2012. The Knotworking consisted of two types of sessions. First, there were shared sessions with the representatives of the client and community participating that took place at the beginning and the end of the Knotworking workshop. Second, there were working sessions in which the designers and specialists were engaged on their assignment of creating and analyzing the alternative design solutions. The groups were allocated one afternoon and one morning to engage in the actual Knotworking. The final result of the Knotworking workshop was five architectural scenarios and 15…20 energy analyses and cost calculations created in eight hours by Knotworking, using BIM and efficient energy-simulation tools.

Learning by experimenting played an important role in the development of Knotworking. There were no explicit tensions expressed between players and experts in the Knotworking experiment. The information needed from other experts was available quickly. It was possible to solve design problems when they emerged with those experts needed in solving them. However, it is important to notice that the experimentation of Knotworking was carried out in a development program funded by TEKES

(Finnish Technology Foundation Innovation) and participating companies. The group members were able to have a shared object of development and they were not contracted to provide an ordinary building project. The participation of the client and the end-users was limited to the beginning and the end of the workshop. It would have been profitable if the client could have been present during the working sessions. Working with the teachers and community members would also require more time.

The idea and the results of the Knotworking experiment were presented to the members of the industry in two seminars. Two other experiments were also organized. After the development program, the participants started to develop their own versions of Knotworking as part of their services. The perspective to organising new kind of Knots is open as new ideas Knotworking are emerging and change the industry.

12. Danish Knotworking experiment: Client driven development project

The idea of a Knotworking project in Denmark emerged in autumn 2013 during a number of meetings between Danish Defense Building Department (DDBD) and researchers from Aalborg University, Technical University of Demark and University College of Northern Denmark. Inspired by colleagues from Finland, DDBD chose in co-operating with the researchers to test Knotworking in the early design phases of the construction project, Rescue Station Skagen, at Skagen harbor. The project was a small building project to 13.5 mio. DKK. Besides the client (DDBD) and the researchers, participated rescuers (users of the building), architect and design engineering consultants, including specialists in sustainability, economy, and scheduling. Students who assisted with different digital/IT software as “design modelers”. The purpose of the Knotworking project was to survey experiences from Finland and optimizes the design phases through collaborative innovation and decisions processes. More specific, the task was to design the building from brief to approval by the authorities using IT model-based tools and simulations. The process of Knotworking took place in spring 2014, starting with planning meetings covering several issues: expectations, working methods, necessary facilities, IT-equipment, software programs, data requirements, etc.

During the workshops, the client, user and advisers sat around a table and participated various thematic discussions that they each contributed with their professionalism and expertise. Ideas and suggestions were discussed and argued in plenary sessions; Knots emerged in a learning process, where common sensemaking occurred.

One of the characteristics in Knotworking is the mediated nature of human activity, for instance, various instruments such as software tools. To “support” the process of new model of activities, the "modelers" fabricated different design solutions from ideas and suggestions from consultants, client, and users. This allowed the participants to constantly relate to the creation (or integration) of various design solutions and discuss the consequences of different choices. They worked with different requirements (ideas, problems, themes), where the leading design and simulations were modelled in several versions by the modelers (students). During the process, the models were expanded to include estimation and planning tools and 4d and 5d environments emerged with cost estimates and schedules. The different scenarios were discussed in collaborative work sessions (in plenary) - and independent work sessions.

There were Knots about the pier building, design and construction choices and climate challenges including water rising subjected to analysis in design and function, sustainable and energy technical solutions as well as cost and time. The facilitator ensured that all participants were consulted and asked for positions on all issues. An example of the process was that the design models were regularly visualized and thus the impact of different aesthetic and geometric choices was made visible compared to existing conditions at the site. By extension, new problems/challenges appeared as the user explained that they in recent years had seen a rise in water levels in the harbor and consequently had more frequent flooding inside the existing building. That stimulated discussion of several different scenarios regarding the rescue station in Skagen:

- The structural engineer was aware of the possible pressure on the entrance to the boat hall by rising water.
- The HVAC engineer and the architect made analyses of a heat loss because users indicated that the entrance to the boat hall was open during rescue operations.
- The client and the architect looked into the surrounding harbor coatings by possibly rising water which would affect the surrounding harbor terrain.
- The Quantity Surveyor continuously calculated the various scenarios by comparing different solutions and conditions of which both the time and financial consequences were discussed.

The example shows that sharing knowledge causes the initiative to change from moment to moment within a Knotworking workshop. The center does not hold. The Knotworking represent a new collaborative cooperation that provides opportunities to develop and facilitate value-adding relationships and integrates different disciplines in a process supported by digital tools. Exploitation of digital technology such as information exchange between disciplines/domains and the underlying data models and interfaces, in some cases, challenged the provision of data. It meant a relapse into known methods instead of supporting new ways of collaboration, but the process showed, opposite to traditional working processes with clear defined roles and tasks, that the participants interacted on re-conceptualizing organisation and the content emerged through common knowledge and created new objects and solutions in the process.

13. Concluding reflections - breaking inertia?

Knots connect groups of people, tasks and tools across organizational boundaries to work intensively to get a problem or task performed in building design. The Finnish and Danish projects worked with BIM-based collaboration, experimenting with new 3D and simulations tools to provide alternative plans for a client's decision-making. Expansive transitions in new collaboration emerge when the participants solve their problems, tensions, and contradictions in their activity (Engeström, 2001).

Through scenarios, the contradictions, which are historically accumulated tensions between and within different activities and that manifest in disturbances, gaps as well as innovative solutions, emerge new organizational structures and activities. Working with Knots through object-oriented actions, i.e. objects of activity that include both material and cognitive constructions, entail directionality, purpose and meaning to collective activity. It implies that participants through their contribution are connected to the overall object of a building project. Another benefit is the problem in the "traditional process" with the poor integration of the different participants' contributions and tasks, which may prevent the effective performance of the activity in project teams may be solved.

Beyond that, the processes led to a specific knowledge to further use in the project design. New "meta – knowledge layer" also developed during the processes for instance in the future operation of the building and future construction projects.

Under the processes, the participants took part in the different Knots, where all contributed with their professional skills and expertise. The experiments with Knots created new objects of activity, enriching the interacting.

It is not possible to find a technology driven solution to the inertia in construction, it is unrealistic to assume that BIM/VDC or any technology can produce the needed change, but we can start by experimenting with open-ended expansive process in which multiple solutions will persist (the development is a differentiation-integration process). Working with Knots demands open-ended expansive processes and requires intensive collaboration across organizational boundaries and hierarchies.

Experiments with Knots have the potential to break in inertia in construction; we doubt that the Knotworking projects have realized the full potential - a paradigm shift in construction? Further research is needed about new ways of collaboration, new roles, contracting, use of technologies, producing – a new configuration of construction processes.

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Defining education to support sustainable operation of buildings in the Nordic Countries

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Abstract

The introduction of sustainable goals and concerns has brought many challenges to the construction sector. In particular, the combination of environmental, economic and social ambitions asks for complex solutions and require multidisciplinary competences. Likewise, construction sector related educations are facing similar challenges requiring them a crossing of barriers between traditional disciplines. Whereas most educations focus on technical and economic subjects, the social aspects of sustainability are often lagging behind. However, studies of implementation of sustainable solutions underline the importance of including all the actors concerned in the process and above all the users, but the different professionals of the sector often lack tools to do so. Engaged in the creation of a summer school gathering construction and facilities management students from three Scandinavian countries, we aim at planning and implementing such tools within our respective educational programs. Building on the stream of Project-based learning (PBL), where students acquire a deeper knowledge through active exploration of real-world challenges and problems, we intend to develop cases integrating issues related to implementations of sustainable solutions within facilities management. Such issues have been identified in a literature review and in a one-day workshop gathering more than 40 participants active in the sector. The challenge is to create a pedagogical platform which includes both theory and practice-oriented contributions and to build on their complementarity to enable the students to learn how to face and possible solve such issues. Moreover, the project offers the possibility to compare and reflect over the different educations in term of sustainability in facilities management as well as to explore the professional and cultural differences between the Nordic countries from your study that will be of interest to the reader.

Keywords: Education, Facilities management, Interdisciplinary, Nordic countries Sustainability

14. Introduction

Facilities Management (FM) can play an important role in implementing sustainable solutions and reducing energy consumption. Buildings as well as their operation and maintenance consume a large amount of energy and material; they also can have an impact on the users' health and well-being. Besides, at the local level, they can have influence on social aspects and contribute to a social coherence of sustainability (Elmualim et al. 2010). However, whereas there is a broad agreement on the need to implement sustainable measures, the concept of sustainability, upon which theory, policy, and practice are developed, is far from offering a clear definition and a shared understanding of its different dimensions and applications (Sarpin et al 2016). Both generally and contextually, the concept carries internal tensions and contradictions, in particular the social dimension creates debate and uncertainty (Buser and Koch 2014). Similarly, it can be difficult for FM professionals to comprehend the complexity of sustainability and make decisions on a daily basis integrating these concerns. In particular, the combination of environmental, economic and social ambitions asks for complex solutions and require multidisciplinary competences. Whereas standards and certifications can provide support to the professionals, they are not sufficient to define, and assess the complexity of the challenges and implement sustainable solutions (Sarpin et al 2016). Even though studies of these types of solutions emphasize the importance of including all the actors concerned in the process and above all the users, the practitioners often miss tools to implement these solutions in their actual practices. Authors (Elmualim et al. 2008, 2010; Sarpin et al. 2016) have underlined the need to develop what they call the *reflective practitioners,* professionals *who are able to navigate a work life rife with contradictions and dilemmas and who can determine the appropriate course of action at the appropriate time,* (Sarpin et al. 2016).

Furthermore, educations related to construction and facilities management are facing similar challenges forcing them to cross the barriers between the traditional disciplines. Whereas number of professional schools and universities have integrated sustainability into their education portfolio, most of them focus on technical and economic topics, neglecting the social aspects (Lozano at al. 2015, Lim et al. 2015). As the number of constructions is growing quickly, the competences needed to manage these portfolios and integrate sustainable solutions is growing accordingly. It is important therefore to find flexible solutions which can be rapidly implemented. Building on the identification of missing competences for FM practitioners, found in by both a literature review and during a one-day workshop gathering FM professionals and academics, our paper presents the development of an approach for a summer school intended for construction and facilities management students from three Scandinavian countries. The aim of this summer school is to test interactive new education tools within our respective educational programs. Building on the stream of Project-Based Learning (PBL) where students acquire a deeper knowledge through active exploration of real-world challenges and problems, we intend to develop cases integrating issues related to implementations of sustainable solutions within facilities management. The challenge is to create a pedagogical platform which includes both theoretical and practice oriented contributions and to build on their complementarity for the students to learn how to reflect and deal with such sustainability challenges. We start the paper with a brief literature review of the challenges and barriers encountered by FM professions to implement sustainability in their practices.

15. Theoretical frame for a summer school

15.1 FM and competences in sustainability

The potential contribution of FM to sustainable development has been clearly demonstrated by researchers and practitioners (Galamba, and Nielsen, 2016, Sarpin et al.2016). FM practitioners can play a central role in this development. As they have the opportunity to view the entire process of managing built assess they have the possibility to influence over the long-life cycle of FM by developing, implementing and maintaining sustainable solutions (Hodges 2005). However, in order to delivered results, FM practitioners need to develop the capacity to define, analyse and examine sustainability issues in a holistic manner. Despite the opportunity to drive the sustainability agenda forward, the FM profession does not yet have sufficient access to specialists' knowledge, tools and case study materials necessary to implement such solutions efficiently (Elmualim *et al.*, 2009). Sarpin et al. (2016) provided a brief literature review on the insufficiencies and barriers that sustainable development face in FM practices and identify four main types of challenges. Table I summarizes these main issues.

Table 2: *Issues and challenges in integrating sustainability with FM practices (Sarpin et al. 2016)*

Challenges	*Authors*	*Descriptions*
Capability challenges	Elmualim *et al.* (2010) Hodges (2005) Shafii *et al.* (2006) Shah (2007) Yang *et al*. (2005)	Lack of capabilities/skills Awareness of building whole-life value Lack of professional capability Unwillingness to implement sustainability Lack of competence in managing the changing attitude process of people and institutions Diversity of FM roles Undervaluation of contribution to organisational success
Knowledge challenges	Elmualim *et al*. (2009) Elmualim *et al.* (2010) Hodges (2005) Lai and Yik (2006) Nielsen *et al*. (2009) Shah (2007)	Lack of knowledge Limited knowledge regarding environmental themes Knowledge gap Management of sustainability knowledge Low level of knowledge regarding sustainability Discrepancy in knowledge
Organisational challenges	Elmualim *et al.* (2010) Hodges (2005) Nielsen *et al.* (2009) Shah (2007)	Time constraints Lack of senior management commitment Lack of incentives to create routine planning on environmental issues Too little time and few resources to implement Increasing liability
Authority challenges	Bosch and Pearce (2003) Nielsen *et al.* (2009) Shah (2007)	Limited data on local consumption of energy, water etc. Performance indicators Lack of guidance documentation

The list of capabilities challenges underlines the deficiency of skills and competences to identify and manage changes requested by sustainable solutions within organisations as well as a lack of awareness and engagement of the management team. The list of knowledge challenges addresses the shortage of information, knowledge and adequate methods to implement sustainability. The list of organisational challenges concentrates on the rigid and pressed situation of daily work and the lack of incitement to integrate sustainability in already existing activities. The list of authority challenges identifies the lack

of guidelines, routines and performance measures to contributing to the development of sustainable solutions.

Furthermore, Meehan and Bryde (2015) emphasize a need for integrated and collaborative strategies adapted specifically to FM practitioners' local context in order to meet the need of the stakeholders rather than developing generic solutions for sustainability.

The most effective way to achieve a transformation towards sustainability is to enhance sustainability knowledge and expertise within the industry (Shelbourn et al. 2006). The challenges presented above underline the need for FM professions to develop their understanding of sustainability, integrate the needs and characteristics of stakeholders and to strategically invest in training to support the development and realize the potential of sustainable solutions. Defining and integrating teaching and training for sustainability is one way to increase the realization of this potential.

15.2 Integrating sustainability in education

Education's providers worldwide are now creating new courses and degrees or modifying existing ones in response to the increasing interest by companies to hire sustainability trained graduates (Lozano et al. 2013). However, many of these programmes remain techno-centric, addressing either environmental and engineering topics or building on normative managerial academic teaching approach (Lozano et al. 2015).

Adding sustainability to already existing programmes presents challenges as well. Ceulemans and De Prins (2010) identify the following barriers to incorporating sustainability in current education: the limited frame of reference of the teachers; the multidisciplinary character of research related to sustainability misunderstanding of sustainability inclusion; the workload of teachers and that sustainability is not seen as a core issue. However, the tasks of designing holistic sustainable courses should not be left to the responsibility of teachers only. Construction and MF practitioners' experiences and needs should be integrated in the programme to increase the production of knowledge and skills related to sustainability (Lim et al. 2015).

To providing a platform for exchanges between academics and industry, one solution is to integrate practitioners directly in the courses. Wilson and Pretorius (2017) underline that there is much potential in practitioners' engagement achieved through various forms of partnerships with stakeholders to enhance student engagement with sustainability issues and to co-create knowledge addressing both the academic and practitioners' interests. However, this engagement by universities with societal stakeholders in teaching and learning for transformation towards sustainability, remains a challenge and still presents opportunity for further developments (Trencher et al. 2015). This can only be done through collaborative endeavours across disciplinary and professional boundaries.

Despite these challenges, integrating sustainability into academic curricula has been recognized to be central for equipping students with the competences and to support the transformation of societies towards sustainability (Lozano, 2010).

15.3 Practice based approaches to teaching sustainability

The perspective of Project-based learning (PBL) is a comprehensive approach to classroom teaching and learning designed to engage students in investigating authentic problems (Blumenfeld et al., 1991). It aims at students acquiring a deeper knowledge through active exploration of real-world challenges and problems. Characteristics of PBL include the following: the students must take the responsibility for their own learning; the problem delivered to the students needs to be ill-structured and allows them the possibility of free enquiry; learning should be integrated from different disciplines and topics; collaboration is essential; a closing discussion and assessment of self-learning is essential at the end of the exercises (Savery, 2015). The engagement of stakeholders in in the process can provide a new dimension to the incorporation of real-world exposure in teaching and learning (Mauser et al. 2013).

16. Towards an integrated summer school

The summer school will run for three full days in March 2017 and builds on complementarity: in one hand presentations from both practitioners and academics on the topics, challenges and methods of handling sustainability; on the other the work of students in groups that gather different types of education and countries, using "real cases". 40 students from the four teaching institutions participating are expected to participate in the school as well as a group of teachers and professionals informed and active in the predetermined cases. The contact with practitioners active in the cases will take place either on site or through internet connection and online meetings. The following section presents the goals, the participants and the organisation of the spring school.

16.1 Context for developing the new course

The spring school is a project co-financed by Nordic Built and the project partners. Nordic Built is a Nordic initiative to accelerate the development of sustainable building concepts initiated by the Nordic Ministers for Trade and Industry. It aims at combining key Nordic competences and know how, providing attractive and effective arenas for collaboration and the realisation of concrete projects. It brings together companies, public administrations and researchers. The project partners include two professional schools in Denmark: KEA in Copenhagen and VIA in Horsens; two universities Chalmers University of Technology in Gothenburg Sweden and the Norwegian University of Science and Technology in Trondheim Norway. The project has been initiated and is managed by the Danish Association of Building Experts, Managers and Surveyors, Konstruktørforeningen (KF) which gathers more than 8000 professionals graduated as Bachelors in Architectural Technology and Construction Management.

16.2 Goals

The goal of the spring school is to build on the already existing educations and provide new pedagogical material to support sustainable operation of buildings in the Nordic Countries. The school does not aim at teaching specific technologies or methods, but at creating awareness about the complexity of implementing sustainable solutions and at developing skills and competences to address this complexity in specific contexts. The students are presented with "real" situations: a project in a concrete context with its stakeholders, limitations, challenges and possible contradictions. By integrating "real world" cases, we hope to enhance students' motivation and engagement in working with sustainable

issues but also to confront them with the existing conditions and practices of professionals active in this development. The students will reflect, discuss and work in groups to develop innovative solutions to the real sustainability challenges.

The long-term objective of the spring school is to provide pedagogical material for students and the educational institutions to develop knowledge of what sustainable Facilities Management practices are in the Nordic Countries context.

According to Lozano (2014), one key element to design and build the content of such course, is learning outcomes, which need to include the demonstrable acquisition of specific knowledge and skills and reflect the institution's objectives and graduate attributes. Once the outcomes of learning have been agreed upon, the strategies for teaching and assessing these outcomes must also be chosen. In our case, the learning outcomes have been developed to answer the challenges identified in the literature and the features identified during a workshop gathering more than 40 professional both practitioners and academics working with sustainability and facilities management.

On the completion of this summer school, the students should be able to realise the following pedagogical goals:

- Identify and evaluate suitable projects in order to deliver sustainable goals in the context of facilities management
- Identify and evaluate positions, needs and dilemmas of the diverse organizations and actors engaged or concerned by the projects
- Identify, select, implement and assess solutions including both technical, economic and social concerns according to this evaluation
- Understand and orient the complexity of sustainable interventions

16.3 Collaborating institutions

Below the participating institutions to the project are presented as well as the team of teachers involved in the spring schools.

16.3.1 Chalmers, Göteborg Sweden, and NTNU Trondheim Norway

Both Chalmers University of Technology and Norwegian University of Science and Technology (NTNU) are offering bachelor, master and PhD education in engineering. The population concerned by the spring school are Master students in both school studying Design and Construction Project Management (Organisering och Ledning i Bygg och Fastighetssektorn).

The students are trained in the skills needed to manage construction projects involving project management methods, financial accounting methods, BIM, logistics, environmental management, strategic management, facility management and sustainability. To prepare the students to demands of the construction industry, where projects are done in temporary and interdisciplinary project organizations supported by networks of colleagues, training and knowledge are provided on organizational culture, leadership, communication, group- and team work, decision making, collaborative relations, and knowledge and learning. Whereas the students at NTNU can graduate in

both construction and facilities management, this is not possible at Chalmers where they can make their master thesis within sustainability FM topics in relation to companies but not graduate in FM or sustainability.

Whereas students are informed and trained in management topics, they lack more concrete confrontations to more practical aspects of what leading sustainable project within facilities management means, such as the contact and management of the different stakeholders and in particular the users.

16.3.2 KEA Copenhagen and VIA Horsens, Denmark

Copenhagen School of Design and Technology (KEA) is an Academy of Higher Education which offers over 30 different educational programmes at Bachelor degree and Academy Professional degree levels. The school counts more than 5000 students enrolled in different trades. The students targeted by the spring school are the "bygningskonstruktør", enrolled in "professional" bachelor. Constructing Architects are primarily engaged in design of building and infrastructure, but they are also employed in other companies related to the construction industry, eg in state and municipal, residential and management companies, banks and credit unions, and technological institutes. Their education is technically oriented and they do not develop a holistic approach to sustainability, they may need further training and develop competences in communication, finance, planning, communication, users' behaviors and participation, technology understanding, organization, process understanding, law, and empathic understanding.

VIA university College Horsens was established in 2008 at the results of several mergers of institutions of higher education. Similar to KEA but situated in Jylland, VIA offers professional bachelors. The target students are here as well the construction architect. VIA however is working closely with practitioners to drive their educations.

The choice of different types of educations related to facilities management is done to mirror the setting of professional practices where different educational backgrounds meet in enterprises and in projects. The participation of the different Nordic countries build on both the similarities between the participants, the Scandinavian models usually refers to flat hierarchy, well organized labour, social values (Sandberg et al. 2013) summarised in the chart of Nordic Built; and the particularities of each of the nations in term of culture, educational models and philosophy.

16.3.3 Summer school participants

The team of teachers gathered multidisciplinary competences (engineers, sociologist, active in three of the Scandinavian countries). Besides practitioners are joining to contribute with both their knowledge of the case and their concrete experiences of working with the different stakeholders. The group of practitioners includes social housing companies and facilities management companies.

16.4 Teaching concepts

Building on the PBL philosophy of teaching, the summer school focuses mostly on students' project work introduced by a few academic lectures and case presentations from professionals working with

sustainability. Merging both the learning from academic research and professional expertise, the goals of the presentations is to draw the attention of these engineer students away from focusing only on the design of technical solutions towards more social aspects such as the roles and the competences of stakeholders and the needs and behaviours of the users.

The cases build on written descriptions of the companies' profiles: size, portfolio, competences, location and the characteristics of the specific project: buildings physics and conditions, actual issues, profile and types of users, budget. These written documents are completed by technical drawings, pictures and video interviews of some of the stakeholders involved in the project (janitors, inhabitants, technic providers). The cases are presented in plenum and the students are introduced to different challenges, they then are distributed in small workshops where two groups of four students work separately on the same case. Each case is attributed a supervisor who provides support to the students' process. Contact with the professionals working with the case are organised so that the students are able to seek information or test the feasibility of their ideas. During the three days of the spring school, the groups work mostly independently. However daily meetings with other students allow a reflection not only on the designed solution but also the methods the groups have chosen and the process they follow as well as their eventual interrogations and doubts in carrying the project.

Most of the cases includes technological improvements for the building. However, the focus is on designing solutions adapted to the specific users and easy to maintain. The results of the groups are presented to the others students, teachers and the practitioners related to the case.

Whereas describing the context, process and goals of the spring school, seems to be rather straightforward defining the outcomes and judging of their qualities appears to be more difficult! The assessment of the students is of course important but the deepness of the learning may be arduous to judge on a very short term basis. Besides the practitioners and teachers have also to agree on the criteria of assessment.

17. Preliminary results

The summer school has taken place in the middle of March in Trondheim. The analysis of the different evaluation strategies (individual and groups assessment, qualitative and quantitative methods including observation and feedback from all the participants: students, teachers, and practitioners) is still ongoing. However, the preliminary results show a real enthusiasm from the all the participants. 90% of the students claim to have increase their understanding of sustainability and would recommend the summer school to their comrades. They have shown an engagement and diligence which have delighted their teachers. The practitioners have asked the students for a copy of their proposals.

18. Discussion and conclusions

The concept of the summer school answers the call of Meehan and Bryde (2015) for FM management education to integrate and collaborate with FM professionals to define education targets including the contextualised needs and knowhow of the practitioners. Regarding, the challenges identified by Sarpin et al. (2016), the project work and the exchanges between various groups and students should help to develop competences in identifying and managing the changes induced by sustainability within organisation and ways to tackle them. The summer school does not advertise for a certain method or

technology, but rather aims at providing the students with a frame of reference helping them to find and organise the necessary information for each particular project. The organisational challenges described by Elmualim et al. (2010) or Hodges (2005) are not directly addressed by the spring school. The PM professionals though are expected to flag the working conditions and remind the students of the reality of the work environment. The authority challenges (Sarpin 2016) is not a central topic, even if they contribute to the development of sustainable practices.

Following the principles of PBL and building on active learning approaches, we hope that the students move away from dependence on teachers as providers of knowledge towards a personal responsibility approach as described by MacVaugh and Norton (2012). The spring school is designed to introduce students to the complexity of sustainability and help them to orient their choices and decisions as future practitioners. In doing so we come closer to Lozano et al. (2015) definition of FM professionals as change agents engaged and contributing to the transition to sustainability. These change agents should be competent to deal with the both the complexities of sustainability understood from a technical point of view and bridging with the 'soft' issues in organizational and stakeholders' management (Lozano et al. 2015). Ous summer school seems to have been a success, and most of the goals seem to have been reached However, there are two questions left: 1. Is this summer school going to have any influence on the professional life of the students who have participated .2. How can we translate the summer school dynamic context and the different actors enthusiasm in a likely more static version which can serve as teaching material and be reused in different settings.

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Cost development in Norwegian public construction projects

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Abstract

Studies show that public investment projects tends to have challenges when it comes to set a realistic cost estimate for the project. This paper aims to investigates causes for cost development in the early phase and in the implementation phase of Norwegian public construction projects. The study answers three research questions; 1) How do cost development in the early phase and implementation phase of a construction project relate to each other?, 2) What are the causes for cost development in the early phase of a construction project? and 3) What are the causes for cost development in the implementation phase of a construction project?

The research method consists of a literature review, document analysis and two semi-structured in-depth interviews. The selected documents are primarily pre-project reports, cost estimate reports, government documents and evaluation reports from 12 projects. The informants were projects managers that had valuable knowledge regarding the history of the project. The results from the document analysis shows that cost development in Norwegian public construction projects does occur both in the early phase and in the implementation phase. The development occurs as cost increase or cost saving.

The paper concludes that slow project progress stood out as a main cause of cost development in the early phase. In the implementation phase, increased need for planning, increased project scope, extended building time and the occurrence of unplanned developments were the main causes. The main cause for cost saving could be traced to a fortunate development in the market situation and from the systematic index regulation of remaining costs.

Keywords: Construction project, public project, cost development.

1. Introduction

All project proposal needs realistic cost estimates, this is important to the client to ensure that right decisions about the size of the investment, and whether or not to realize it. Similarly, every project manager is dependent on realistic cost estimates to allow for successful cost management during the project. Budgeting and cost control is critical but also challenging due to the uncertainty of projects. Cost underestimating in public projects is a global phenomenon and has been a challenge for decades (Flyvbjerg, 2009, Flyvbjerg et al., 2002). Project costs will be estimated at different points in time of a project, from the very early stage until the project is finished.

Project costs will be estimated in the early phase of a public construction project. At a certain point in time, usually right prior to the final decision to fund the project, a steering goal for the project costs is decided, based on a updated cost estimate. The steering goal is the amount of money the project manager has available for the project. Cost development in this study is seen as all types of deviations from the steering goal. This mean both positive and negative deviations. Positive cost deviations will be seen as a cost overrun and negative deviations will be seen as cost savings.

A major challenge in project planning is realistic cost estimation (Project Management, 2013). Cost deviations is a challenge in construction projects (Shane et al., 2009), this is challenging in construction projects do to critical factors like scope and design changes and project complexity (Torp et al., 2016). Realistic cost estimation is also challenging in IT-development projects based on a comprehensive review of cost deviations in previous cost estimation papers and articles (Kemerer, 1987, Jorgensen and Shepperd, 2007), oil and gas projects (McIntire, 2001), and in defense and aerospace industries (Erkoyuncu et al., 2009).

Different project models are presented and the different project models divide a project into different phases (Project Management, 2013). Samset (2008) shows a simple model where the early phase is determined to be from the first idea of a project until the final decision to fund is granted by the Government. This means that the implementation phase will be from after the final decision to fund the project and until the project is finished. When it comes to how to execute a project, many different methods and models are in use today. Most of the organizations working with projects develop and implement their own project model. A project model can be viewed as a template or framework for how a project should be implemented (Karlsen and Gottschalk, 2005). Westhagen and Faafeng (2002) point out that a project model should describe at minimum the main conditions for how to execute a project. In this context, conditions are aspects such as project phases, decision gates and tasks related to the start, the implementation, and the end of the project.

The aim of this study is to investigate causes for cost development in the early phase and in the implementation phase of Norwegian construction projects. Three-research question fulfill the purpose of the study: 1) How do cost development in the early phase and implementation phase of a construction project relate to each other? 2) What are the causes for cost development in the early phase of a construction project? and 3) What are the causes for cost development in the implementation phase of a construction project?

This paper presents a brief theoretical framework for the subject. Secondly, a description of the methods that are used to collect and obtain the data in this study. Thirdly, the findings and analysis from the

investigation are presented. Finally, the paper discuss and conclude based on the findings and analyses in this study.

2. Theoretical framework

This chapter summarize the literature review conducted in this study, and it forms the theoretical framework that this study are based on.

2.1 Cost control

Rasdorf and Abudayyeh (1991) concludes that cost control is one of the most important managing tools in a construction project. Not surprisingly, most projects are found to have some kind of method to implement cost control. The basic principle governing most control systems is the use of some sort of system where the actual cost is compared to the estimated cost. The aim of cost control is to ensure that the cost does not exceed the steering goal for the project (Olawale and Sun, 2010).

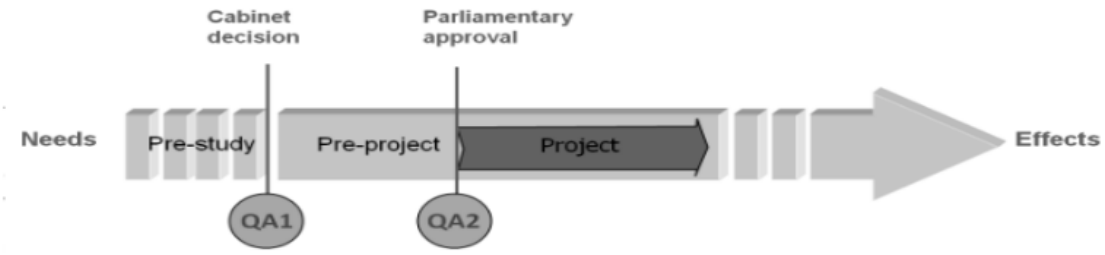
Many projects implement some kind of method for cost control, but nevertheless many projects suffer from inefficiency control due to inadequate flow of information (Rasdorf and Abudayyeh, 1991).

Love et al. (2013) refer to cost overruns as always having to be counted from the point when it has been decided to start the building phase. This is also supported by the literature that concerns public infrastructure projects, where it is common to use the decision to start building as a reference point. In contrast, the literature that describes public construction projects often uses the point where contract is signed as the reference point. This is justified by the assumption that the scope could be changed a lot between the point of the decision and until the contract signing (Love et al., 2013). Flyvbjerg et al. (2002) and Odeck (2004) define cost overrun as the difference between the steering goal and the final cost.

A study that investigated public projects in the Netherlands found that cost overruns usually occur in the time between the decision for building and the start of the building phase (Cantarelli et al., 2012).

All Norwegian public projects that have an initial cost estimate over 750 MNOK have to go through the quality assurance scheme (illustrated in figure 1). The model is designed to ensure the quality of the project concept and the valuable contribution that the project result is going to give the Norwegian society. The model has two control points. The first is intended to ensure that the project concept has reached sufficient quality, and the second is intended to ensure that it is possible to complete the project within the estimated steering goal. The first control point is the quality assurance of the choice of concept before the Cabinet decision to start a pre-project (QA1). The second control point is the quality assurance of the management base and cost estimates before the project is submitted to the Parliament for approval and funding (QA2). In this paper there are set some limitations regarding the early phase, the study only investigated the period between pre-project and the approval of Parliament. The limitations only apply to the early phase; the implementation phase follows the definition presented earlier.

Figure 1: Quality assurance scheme (Concept, 2016).



2.2 Causes of cost development

A study carried out by Westhagen and Faafeng (2002) claims that the majority of the causes for cost overrun actually derive from a lack of awareness and focus on strategic risk. Samset (2008) says that there are mainly four causes for cost development or cost overruns: 1) underestimating,

2) Information and method for cost estimation is unsatisfactory, 3) unforeseen conditions and 4) the cost control in the implementation phase is not good enough.

Individual factors that can lead to cost development are divided into two groups, internal and external (Shane et al., 2009). An overview of the subdivision can be seen in table 1.

Table 1: Internal and external factors that can lead to cost escalation (Shane et al., 2009).

Cost escalation factor	
Internal	**External**
- Bias	Local concerns and requirements
- Delivery	Effects of inflation
- Project schedule changes	Scope changes
- Engineering and construction complexities	Scope creep
- Scope changes	Market conditions
- Scope creep	Unforeseen events
- Poor estimating	Unforeseen conditions
- Inconsistent application of contingencies	
- Faulty execution	
- Ambiguous contract provision	
- Contract document conflicts	

A cause that is pointed out to be common when it comes to cost development in public projects is the phenomenon of underestimation. This phenomenon could also be seen as tactical budgeting to make the project more attractive and ensure that the project is considered in the selection process (Samset, 2008). The explanation for this, in many cases, is divided into three categories: political-economic, technical and psychological conditions (Westney, 2016, Flyvbjerg, 2009).

Political-economic explanations are used as explanations when the benefits from the project results are intentionally overestimated and for when the cost is intentionally underestimated. This is often done to increase the chances for their project to be chosen (Flyvbjerg, 2009). The technical explanation is often used in situations where wrong methods or techniques have been used to estimate the cost, where there were not good enough skills in the project group, or where there simply have been honest mistakes.

This explanation is the most common cause for inaccuracy in the estimate in the early phase according to Flyvbjerg et al. (2002). A psychological explanation is the aspect of too much optimism around the planning of the project and that people have difficulties anticipating the future. This is also called optimism bias. Causes for cost overruns and benefit shortfalls that come from psychological conditions can often be explained by too optimistic planning (Flyvbjerg, 2009, Lovallo and Kahneman, 2003).

3. Research methodology

To answer the research questions, namely to identify causes for cost development in the early phase and in the implementation phase, and to analyse how these two relates together, this paper investigates twelve construction projects. All twelve projects are public building projects, carried out by Statsbygg. Statsbygg is the Norwegian Government's key advisor in construction and property affairs, a building commissioner, a property manager and a property developer. At any given time, Statsbygg organizes, plans and implements around 150 projects – large and small – of which 20-30 major projects are completed every year. Statsbygg has developed their own project model, which are used on all their construction projects, and it is customized to each individual project. Statsbygg usually takes over the project after the pre-study phase and then starts the planning of the pre-project (according to the project model illustrated in figure 2).

The document analysis was the primary activity in regards to collecting the research data from the 12 projects. The aim of the document analysis was to accumulate all available information regarding the costs of the projects, all the way from the front-end until the end. The selected documents that were analyzed were primarily pre-project reports, cost estimate reports, government documents and evaluation reports. The documents were systematically analyzed to explore which cost elements that experienced a development and why this development occurred. After the cost elements with unusual developments were detected, each of the elements were investigated to detect the causes for the cost development.

To investigate if there is any connection between the cost development in the early phase and the implementation phase there was done an analysis of all twelve project chosen in this paper. To investigate the early phase, estimates from the pre-report were compared to the decided steering goal for the project. To investigate the implementation phase, the steering goal was compared to the final cost of the project.

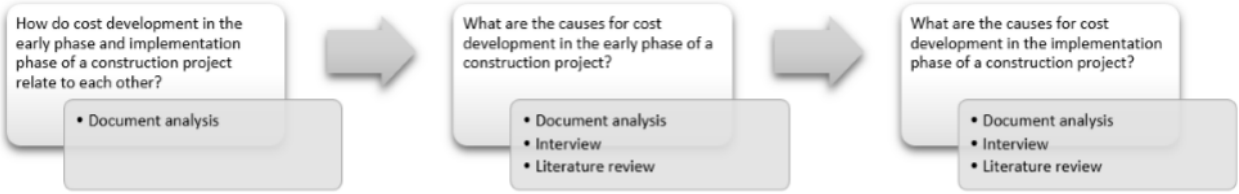
The twelve projects chosen in this analysis consist of nine education and research buildings, one prison, one opera house and a customs facility. The twelve projects were selected based on the following: 1) the project had been through the second check point in the Norwegian quality assurance scheme; 2) that the project had experienced a cost development either in the early phase or in the implementation phase; and 3) that Statsbygg did have enough available data for the project.

Two projects from the selection were chosen for an in-depth analysis. The aim was to detect the causes for the cost development in the projects, both in the early phase and the implementation phase. The two projects investigated were selected based on: 1) the high cost development that the project experienced; 2) the availability of data regarding costs; and 3) the recommendation from Statsbygg to choose these two projects. Statsbygg wanted to look at these two projects since they both had experienced a relatively

high cost development. In the rest of this paper, the two project will be referred to as Project A and Project B.

The research approach used in this study is mainly the document study and literature review. The document study was chosen based on the need to gather as much as possible of the documented information that was telling something about the cost development in the projects. On this basis the document study was seen as a good approach to gather the necessary data for the study and for answering the research questions. By conducting a series of interviews this would increased the studies credibility, but this was a challenge, and are more explained in the next paragraph. To establish the theoretical framework for the paper, a literature review was conducted. The literature review was based on the approach presented by Blumberg et al. (2011). The approach is divided into five steps: The first step consists of building an information pool, the second step is to apply a filter to reduce the pool, the third step is to do a rough assessment to further reduce the pool, step four is to analyze the literature and step five is to refine filters or stop searching. The research has a qualitative approach in regards to investigating the phenomenon of cost development in Norwegian public construction projects. The method is based on Yin (2009)'s prescriptions for qualitative research design. Figure 2 provides an overview of how each of the research questions have been answered.

Figure 2: Research question and chosen method



To increase reliability, the study implemented one semi-structured in-depth interview for each of the two projects. The informants were projects managers that had valuable knowledge regarding the history of the project. Unfortunately, several of the persons that had a key role in the selected projects did not work for Statsbygg at the time this study was conducted. Therefore, it was difficult to get these people to contribute, and therefore the interviews were limited to the project managers. The interviews were structured according to an interview guide developed prior to the interviews and after the documents were analyzed. To compensate for the small number of interviews, there was implemented some unstructured interviews with persons that had been a part of the project team, but had not been in the project through all of the phases. The information gathered through this approach gave support to the data that was gathered through the document analysis. Therefore, the number of interviews was considered satisfactory despite being so few.

4. Findings

The following chapter presents the results from research question number one followed by the investigation of project A and project B.

4.1 Comparison of cost development in various phases

The findings from the analysis of the twelve projects showed cost development in form of both cost overrun and cost saving, and that it occurred in both the early phase and in the implementation phase. In the early phase, it was discovered that only five of twelve projects actually did experience a form for cost overrun. Two of the twelve projects had no deviation from their steering goals. The overall result for the portfolio is therefore that 40% of the projects have experienced a cost overrun during the early phase. A complete overview of the cost development for the projects during the early phase can be seen in the figure 3.

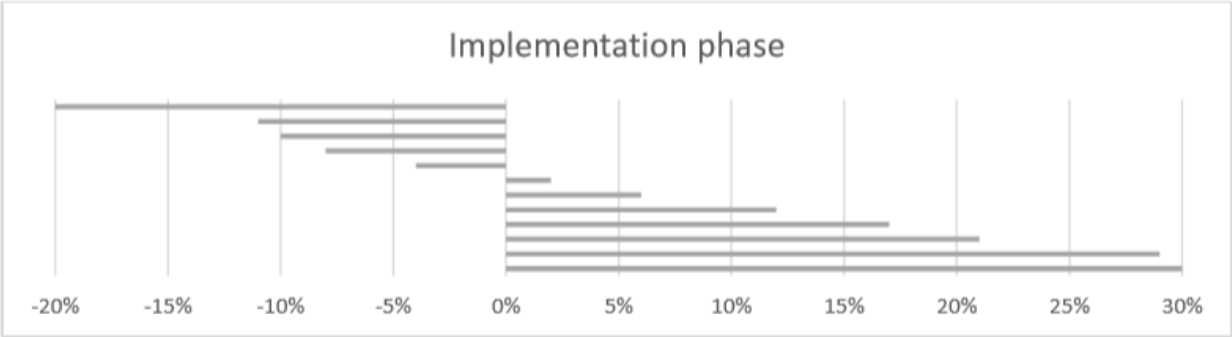


Figure 3: The cost development in the early phase (n=12)

In the implementation phase, the analysis showed a slightly different result. The overall result for the portfolio is that 60% of the projects experienced a cost overrun during the implementation phase. A complete overview of the cost development for the projects during the implementation phase is shown in figure 4.

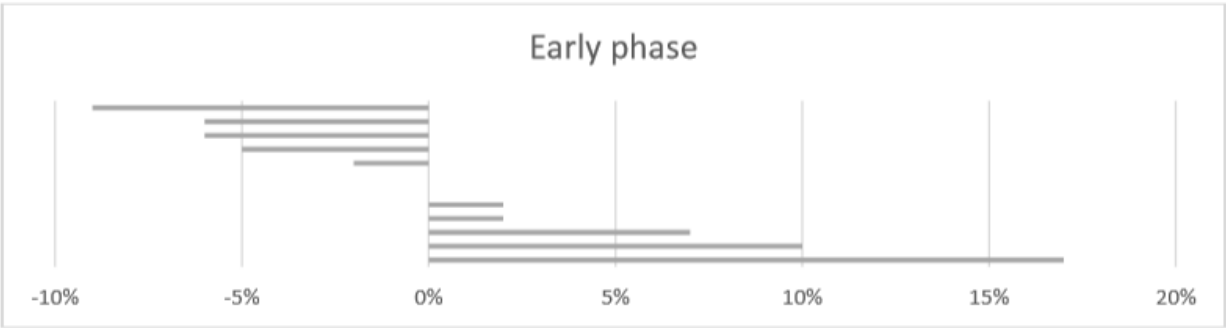


Figure 4: The cost development in the implementation phase (n=12)

To summarize the relation between cost developments the early phase and the implementation phase the different outcomes are presented in figure 5. The notation in the figure describes first the result from the early phase and then the result from the implementation phase. Therefore, "overrun – overrun" means that the project has had an overrun in both the early phase and in the implementation phase.

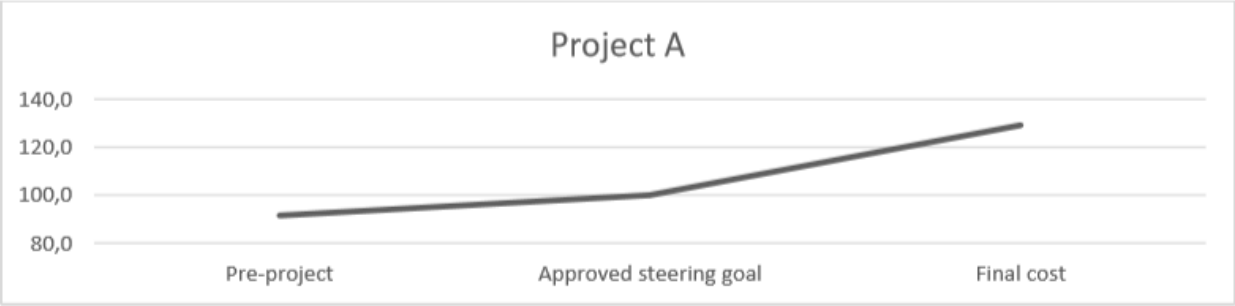


Figure 5: The relation between the early phase and the implementation phase (n=12)

As figure 5 shows, there is no clear relation between the development in the early phase and in the implementation phase. All the four possible outcomes are represented, and there is none of them that are major represented.

4.2 Project A

The first pre-project was presented in 2006. The project did not get approval to continue and was therefore put on hold. The pre-project was revised in 2009, and the project concept had been changed because of the focus of the client had changed over the period between 2006-2009. At the end of 2009, a new pre-project was presented. After this, the project was again put on hold and did not get funding from the Government until 2013. The most interesting period to investigate for the early phase in this project was the 2009-2013 period since the estimates that were presented earlier on were not comparable to the final project result. The development from the pre-project to the final cost can be seen in figure 5.

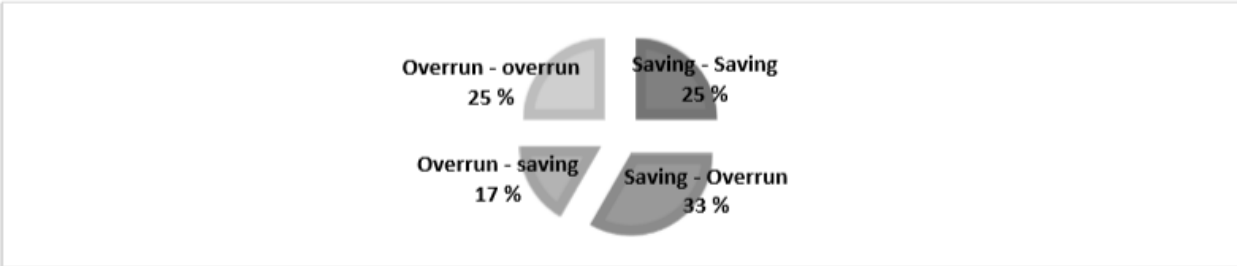


Figure 4: The cost development in project A, presented relative to the approved steering goal for the project.

Cost development during the early phase

From figure 6 we can read that the cost estimation presented in the pre-project was approximately 10% lower than the later approved steering goal and it is therefore considered as a cost development in the early phase. Through the document analysis, it became clear that the costs that were planned to be used on planning, design and project management were one of the cost items that developed most during the period that the project was put on hold. This cost was first estimated to 37 MNOK in 2009, while in 2013 the cost was estimated at 74 MNOK. This is a development of 100%. During the same period, the building cost escalated by 11 % and the consumer cost escalated by 4%. This means that the inflation through the period may pose a development of 22 MNOK (note that this is the worst potential development).

Cost development the implementation phase

The project also experienced a cost overrun during during the implementation phase. In reference to the steering goal approved in 2013, as we can see in figure 5 the project experienced a total cost overrun of 29% in the implementation phase. The analysis indicated that the choice of contract strategy could be the cause of some of the overrun. The strategy demanded a lot more project design than what was planned and foreseen. The cost for planning, design and project management experienced a development of 100 % during the early phase and experienced a further development of 40% during the implementation phase.

The project team had implemented a strategy of careful planning with the purpose of executing the implementation phase quickly and achieving a short building time. This did not go as planned and resulted in even more planning and a longer building time. The building phase developed from 12 to 20 months. This was the main cause of the cost overrun of 15 MNOK. It is essential to mention that some unplanned scope changes also occurred. The documents indicated that this also had an impact on the cost overrun.

4.2 Project B

The first estimate for this project was presented in 2003. The first pre-project was presented in 2005, was considered for QA2 in 2006 and had a planned building start in 2007. The project did not get the necessary approval for funding in 2006 and was therefore put on hold. In the beginning of 2009, the preproject was through a new QA2 and the project finally got approval and funding medio 2009. The cost has essentially been investigated for the period 2006-2009. The development from the pre-project to the final cost can be seen in figure 6.

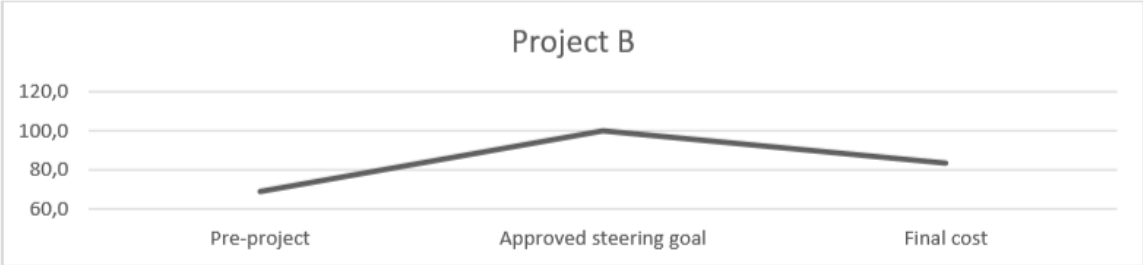


Figure 6: The cost development in project B, presented relative to the approved steering goal for the project.

Cost development in the early phase

In the pre-project the cost was estimated over 30% lower than the later approved steering goal, this can be seen in figure 7. To ensure that projects can be completed within the cost frame, a buffer is created to account for unseen events during the project. In this project, the buffer experienced a development of almost 300%, which is equivalent to a cost development of 142 MNOK. From the cost estimate, two elements especially stand out. These are the administration cost and the cost regarding the building of the construction, which alone account for 40% of the development in the early phase. During the period investigated, the building cost escalated by 20% and the consumer cost escalated by 9%. This means that the inflation through the period may pose a development of 180MNOK (note that this is the worst potential development).

Savings in the implementation phase

After a cost development during the early phase, the project experienced a turnaround with cost savings during the implementation phase. As seen in figure 6 the project saved approximately 20% of the approved steering goal, which was equivalent to 400 MNOK, during the time period 2009-2016. The cause was indicated to be linked to the financial crises that occurred in Norway during 2009-2010. It seems like this had driven the tenders down and therefore had a positive impact on the project costs, i.e., the project had estimated that the tenders would be higher than they actually were. Through the whole project, the remaining costs have been systematically index-regulated. The systematic index regulation and the contract strategy are considered the causes for the savings that the project experienced.

5. Discussion

In the following chapter, the results from the investigation are discussed with respect to the theoretical framework that are compiled for this study.

5.1 Cost development in the early phase and in the implementation phase

The analysis shows that 60% of the projects did not experience a form for cost overrun during the early phase. This did not quite correlate with previous findings; the literature showed a slightly different trend. Samset (2008) says that the problem with cost development in Norwegian public projects could be sourced to the early phase of projects. An explanation as to why the results do not match could be assigned to the selection of the case projects and the sample size.

The analysis of the implementation phase shows a different result compared to the result from the early phase. Here, 60% of the projects have a cost overrun. This result is supported by international literature, which states that it is mainly during the implementation phase that cost overruns occur (Flyvbjerg et al., 2002). Although the result is supported by existing literature, there is no guaranty that the selection of case projects is representable based on the results from the early phase.

To ensure that a project's value is worth the cost, and that the right project is selected, all projects are analyzed and the cost of the projects is assessed against its intended value. The cost-benefit analysis is only emphasised in the early phase by the Norwegian quality assurance system for major public investments. This is why it is important to estimate the cost as accurately as possible in the early phase, and why this aspect is highly empathized in Norway. If the cost does develop after the analysis, decisions made based on the analysis could be invalid. This could be the case because a project's value could be affected by such development, i.e. it is not certain that the project result has the same value after the cost development. If this is the case, it would not be beneficial to go through with the project and it will be the wrong project to choose. It is important to have knowledge of this aspect because of the possibility that the "wrong" project is carried out at the expense of other projects that could have contributed a higher value to the Norwegian society. The result of choosing wrong could lead to the Norwegian society missing out on the benefits and the value that the project was intended to create. It is important to have knowledge of why some projects experience cost development so it is possible to overcome the possibility of the occurrence of this phenomenon.

5.2 Causes for cost development in the early phase

During the investigation of the causes for cost development, it was shown that slow project progress stood out as a main cause of cost development for both projects A and B. In this context, project progress is the time between the finished pre-project and until the project gets funded by the Government.

Both projects were put on hold for a period of three years. The literature does not address such causes, however, inflation is pointed out as the external cause driving cost development. A direct cause of the slow progress is that the projects have to follow the Government's quality assurance scheme. Due to the strict nature of the quality assurance scheme, the projects need to get approved in both QA1 and QA2 before moving forwards. If the projects do not get approved in one of the quality check points, the project is put on hold, which naturally slows down the project progress.

The result from the analysis of the early phase of project A indicates that the scope of planning and design increased a lot during the early phase. Compared to the literature, this is seen as one of the five biggest inhibitory factor in conjunction with cost control (Olawale and Sun, 2010). According to Flyvbjerg (2009)'s three causes of cost development, the cause in this project fits both the technical and psychological explanations. The results show clear evidence that there has been some kind of optimism bias in the project's early phase, which fits in the psychological explanation. It also fits the technical explanation since the project experienced a scope change. Nevertheless, it is difficult to say with certainty whether this was derived from increased scope or wasted time in design. This is due to the strategy of focusing on planning and designing an optimal project description, so that the building could be completed faster and thereby recover the extra time used on planning and design.

The result from the investigation of the early phase of project B, shows that a change in the project scope, which could be related to the time period the project was put on hold. According to Flyvbjerg (2009), we could categorized this as a technical explanation. However, the scope change is also related to the slow project progress. This is a type of cause that is difficult for the project management to control, as it is an external factor. The explanation is clear and fits the technical category; however, the reason for the cause is not clear. From the analysis, it seems likely that the project's long time on hold had a vital impact. When a project is put on hold, a lot can change regarding the design and scope.

5.3 Causes for cost development in the implementation phase

For the implementation phase, the explanation for the cost overrun in project A is considered to be the same as for the early phase, and the causes could mainly be put in the same categories. However, the reasons for the technical causes are not the same as in the early phase. In the implementation phase there was higher need for use of resources on design work than there normally is in this phase in a construction project. Shane et al. (2009) points out that poor estimation could be one of the reasons in a case like this. There was also an extended building time, which is a key reason that causes cost overrun (Mansfield et al., 1994). Another reason that is pointed out by Flyvbjerg (2009), is the occurrence of unplanned development. Doloi (2013) says that events like this often come from optimism bias.

During the implementation phase for project B, the cost development from the early phase turned into a cost saving situation. The main cause could be assigned to a development in the market situation. A

more unstable market was expected. In regards to uncertainty, this activity was analyzed to be the one with the biggest range of uncertainty.

6. Conclusion

The results from the document analysis shows that cost development in Norwegian public construction projects does occur both in the early phase and in the implementation phase. The development occurs as cost increase or cost saving. The results from the early phase do not correlate exactly with some of the previous results from the literature on the subject. The results from the investigation of the implementation phase shows an interesting match between the findings of this study and international literature addressing this subject. The research addresses that the findings presented are interesting, but that the project selection is too small to be used in a generalization regarding "all" projects.

For the investigation of the causes for cost development, it was shown that both projects had similar results in the early phase. Both projects had a slow project progress from the finishing of the pre-project until the project actually got approval by the Government. Slow project progress is seen as the main factor for the cost development experienced.

Inflation is also a factor that is applicable on the basis that the project was put on hold for an extended period. In the period that the projects were on hold, the building cost escaladed twice as much as the consumer costs.

The results from the implementation phase were not the same for both of the projects like it was for the early phase. Project A experienced a cost overrun of 20% and Project B experienced a turnaround between the results after the early phase and the finished project. The project had a total cost saving of 20% seen relative to the steering goal for the project. The causes for the various developments are presented in the table 2.

Table 2: Causes for cost development in project A and project B

Causes for cost overrun in project A	**Causes for cost savings in project B**
Increased scope of the "outdoor work"	A "positive" market situation
Increased scope of design and project planning	Systematically index regulation of rest cost
Extended building time	
Discovery of unforeseen conditions	

The findings are interesting and should therefore be investigated further. This study is limited to an investigation of a total of twelve projects, where two were investigated in-depth. A suggestion for further work is to initiate an in-depth investigation of a greater selection of projects. The aim should be, to a further extent, to generate significant evidence to what causes cost development in public construction projects.

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The complete robot? The human-machine interface in temporary off-site construction work

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Abstract

Increasing prefabrication has long been a holy grail for construction work. The potential of small-scale robots for performing tasks alongside the increasing digitisation of construction information offers new possibilities for exploiting off-site construction more flexibly and at more modest scales than previous visions of total automation. Previous task-specific methods of system design have typically involved a limited range of standardised operations, with cutting, drilling and fixing being foremost. However, more adaptable and configurable processes, utilising these emerging technologies and oriented to short production runs may offer a more viable approach.

However, innovation brings challenges, not least in reconfiguring the socio-technical relations and expectations around existing work processes. Automation requires defining new human- machine interactions, and rehearsing organisational, cultural and skills changes necessary to facilitate this. This paper presents and describes research currently underway at the University of Reading examining the challenges associated with this. The empirical focus is on the pilot stage of a project that is developing the concept of 'Flexible Robotic Assembly Modules in the Built Environment' (FRAMBE).

Drawing on theory from the Information Systems (IS) field and concepts relating to the interface between humans and robots a review of the current practice and implementation approaches of robotics and automation in the construction industry is presented along with the proposed research approach and analytical framework adopted to systematically capture skills needs and culture change throughout the pilot project.

Keywords: Robotics, Automation, Prefabrication, Off-site manufacture

Introduction

The technological feasibility of robots to perform construction tasks is well researched. Robotic applications range from single-task construction robots that execute one process or task or replace the physical activity of human workers, such as welding, cutting and fixing (Linner 2013), to automated on-site building construction systems that utilise climbing factories and multiple cooperating robots (Parasuraman et al. 2000). Studies have also looked at augmenting human workers with robotic limbs to enable them to complete manual tasks alone that would normally require collaboration between two or more workers (Seo et al. 2016). The benefits of using robotics within construction include cost savings related to productivity improvements and less dependency on direct labour, improved worker safety by removing human workers from hazardous environments and replacing dangerous and repetitive work, and quality improvements related to greater control over the production process and reduced variability among others (Martinez et al. 2008; Balaguer et al. 2008; Strukova & Liska 2012)

However, despite these benefits and despite the level of technological capability within the field of robotics the industrialised application of robots within the UK construction industry, whether based in factories or onsite, is limited (Linner 2013). The singularity of construction projects and the associated complexity of interrelated design and construction practices, along with the high number of project participants and the high variability of materials, work and teams at construction sites have consistently proven to be a challenge to the introduction of automation within construction (Slaughter 1997; Mahbub 2015).

For example, the investment cost of designing and implementing a robotic system for specific onsite tasks outweighs the added value it would bring in terms of productivity (Slaughter 1997). It is a similar case for prefabrication; the benefits are well espoused but the business case for standardising building components conflicts with the cost of implementing the necessary requirements to make it a viable construction method; such as longer lead in times and standardisation of components (Pan et al. 2007). The economics of adopting robotics within construction aside, the actual process of actually implementing them within an organisation or using them on a project and the challenges of doings so are less well documented or understood.

The case described within this paper - FRAMBE - presents itself as a solution to these issues by both affording the benefits of offsite production by bringing the factory near to site and by delimiting the complexity to those required for specific components of a specific project. FRAMBE is a scalable, automated and modularised Flying Factory solution that will integrate advanced robotics to manufacture a wide range of building components that are appropriate to the needs of a specific project. Using robotics in a Flying Factory setting to automate a range of construction processes brings a broad set of benefits to both the project and the operatives involved, such as improvements to health and safety and productivity by using machines to carry out physically demanding and repetitive tasks in dangerous environments. This task- general approach to robot design also has a number of potential benefits including: reduced threshold and personnel training costs; provides a better economic justification by distributing initial capital costs across multiple projects; and also provides the opportunity to lease the robotic system (O'Brien, 1996).

The aim of this paper is to explore the potential organisational, cultural and socio-technical impacts of implementing flexible robotics. The paper is structured as follows: first, key concepts relating to

human-robot interaction are defined to prompt discussions surrounding skills needs; second, the literature regarding the organisational impact of robots is discussed and positioned within the IS implementation in construction literature to highlight culture change; third, the analytical framework that will be used to examine the skills needs and culture change for FRAMBE is presented; and finally the FRAMBE pilot project is described along with the current challenges of introducing robotics into this context.

1. Robotics and automation implementation in the construction industry

Generally speaking, in a construction setting, automated robotic systems are designed to replace or support the work of humans - not the humans themselves. In which case, regardless of the level of robot autonomy at some point during use workers will be required to engage with the robotics system (Sheridan & Parasuraman 2005). The extent of human-robot interaction that occurs will vary depending on the role of both worker and robot, however, the effectiveness of this interaction can influence the effectiveness of the system as a whole (Yagoda & Coovert 2012). Accordingly, if the introduction of automation and robotics are to be effective they should be designed to work in combination with the skills and abilities of the humans controlling or otherwise interacting with the robotic system (Kidd 1992). Scholtz (2002; 2003) also makes the point that robotic systems should be usable by domain experts more so than robotic experts. Significant attention should be paid to which tasks within the existing system the robot is intended to improve and how the system is currently configured to perform those tasks. The reason being is that the current system could be inefficient for more reasons than a robot could solve and adding automation will likely produce a highly automated yet inefficient system (Miyatake et al. 1993). Introducing a different technology into any system will necessarily create new interfaces but increasing programmable automation also brings interdependencies between those interfaces and a need for coordination among systems (Woods, 1996). Furthermore, increased system complexity leads to increased operational complexity and new task creation in other elements, components or systems that changes the skills needs of the labour pool (Slaughter, 1997). 1.1 Skill development in automation

The importance of skill development was highlighted by Mital et al (1999) who critiqued the suitability of industrial skills training programmes to meet the demands of advanced manufacturing technology in the U.S. They argue that the skill of the workforce is a defining factor of the effectiveness and efficiency of the manufacturing process and see training and skills development within an organisation as an opportunity to maintain or regain competitiveness within a global market. They also state the importance of linking skills development to the manufactured products and the specific skill required to maintain the quality of the product. For example, whilst manufacturing technologies are intended to replace the dangerous, repetitive and physically demanding work of humans, the nuances of specific tasks reside with the workers. Workers have implicit knowledge and understanding of the materials and components they work with along with the overall business processes, and therefore bring experience and understanding to the correct execution of the task (Khatib et al. 1999). These skills could prove invaluable within a robotic system if, for example, the system fails to deliver the required quality in which case the workers would be able to identify the necessary problem and report accordingly.

However, introducing new technology brings with it the potential for new types of problems and changes the potential of previous problems and new interactions between humans and robots require a

separate and distinct set of skills to avoid or respond to system failure (Woods et al. 2012). In particular, Prewett et al. (2010) highlight the importance of expertise to identify and interpret cues from the robotic system, noting that the level of experience an operator has of the background processes of the automation is likely to determine the effectiveness of their response. Human operators need to exercise judgement during their interaction with the automation to run and maintain the task the system is carrying out. Inaccurate assessments of required action have an effect on the operational effectiveness of the robotic system and so it is important to explore the type of human performance associated with automation success and failure. These provide insight into critical areas of human-robot-interaction and illustrate the skill differences between manually performing a task, and supervising and controlling an automated task.

Rasmussen (1983) describe three levels of human performance among which the conscious control an individual exerts over their actions varies depending on the type of information processing required. Firstly, skill-based performance involves familiar and routine tasks that require little conscious effort to perform where the human primarily relies on looking rather than seeing. This can present itself as a problem if humans over rely on the automation, becoming out of the loop, for example, performing the wrong action on the right object or the right action on the wrong object. Rule-based activities involve familiar problems that are solved using remembered sets of rules and procedures. In this instance, errors occur when the rules and procedures are misapplied based on a misinterpretation of feedback on system states. At a knowledge-based level an individual has no rules or procedures available to them and must exert considerable mental effort to solve an unfamiliar problem, errors occur from insufficient information and incomplete or an inaccurate mental model of the problem space. In all cases some degree of training is required to unlearn existing mental models and replace them with more complete and accurate models.

Also important to the successful operation and maintenance of automated and robotic system is the level of situational awareness an operator possesses. Situational awareness is the understanding an individual has of their environment and the task they are performing, Endsley (2000) defines three levels of situation awareness in the operation of an automated system: perception, comprehension, and projection. Perception of cues is considered a fundamental aspect of situational awareness since being able to recognise important information improves overall understanding of the situation. Comprehension refers to the ability of the human operator to synthesise a number of cues and their meaning to task completion and system performance. Projection refers to the ability to forecast from current situation events to predict future situation events and requires a high level understanding of the situation. Additionally the situational awareness of the operator will vary depending on their existing mental model and the goals that determine that model. Prior experiences of situations provide general mental representations of the components within a given situation. These mental models provide a mechanism through which the current state of the situation is interpreted. The significance of this is that if an inaccurate or incomplete mental model is used to interpret an event within a situation the relevant cues to respond effectively to that event may not be perceived. This will affect the comprehension of that event and consequently the level of consciousness exerted by the operator, the effectiveness of human-robot-interaction, and ultimately the effectiveness of the robotic-system.

1.2 Culture change: the organisational impact of robots

Previous research into construction automation and robotics have tended to focus on the development of construction technologies from a manufacturing perspective where efforts are generally centred on technology adoption to automate tasks and processes (Everett & Slocum 1994).Less attention is paid to the particular context of the construction industry and the wider organisational implications of introducing robotics. For instance, a fundamental requirement for the use of robotics and automation is the translation of construction information into programmable data to define robot task execution. This increases the level of interdependence among project partners necessitating a change management process that reaches further than simply introducing technology. Literature regarding socio-technical approaches to implementing information systems and technologies provide a useful reference point for the implementation of the information management aspect of introducing robotics and automation in construction. For example, Erdogan et al. 2008 identified five categories of issues commonly found within technology implementation at user, project, and organisational level: poor capture of user requirements, lack of strategic approaches and specifically lack of alignment between the IT strategy and organisational strategy focusing on short term solutions, lack of proper planning/project management, user resistance to change, and lack of user involvement.

However, the direct interaction humans have with a robotic system presents different issues for construction organisations to consider when managing change. Introducing automation and robotics necessarily displaces workers by reallocating tasks between people and robots. Resistance to change occurs when insufficient consideration is given to how work will be reorganised and what impact this will have on the individuals working within an environment with established practices, processes and social relationships.

Negative employee reception to robotics predominantly relates to increased stress and anxiety associated with job insecurity, uncertainty, and an increase or decrease in cognitive workload that is incongruent to their skill-level. Argote & Goodman (1985) attempt to address these issues by suggesting a framework of five areas of consideration for an organisation implementing robotics to develop strategies and initiatives: managing job displacement, anticipating individual's reactions to new technologies, anticipating larger-scale organisational effects, implementing change, and being open to change. In a more recent study, Charalambous et al. (2015) found that operator participation in the implementation process, communication of the change to the workforce, senior management support, sufficient training, and process champions had a significant impact on the success of implementation.

These implementation studies from both the construction and robotics domains highlight the breadth of impact from introducing automation and robotics into construction and constitute some of the major themes for investigation throughout the FRAMBE pilot project. These themes, along with those within the human interaction literature are used to shape the research design for the investigation of skills needs and cultural change necessary to facilitate the implementation of FRAMBE.

2. FRAMBE – case and method

The FRAMBE pilot project forms the early stages of a larger innovation project aiming to expand the concept of mobile 'flying' factories to include robotic automation. Prior to industrialisation Skanska are testing the feasibility of introducing robots and investigating the process change and technological requirements through a pilot project. The consortium, led by Skanska UK, have chosen to focus the

pilot project research activities on the introduction of welding robots at Skanska's factory in Slough UK to improve the efficiency of loose pipe spools manufacture. The purpose of selecting this case is that the prefabrication division of Skanska UK already have relatively consistent and well-defined workflows in place. These provide an ideal scenario within which to test and prove the information management solutions developed by the consortium that are necessary for the introduction of robotics into one of the factory's welding bays.

Other commercial members of the consortium include a major robotics manufacturer who are designing and developing the robotics technology, a lean consultancy firm who are mapping existing factory processes and the higher level feasibility processes that a company will need to go through to identify tasks for automation, and a CAD/BIM consultancy firm who are developing the 3D models from which to derive programmable data for robot task execution.

2.1 Method

The University of Reading are engaged within the consortium in a research capacity to examine the skills needs and cultural change required to facilitate the implementation of FRAMBE at an industrial scale. The empirical work has involved observation of early factory visits and consortium meetings, and informal discussions with Skanska's project manager and industrialisation manager. The primary purpose of these visits was to form an initial understanding and conceptualisation of the problem – skills needs and culture change – and collated to form an overview of the current information management processes of the factory (Section 4).

This is an ongoing project in the early research stages and this paper represents the design and development of the methodological approach that has been used to make a preliminary investigation of how to capture skills needs and culture change and what has been discovered thus far. The analytical framework presented within the following subsection, along with the literature reviewed, form the frame of reference through which empirical events have been observed. The findings to date are discussed within Section 4.1 and also highlight areas of further enquiry required.

2.2 Analytical framework

Employed from the field of HRI, Sholtz's model of human-robot-interaction is used within the context of this research as a framework to comprehensively capture skills needs. Sholtz (2003) begins to link the concepts of human performance, mental models and situational awareness in their model of human-robot-interaction. Their HRI model proposes five types of interaction roles: Supervisory, Operator, Mechanic, Peer/teammate, and Bystander. Scholtz (2003) focuses on the perceptual aspects of human-robot interaction and being to define the type of information required by each role. These are described within the following paragraphs.

A supervisor - characterised by monitoring and controlling interactions – will require the following information: an overview of the situation; the overall goal of the system; the expected behaviour of the robots to achieve that goal along with any deviating behaviour that may require a decision regarding intervention; and lastly, other roles interacting with the robot.

An operator – defined within a robot-behaviour-modification capacity – is assumed to have a more technical understanding of the robotic system. Their role, by definition, requires knowledge of robot architecture and programming and as such will include the following information requirements: the technical model of the world in which the robot is operating, such as spatial and temporal parameters; the execution plan of the robot performing a specific task; the status of the robotic system and other interactions that concurrently occur; and the impact of any adjustments to the robot execution plan on other interactions within the robotic system.

Mechanic - for the purposes of FRAMBE it is assumed that the maintenance of the robots will be carried out by experts external to the workers using the robotic system. However, the information that a mechanic may require will need to be relayed by other roles interacting with the robotic system, which includes: the robotic behaviour that failed and how; the physical configuration of the robot; and, the environmental and task parameters used to define the robot behaviour.

Peer/Teammate - In a human-robot team the emphasis is on the human teammate to interpret and comprehend cues from the robot to ensure an effective working relationship. In which case, the information requirements include: the spatial and temporal model of the robot's behaviour; the current status of the robot; the type of other interactions that are occurring; and the extent of activities the robot can currently perform so as to not under or overload the system.

A bystander – characterised as co-existing within the same environment as the robot – has the least direct interaction with the robotic system but can still have an impact on its effectiveness depending on their level of situational awareness and understanding. Such information would include: what the robot is doing and why; what the robot might do next and how the bystander can affect this; the range of behaviours the robot can exhibit and which of these are prompted by the actions of the bystander.

Whilst these roles and the information required by them do not explicitly state the skills needed within a robotic system they have the potential to provide a useful framework to systematically consider the specific skills that might be required for FRAMBE. In addition, the type of activities each role carries out and the information required for each role is used to provide an indicator of skill requirements and form the basis of the method of analysis.

3. Empirical findings

3.1 Current factory processes

Information management process: The information management process of the factory as it currently stands is as follows - the factory receives client drawings, specifications and site movement restrictions/limitations. Drawings and specifications are reviewed in liaison with the structural engineers to achieve a built co-ordinated solution. Currently, the factory receives 2D and 3D drawings that, in many cases, must be re-modelled/drawn to provide cut-sheets for welders to use on the factory floor. The prefabrication engineers in the factory take the architectural schematics and specifications, redesign/draw in their own preferred software to develop an assembly module that is rationalised according to manufacturing and logistical purposes. The cut-sheets include the relevant parts – each with a unique identification number - are then drawn from this model (they are not spooled from the model). Finally, the welders work off these cut sheets on the shop floor.

Welding bay process: Generally speaking, the configuration of operatives within the welding bays consists of two-person teams of a welder and welder's mate. Using the cut sheet provided by the prefab engineering team that has the unique identification number for each part, the welder's mate collects and arranges the relevant components from around the factory into the welding bay where the welder then prepares and manufactures the pipework. The welder then assembles and welds the components in the configuration specified on the *cut sheet*.

Figure 1 illustrates this process and also highlights the areas of process inefficiency within the information management process that pose the most significant challenges to the design and development of the robotic system - more specifically, the fact that there is currently no usable 3D data to extract coordinates and path execution parameters to translate them into programmable data.

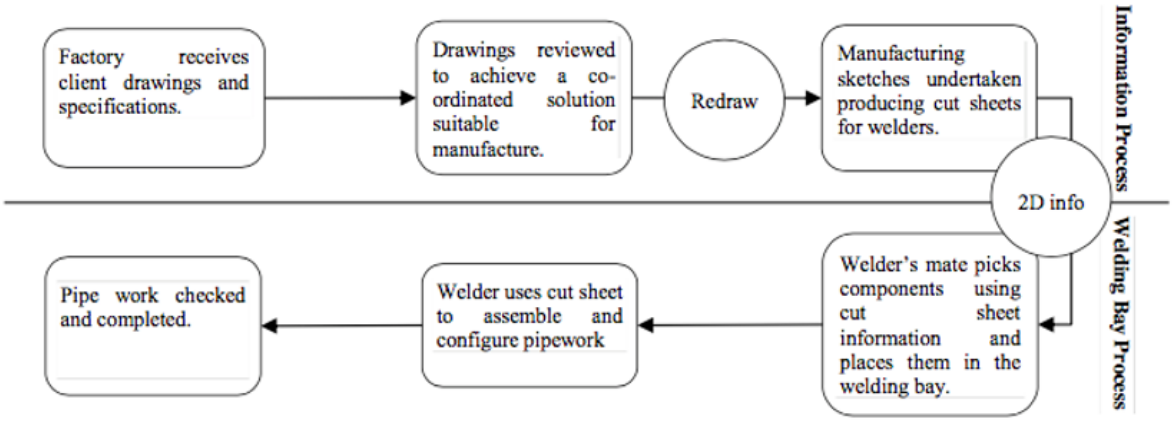

Figure 1: Current factory process

3.2 Robotic system design

Information management process: To introduce the welding robot into the factory setting an additional stage of remodelling is required to produce the requisite programmable data for the robotic system. For the purposes of the pilot project this is currently being carried out by the CAD/BIM consultancy in conjunction with the robotics team who are specifying the required information. Welding bay process: Figure 2 shows the anticipated level of task allocation between humans and robots for the production of loose pipe spools. The robots themselves will be static and therefore a human operator will be required to present components for manufacture to the robots. In the current factory setting, this division of labour is between the welder and the welder's mate – a human-human team – whereby feedback is through communication and direct observation.

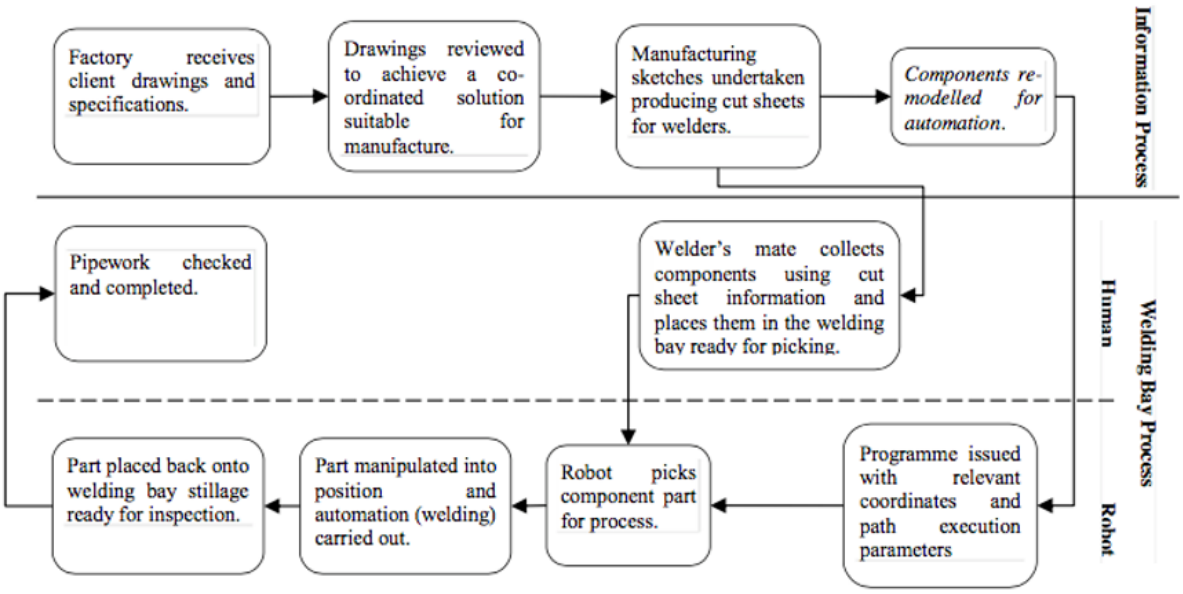

Figure 2: Robotic system factory process

3.3 Preliminary analysis

Using the current understanding of existing factory processes the analytical model and the roles defined within it has been used to make projections regarding task allocation among factory operatives (Table 3). From this, it is expected that the impact on organisational reconfiguration can be better understood and therefore the extent of culture change required along with appropriate supporting mechanisms to facilitate the introduction of robotics into the factory environment.

Interaction Role	Supervisor	Operator	Mechanic	Teammate	Bystander
Proposed Role	Floor Manager	Welder	N/A	Welder's Mate	Other operatives
Key activities	Monitoring production schedules Health & Safety Organising work	Programming robot? Quality checking finished parts	Maintaining and responding to system failures	Collecting and placing components within welding bay stillage	Stock movement Painting
Information req.	Production schedules Stock status Robot operating status Operatives currently working with robots	Assembly module being manufactured Coordinates and path execution parameters	Nature of fault Activity occurring at time of fault	Components specific to the pipe spool being manufactured	Current processes underway within factory and how their activities interact with them and vice versa
Skills Needs	Forecasting abilities to understand the impact of system failure on wider factory operations	Comprehension of robotic system architecture and technical model in order to programme robot execution plans	N/A (Externally defined)	Comprehension of robotic processing capacity to avoid overloading/under -loading the system	Primarily perception & situation awareness to avoid interrupting robotic system and associated processes

Table 1: Project skills need

However, defining skills requirements are only one part of the implementation process; the way in which the organisational environment may need to be remodelled to support and upgrade worker skillsets is of equal, if not more, importance. For example, the information management process is somewhat designed around the work practices of the welding teams whose training and experience has largely revolved around the use of cut-sheets to coordinate the movement and assembly of pipework components. The current design of the pilot continues to include the use of cut-sheets yet this is an additional step that contradicts the productivity benefits of automation. New types of technology are necessary and how this will integrate with existing systems and processes requires further investigation.

4. Discussion & conclusions

The key themes identified within the literature provide an initial frame of reference from which to investigate the skills needs and culture change required for FRAMBE. The human-centred approach to robotic design literature stresses the importance of designing robotic systems with humans and their existing processes and practices in mind. However, as Woods (1996) points out the introduction of automation and robotics will necessarily require the integration of existing systems and processes. Therefore, it is not just the design of the robotic system that needs to be considered, it is also the reorganisation of existing work associated with the integration of systems.

Particularly in the case of FRAMBE, one of the key considerations in the cost-effective application of welding robots is the translation of 2D cut sheets into a 3D model from which the robots can derive coordinates and path execution parameters. Therefore to make FRAMBE a viable method of on or near-site construction it is necessary to eliminate any instances of information reproduction (an example of which is shown in Figure 2) - failing to do so would undermine the purpose of automating a particular aspect of the process as a whole. However, this scenario will inevitably result in the introduction of new technology and new information formats unfamiliar to the existing workforce but more significantly to the focus of this paper it will change the skill requirements of the operatives in terms of information processing. These considerations raise further questions; more specifically, how should we conceptualise the implementation of robots in construction, and what is this most appropriate way to do this methodologically?

In the context of the pilot project described within this paper the HRI model defined by Scholtz (2003) is suggested as a framework to systematically capture skills needs. Supervisory, Operator, Mechanic, Peer/Teammate, and Bystander roles will be used as categories to define activities specific to each role along with their information requirements to perform the overall goal of the robotic system. These will then be compared to existing processes derived from documentation from the lean consultancy firm tasked with capturing existing processes. In doing so, expectations around existing work practices will be matched to the extent of change required to implement the robotic system, ensuring the effective interaction between humans and robots.

To achieve this, skill needs will be further examined throughout the pilot project through direct observation of human-robot interaction within the robotic system and how the wider organisational culture impacts the success of these interactions. The key themes derived from the robotics and construction literature, such as senior management support, critical management support, training, and communication of change will be used to ascertain the current culture and approaches to technology

implementation of Skanska. These findings will then be used to propose strategies for the effective implementation of robotics.

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Enhancing Stakeholder Management Competences in Construction Projects using Serious Games

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Abstract

Projects are applied as a work-form in several organisations. Both public and private sectors widely adopt the project concept to create the product or service that they aim at. Projects are goal-oriented, one-time activities that have time and resource limitations. Even though projects are widely applied in modern organisations, project management is recognised as one of the more challenging tasks in business and one that requires multiple skills to master. The skills encompass technical project management skills such as resource planning and managing a budget; but also a complex mixture of soft skills such as communication, trust building and managing the stakeholders of a project. Current methods for training project managers have received criticisms that call for new approaches to support learning. One such approach is experiential learning for fresh project managers to gain a variety of project experiences in a virtual environment through serious games. This paper discusses the aspects of learning that are important for project manager; in particular, the diverse set of soft skills that are important to managing stakeholder, which are of vital importance for successful projects. The aim of this paper is to examine how specific affordances of serious games can support learning for project managers in construction projects. The main research question that we aim to answer in this paper is: How can serious games support competence development for project managers? This is a conceptual paper and the discussions have been by our work in understanding the diverse technical and soft skills in project management and stakeholder management. This paper aims to contribute to an increased understanding of the competences and how they can be supported by serious games.

Keywords: Serious games, Project Management competences, Stakeholder Management, Learning and reflection, Construction Projects

1. Introduction

Modern project organisations face several challenges; for instance, globalisation and distributed work-teams. And, there has been an increasing focus on project managers developing their soft skills (such as communication, leadership and stakeholder management) sufficiently in addition to their technical skills. Current project management training approaches are focused on certification and provide the basic training to manage projects (e.g. (IPMA, 2006). The skills and experience to manage large, international projects are acquired from several years of managing such projects. How can such skills – specially, soft skills – be developed in a relatively shorter period of time? Serious games is a means of supporting rapid competence development for project managers and can facilitate experiential learning for fresh project managers to gain a variety of project experiences in a virtual environment.

This is a conceptual paper where we consider serious games as a means of training project managers and increasing their competences – specially their soft skills. In this regard, we will look at stakeholder management as an example. Stakeholder management is an important aspect of project management. (Aaltonen, 2010) says that (Cleland, 1986) brought stakeholder thinking to the realm of project management from mainstream general management. She also points out that a definition of the concept of project management, provided by Project Management Institute (PMI), looks at the concept through the lens of stakeholder management: "The process of adapting the specifications, plans, and approaches to the different concerns and expectations of the various stakeholders" (PMI, 2008). (Meng & Boyd, 2017) say that the construction industry has a significant focus on stakeholder management (project-based relationship management). Quoting on several previous studies, [(Yang et al., 2011):page 901] say that "[...] stakeholder involvement is important to project outcomes, and recognition of the concept of stakeholder management has grown in recent years". Hence, it is important to look at enhancing stakeholder management competences in construction projects.

A "serious game" is a game designed for a primary purpose other than pure entertainment. The term "Educational games" is also used to describe games that are designed to teach a specific skill or enhance knowledge as we play. Educational games support a situated context for learning in a virtual world because when you learn by playing a game, you apply that learning immediately in the game and move on to learning new skills (Gee, 2003). Game scenarios and characters in the game that reflect the real world will enable a near-transfer of knowledge. The learning environment of serious games that contributes to rapid competence development can be characterized by the instant feedback on the choices of action that the learner makes, timely feedback on the overall performance of the learner at the end of every game-session and the possibility to play the game several times, choosing alternative paths of decisions every time, based on reflection and experience gained from the previous game-sessions.

Designing serious games or similar virtual environments for supporting project managers to acquire their necessary soft skills requires a fresh look at the training approaches that are currently available. In this paper, we present project management and stakeholder management competences in such a way that they highlight the technical and soft skills, which takes into account an individual's abilities and personality, the knowledge-areas that the individual deals with, organizational factors and environment factors that define a specific situation. We have used the OKEI (Organisation, Knowledge, Environment and Individual) competence modelling framework (Petersen & Heikura, 2010) and (Cowley, Bedek, Rabeiro, Heikura, & Petersen, 2012) to describe the competences. In addition, we

discuss how serious games can contribute to support rapid competence development for project managers.

The aim of this paper is to discuss serious games as an effective means of competence development, with a focus on developing stakeholder management competence, for the construction industry. The rest of this paper is organised as follows: Section 2 discusses project management and construction projects; Section 3 describes stakeholder management ; Section 4 describes competences for stakeholder management; Section 5 discusses the challenges in competence development for project managers and stakeholder management; Section 6 provides a discussion of serious games for developing stakeholder management competences and Section 7 concludes the paper.

2. Project Management and Construction Projects

According to PMI "a project is a temporary endeavour undertaken to create a unique product or service" (2008:5), (Olsson, 2006). Projects are traditionally seen as temporary organisations designed for unique tasks (Cleland, 2004), (Olsson, 2006), often in contrast to the massproducing core activities of organisations. Application of project concept has a vital role in the construction industry. A significant portion of construction endeavours are done through projects. The construction industry is highly fragmented. Construction is one of the most complex industries and it involves a great number of variables affecting any project development. Winch supports this idea arguing that construction projects are amongst the most complex types of endeavours (Winch, 1987). Dubois et al. supports this idea suggesting that this industry is a "loosely coupled system" characterized by (1) complex elements of uncertainty and tasks interdependences, and (2) inefficiency on its operations (Dubois & Gadde, 2002). These characteristics highlight both the importance of and challenges related to stakeholder management in construction projects, as well as the need to focus on developing / strengthening stakeholder management competences.

Over the years, various standards have emerged in order to frame how project management should be performed. Organisations such as The International Project Management Association (IPMA, 2006), the Australian Institute of Project Management (AIPM (Australian Institute of Project Management), 2008) and Project Management Institute (PMI, 2008) all provide certification in project management. We experience that PMIs standard has increased in popularity all over the world. In addition to these programs, academic institutions all over the world teach project management at different levels and organisations also create their own inhouse project management courses according to their own "standards". As we mentioned before, we believe that serious games can provide an effective learning arena for developing project management and stakeholder management competences rapidly.

3. Stakeholder Management in Construction projects

A project stakeholder has been defined as "a person or a group of people who have a vested interest in the success of the project and the environment in which the project operates" (McElroy & Mills, 2000). Stakeholder management is an important aspect of project management. A project can be seen as a temporary coalition of stakeholders having to create something together (Andersen, 2005). Success of projects can be determined by how stakeholders of the projects are dealt with and managed (Aaltonen, Kujala, Havela, & Savage, 2015) and (Eskerod & Vaagaasar, 2014). Jepsen & Eskerod (2009, page 335) say:

"Contributions (e.g. deliverables or supporting decisions) from a strong coalition of supportive and influential stakeholders are necessary to carry out a project successfully and it is the responsibility of the project manager to ensure such contributions through management of the stakeholders. An important component of stakeholder management is stakeholder analysis [...]. Proponents for stakeholder analysis [...] argue that stakeholder analysis increases the project manager's ability to anticipate opportunities and problems for the project at a time when the project team still has time and opportunity for manoeuvring. Accordingly, a stakeholder analysis is often carried out front end [...]."

The above description points out the importance for the project manager to have the competence in stakeholder management. Based on previous studies, Jepsen & Eskerod (2009, page 336) presents the following activities as parts that constitute stakeholder analysis: (i) identification of the (important) stakeholders; (ii) characterization of the stakeholders pointing out their needed contributions, expectations concerning rewards for contributions and their power in relation to the project; and (iii) decision about which strategy to use to influence each stakeholder. These activities suggest what aspects that can attribute to the competence that project managers should have in stakeholder management.

The most important stakeholders in construction projects are the owner and the contractor (Jespen & Eskerod, 2009). In addition, all, atleast most, projects have a diverse set of stakeholders as illustrated in (Olander & Landin, 2005). The stakeholders may be related to the environment the project operates in, the community around the project, the cultural landscape and the neighbourhood demography. The local and/or the national government can be an important stakeholder depending on the nature of the project. The media is an important stakeholder that is sometimes overlooked or the influence of whom is sometimes under estimated. The media, although often is not a direct stakeholder, it can be extremely influential on the other relevant stakeholders of the project such as the community or the neighbourhood. Example in this regard is illustrated in Olander & Landin (2005). They also illustrated that stakeholders and their relationship to the project is not a static picture. They can vary in many ways such as the relevance of the stakeholders to the project. Their power in the community and how this could affect the project and all these could vary during the lifecycle of the project. The coalition of the stakeholders as something that is constant is a false assumption and this dynamic and complex picture of the stakeholders and their relationship to the project needs to be well understood by project managers.

Stakeholders may be individuals or groups or organisations and they can influence one another. The analysis of stakeholders should be an interactive activity with the stakeholders rather than a desk activity conducted prior to the project start. Guidelines for understanding stakeholders and uncovering the stakeholder coalition is complex and requires experience. Managing stakeholders is not always clear and managers have been criticised for their inadequacy (Jepsen & Eskerod, 2009)).

4. Competences for Stakeholder Management

Stakeholder management in construction projects encompasses a complex set of knowledge and skills that form an important part of the project management. The types of skills include theoretical knowledge such as methods, technical skills of project management such as planning and management. Most importantly, the soft skills are pivotal to successful stakeholder management. As we have seen from our earlier work in analysing project management competences; e.g. (Petersen & Heikura (2010), a project manager must look beyond the current project, the organisation and the obvious stakeholders.

Thus, a closer examination of the competences illustrates that knowledge of one's own organisation, the organisation of the stakeholders and the environment or the context that the project is operating within play a significant role in the success of the project.

The OKEI (Organisation, Knowledge, Environment, Individual) competence modelling framework was developed in an earlier project to support to support rapid competence development using serious games (Oliveira, Andersen, & Torvatn, 2013). In general, the OKEI competence modelling framework highlights the interdependencies and dialogue between intraorganizational factors (e.g. strategy, work organization etc.), external / operational environment factors (e.g. law, culture, infrastructure etc.), knowledge related factors (e.g. the existing body of knowledge relating to the work process, the bulk of which resides outside of any individual), and individual and personal factors (e.g. knowledge, skills, motivation, personality, mental models of work and intentions). The framework aims to function as a check list of the sort of contextual issues which are present in the actual contexts and situations where the learner will be applying the knowledge that he/she needs to acquire. The OKEI factors are described below:

- *Organisation:* represents the organizational aspects that influence the work performance and the application of competences. They include strategies, values and goals of the organization, work processes, organization structure, roles of people within the organization and e.g. the power structure embedded in people and functions.

- *Knowledge:* refers to the external knowledge resources that could be useful to apply. The knowledge resources referred to here may be academic, theoretical or practical.

- *Environment:* considers the context outside of the organization. The environment includes other companies and industries, networks, public sector and governance, the laws and norms, existing technologies and infrastructure, the market and culture, not to mention the people as consumers, users and citizens.

- *Individual:* refers to individual and personal factors that may be applied in work situations and that have varying connections to ones performance level. Among other things, knowledge, skills, past experiences, personality traits, mental models, attitudes, motivation, intentions, perceptions and emotions can influence the work tasks in some way.

We have analysed the competences required for stakeholder management using the OKEI competence modelling framework. We have used the IPMA Competence Baseline (IPMA, 2006) as our starting points and complemented that from other relevant literature (referenced elsewhere in this paper). Table 1 shows stakeholder management competences with respect to the OKEI factors.

Organisation	Environment
• Knowledge about the organisations interest in the project • Knowledge about the organisations importance for the project • Knowledge about the expectations of the organisation in the project • Knowledge about the level of influence the organisation can have on the stakeholders • Knowledge about the position of the project in the organisation • Knowledge about the position of the project in the stakeholders' organisations • Knowledge about the context of the project for own organisation	• Ability to analyse the diverse stakeholders according to their interests and their importance to the project, in the different lifecycle phases of the project. • Knowledge about how the other parties see the organisation's importance in the project • Knowledge about the expectations of the stakeholders in the project • Knowledge about how the stakeholders can influence the project • Updated knowledge about stakeholders (any information that may affect the project such as their organisational maturity, standards, practices, etc.) • Knowledge about the context of the project for all stakeholders
Knowledge	**Individual**
• Methods and means of developing strategies for expectations management • Methods and means of developing networks, internal and external, formal and informal • Methods to identify and evaluate the influence of stakeholders on the project and to detect the influences and consequences of changes in the stakeholders (e.g. if a new party joins or one leaves). • Strategies to cope with stakeholders • Ability to assess the risks and opportunities represented and methods to deal with the risks represented by the stakeholders • Methods to ensure the satisfaction of stakeholders throughout the project and during the different lifecycle phases • Methods and means of developing communications strategies for stakeholders (stakeholder communication plan)	• Ability to build trust with the diverse stakeholders and work on building a relational trust with them • Good communication skills • Knowledge about how the other parties see the organisation's importance in the project • Knowledge about the expectations of the stakeholders in the project • Knowledge about how the stakeholders can influence the project • Updated knowledge about stakeholders (any information that may affect the project such as their organisational maturity, standards, practices, etc.) • Knowledge about the context of the project for all stakeholders

Table 1 Competences for Stakeholder Management

In designing competence based learning games and simulations, the framework guides to list the relevant contextual factors (organization, environment, knowledge), in addition to the factors pertaining to an individual person, such as the personality, attitude or strength of character, which play a role in the application of a competence. In order to be able to do this, in most cases, the competence needs to be elaborated and more detailed sub-competences need to be defined so that the relevant contextual factors can be identified and taken into account in designing games for learning.

5. Challenges in Competence Development for Project Managers and Stakeholder Management

Despite all the training and standardisation of project management, we still see failing projects. Some of this is due to the fact of an increased level of complexity, chaos and uncertainty in projects environment (Thomas & Mengel, 2008). Most of the educators today provide knowledge about the tools to use in order to perform project management; few provide knowledge about how to use these tools in complex situations. There has been a growing criticism of current project management research for being too weak in their relevance to practice and in their general understanding of research methodology (Winter & Smith, 2006). The critique is first of all directed towards the gap between theory and practice in the project management field. Conventional theory on the field has a narrow focus on management of a project and doing it right. In essence, conventional project management theory still remains within the ontological foundations of the 1950s and 1960s with its emphasis on technical concepts of organisations and projects, and realist assumptions about "projects" as existing out there independent of the people involved (Winter & Smith, 2006), (Packendorff, 1995). There is a need now to develop the field further, including new training methods in project management (Berggren & Söderlund, 2008). In order to meet the complexity in everyday project life, there is a need for reflective tools supporting change, creative and critical reflection, cross-cultural and online communication and coping with uncertainty (Thomas & Mengel, 2008). This implies the necessity to focus adequately on soft skills.

Project managers, as a part of their work, interact with other people, such as the diverse set of stakeholders, and various tools for conducting their work. Through working as project managers, they go through different experiences and build up their experience base. Projects are per definition unique, and they usually deal with a high degree of uncertainty, complexity and multidisciplinary nature. For example, project managers often have to work with new people and people that they do not know from before. Good interpersonal relationship is thus essential for fruitful cooperation with the stakeholders and effective execution of projects.

The main challenges in competence development for project managers and stakeholder management can be summarised as follows:

- Understanding the complex and diverse picture of stakeholders and their influences and expectations.
- The possibility to see and perceive the situation well within the context of operation of the project; the development of perceptual skills.
- The possibility to gain experience rapidly over the variety of situations that a project manager may face.
- The possibility to practice their knowledge and skills, in particular, the soft skills such as communication, interaction and reflection upon previous experiences.

6. Educational Games for developing Stakeholder Management Competences

The term "Educational games" or Serious Games is used to describe games that are designed to teach a specific skill or enhance knowledge as we play. Educational games facilitate a situated context for

learning in a virtual world. That is, when a player learns by playing a game, then the player applies that learning immediately in the game and moves on to learning new skills (Gee, 2003). Examples of serious games in the area of project management are described in (Oliveira et al., 2013) and (Petersen & Ekambaram, 2012). One of the main advantages of serious games for learning is the opportunity offered by the virtual environment in the game for the project managers to gain experience with timely feedback in a safe and risk-free environment that does not incur the costs of undesirable consequences.

Serious Games can support interaction, reflection and learning from experiences through challenging game scenarios that are adapted to challenge and engage the user, and guide the user through a motivating learning experience, in a virtual environment. Experiential learning and reflection in Serious Games are illustrated in Figure 1, where the experiential learning cycle (Kolb, 1984) and the reflection model are merged (Boud, Keogh, & Walker, 1985). When a learner is playing a game, the player goes through a virtual experience, receiving feedback on her actions, where she is able to reflect-in-action and actively experiment in the game by selecting different options and choices. Environments that promote interpersonal interaction may result in greater reflection (Bandura, 1977). We believe that this statement suits to virtual environments too. After playing the game, the player received feedback on her performance, she could revisit the game play and reflect-on-actions during the game play. When she (the project manager) is at work, she has the possibility to conceptualise what she has experienced in the game, possibly discuss with colleagues, thus supporting individual and social learning with her colleagues. Articulation of experience plays an important role in developing project management competencies (Berggren and Söderlund, 2008). Social interaction enhances motivation and prolongs engagement. Engaging in social interaction brings forth different ideas that could be shared and perhaps result in deeper thinking and reflection about the experiences (Wenger, Trayner, & de Laat, 2011). The prompt, interactive nature of serious games allows the player to receive instant feedback on her choices of actions. Feedback on the player's performance can also be provided at the end of each session of the game or during game play. Timely interaction and feedback and responses from the game environment can lead the player to reflect on what she does – reflect on how the interaction progresses as well as her choices of action, while the interaction / play goes on.

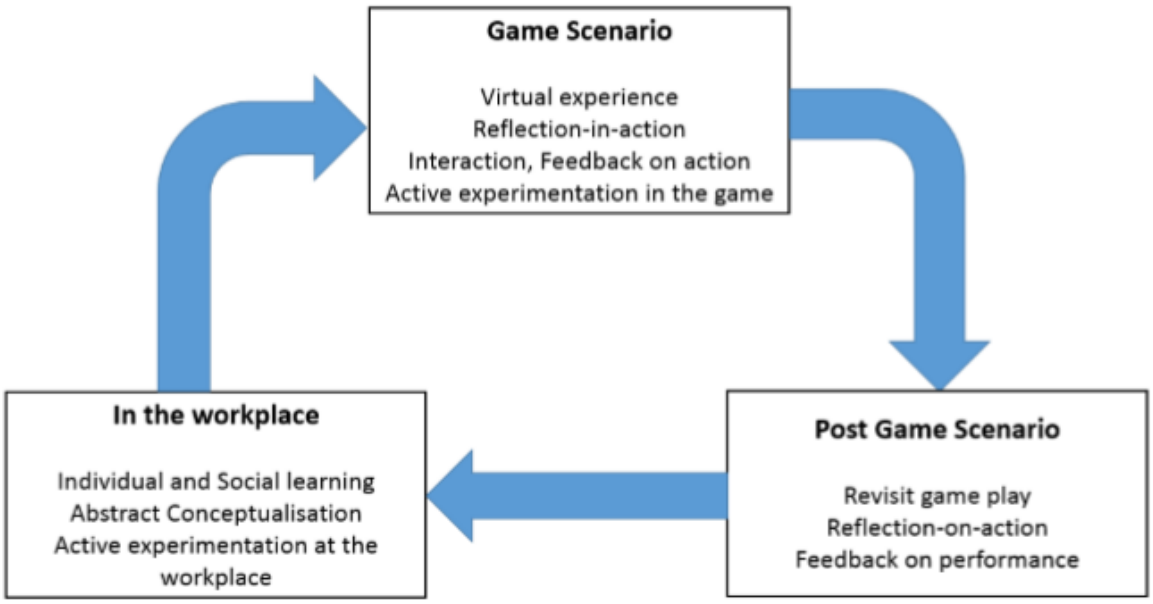

Figure 1 Experiential learning and reflection in Serious Games (Petersen & Ekambaram, 2016)

This can be seen as, what Schön calls reflection-in-action (Schön, 1983). Furthermore, Schön says that, "Reflection-in-action necessarily involves experiment". Experimenting can be seen as a source or instance of learning. This experimenting is done in a safe and interactive manner in serious games. Schön also describes another concept called "reflection-on-action". When the player plays the game one more time, then the player would reflect on what he/she did in the previous playing session(s), and accordingly take actions (modified choices of action) in order to obtain better results this time. Reflection-in-action and reflection-on-action are acts that contribute to making sense of the situation, which can in turn facilitate better stakeholder management. Furthermore, interaction, feedback, reflection, and the possibility for the player to play the game several times can also be looked at in connection with creating more learning experience for the player in a comparatively shorter period of time, and thus facilitating rapid competence development. Careful design of tasks, the problem space for the player and the feedback and timing of the feedback can provide the right balance between the working memory and the cognitive load for the learner (Boyle, Ramsay, Terras, & Boyle, 2016). An example of a serious game supporting competence development for stakeholder management in a construction project was developed in the EU project TARGET (Oliveira et al., 2013) and (Bedek, Petersen, & Heikura, 2011).

Games and virtual environments support contextualised learning, which enhances the understanding of the bigger picture and supports the development of perceptual skills, which is of utmost importance in stakeholder management. The learning context enriches the player's learning of core knowledge elements that are situated in / integrated into the operational context. The context can be considered as the situation in which the competence is applied, which includes the people that are involved in the situation, perhaps their personal qualities, workloads and competences, the organisational culture or the country in which the situation takes place. Understanding the context in which the knowledge is applied is very important in stakeholder management. In addition, playing the game several times allows the player to go through different alternatives of the context or the situations in which a competence may be applied, and hence, it provides the player various instances of learning. Even to make wrong managerial decisions (in a safe learning environment such as serious games) and understand the consequences of them is an effective way to obtain valuable knowledge.

Serious games provide a safe environment to learn from mistakes and for experimentation; learn from making wrong decisions. Unlike in the real world, there will be no damage or cost due to any wrong decisions that are made in serious games. Mistakes provide opportunities to learn from. In a video published on BBC's website, the CEO of Lego, a Danish toy company, (Knudstorp, 2012) says: "The ultimate survival technique is experimentation. When you experiment, you have also said that you are willing to fail. Failure is best way to learn."

Serious games can provide a broader / systemic understanding. According to systems thinking, the focus will be not only on elements that constitute a system, but also on how the elements are interconnected and interact with each other (Senge, 1990). Serous games provide a broader understanding of stakeholder management by presenting consequences of alternative ways of managing stakeholders and allowing the player to try the stakeholder management process several times with various alternatives, in different contexts.

Game scenarios and characters in the game that reflect the real world will enable a near-transfer of knowledge. To summarise, the following aspects can be seen as some of the key contributions of serious

games to competence development: (1) Practice interactions with stakeholders (2) Learning in context (3) Timely feedback (4) An opportunity to learn from mistakes without risks.

7. Concluding Remarks

In this paper, we have discussed serious games as an effective means of competence development for project managers, and in particular, stakeholder management in construction projects. We have discussed the relevance of the context in which a competence is applied to determine the ability of a project manager to apply the competence appropriately. We have presented a detailed analysis of the technical and soft skills that encompass the diverse and complex competences involved in stakeholder management, using the OKEI competence modelling framework.

Stakeholder management in construction projects involves several stakeholders ranging from the direct stakeholders such as the owner of the project and the contractor, the community and the context in which the project operates in and perhaps the national and local governments. The influences and expectations of the stakeholders vary during the lifecycle of the project. The project manager has a demanding role that requires a combination of skills to ensure that all stakeholders are satisfied both during and after the project's lifecycle. This requires experience to be able to recognise and analyse the different situations, the ability to communicate, build trust and skilful interactions with a wide variety of stakeholders in complex and demanding contexts. Current means of developing such competences rapidly are limited. Hence, this paper analyses the contributions of serious games to develop the competences for projects managers in stakeholder management.

Serious games provide a virtual environment where project managers could explore and experiment relevant scenarios and practice different skills in a safe and risk-free environment. It is cheaper and safer to make mistakes and learn from one's mistakes in a virtual environment than in the real world. Aspects such as prompt responses, timely feedback on the player's performance at the end of each game-session and the possibility to play the game several times can lead to rapid competence development through experimenting, reflecting, making trial and error and sense-making.

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What are the practical tools for planning and managing time in projects? – A study in Norwegian organizations

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Abstract

Delivering projects on time is a significant challenge in the project world. The time component – as it is closely connected with other components of projects, for example, cost – has a huge impact on both the execution and success of projects. It is also widely known that several projects fail – including, in terms of delivery in time. In order to make sure the effectiveness and success of projects, better time management practices are necessary. Identifying better practices requires a study on current practices as a first step.

The main purpose of this paper is to contribute to the improvement of time management in projects by presenting a study on the current situation and practices regarding time management in projects, and suggesting possibilities for improvement. The paper will look at project-based organizations in Norway. This paper is connected to a research and development project called "SpeedUp".

This paper will first describe a summary of current practices in the organizations (AS-IS study). In this regard, it will provide an overall framework, tools and methods, roles and responsibilities, competence development initiatives and aspects that facilitate effective time planning and management. Secondly, a model for planning and managing time (including a link to a list of "best practices") will be presented. The results from the AS-IS study can be considered as a base for deriving suggestions and devising initiatives for improving time management in projects. One such initiatives is to develop this model for time management in projects. In addition, this paper will present a discussion on competence development that can support sharing and utilization of "best practices".

Implication of this paper can be described as follows: The model and the tools correspond to some of the important issues that the results of the AS-IS study point out. The model and the tools can be seen as readily applicable practical results. This paper is based on both qualitative and quantitative studies.

Keywords: Time planning and management, Project, Tools, Productivity, Competence

1. Introduction

One of the challenges that project-based organizations face is ineffective use of time. Delays and unnecessary use of time are not uncommon in projects, and they cost much. Studies on time planning and management in construction projects (e.g. Zidane et al., 2015; Eik-Andresen et al., 2016) describe the nature of non-value-adding time-usage in large projects, and suggest that there is a need to address this problem. This is the major motive for engaging in the topic of time planning and management, and finding out means to improve the situation.

The purpose of this paper to contribute to the improvement of time management in projects. This paper aims to accomplish this purpose by presenting (1) a study on the current situation and practices regarding managing time in projects and (2) a model for planning and managing time, along with a link to "best practices" (3) a discussion on competence development that can support sharing and utilization of "best practices". The paper will look at project-based organizations in Norway. This paper is connected to a research and development project called "SpeedUp". The project is classified under the category of "User-driven Research based Innovation".

This paper will first describe a summary of current practices in the organizations (AS-IS study). In this regard, it will provide an overall framework, tools and methods, roles and responsibilities, competence development initiatives and aspects that facilitate effective time planning and management. And then, a model for planning and managing time will be presented. This model can be seen as a result of the AS-IS study. This model has a list of practical tools ("best practices") that correspond to each component of the model. These tools are currently used in organizations that are involved in the study on which this paper is based.

The structure of this paper is as follows: After the introduction, this paper will provide background information regarding the project that this paper is based on. Then, relevant concepts will be presented. In this regard, productivity and competence development will be described, and will be followed by a description of research methods. This paper is based on both qualitative and quantitative studies. The results will then be presented. Some observation and general reflection followed by concluding remarks will finally complete this paper.

2. Background information: The point of departure

This paper is connected to a research project called "SpeedUp" (http://www.prosjektnorge.no/index.php?pageId=635). This research project is funded primarily by the Research Council of Norway.

The objective of the project "SpeedUp" is to support and enable participating organizations to reduce execution time in their projects with 30-50%. The participants of the project believe that this is possible to achieve, based on their own experiences. Furthermore, recent research studies show that productivity in the building and construction sector have had a negative development in the last 10 years (see for example, Parliament-report: St.mld. 28, 2011-2012). Speed Up will develop and test strategic, tactical and operational concepts that can improve the total timeusage on projects together with its industrial partners.

The current budget of the SpeedUp project is approximately 48 mill. NOK (approximately 4.8 mill. EURO). The project is classified under the category of "User-driven Research based Innovation".

There are 9 industrial partners (both from the public and private sectors) and 5 academic partners who are involved in this project.

3. Relevant concepts

Here, we will present some key concepts that are related to time management in projects. These concepts can be categorized as (1) productivity and (2) competence development.

3.1 Productivity

Productivity is about the relationship between input and output of a system. It is defined in several ways. A general definition can thus be described in a ratio-form: Output/input (Andersen, 1995).

A recent McKinsey report (Barbosa et al., 2017) says that the construction industry remarkably poor productivity compare to other industries. According to this study, "global laborproductivity growth in construction has averaged only 1 percent a year over the past two decades (and was flat in most advanced economies). Contrasted with growth of 2.8 percent in the world economy and 3.6 percent in manufacturing, this clearly indicates that the construction sector is underperforming" (ibid).

Time management contributes to determine the degree of productivity – that is for instance, planning and managing time (including resources associated with the time) in order to produce a desired output. How smart the time (and associated resources) can be used to produce an output productively is hence the central focus. There are several tools and approaches of time management that are applied in project settings to obtain productivity. Since this paper is about practical tools for time management, it is relevant to look at few traditional tools and methods:

- Productivity in terms of time planning can be seen historically from Gantt chart. Gantt Chart was developed by Henry Gantt. This is one of the most used, common project management tools (White & Fortune, 2002). Several authors (Field & Keller (1998), Meredith & Mantel (1995) and Nicholas (1990)) point out that Gantt chart was developed by Henry Gantt in the First World War (Wilson, 2003). Gantt's work can be seen in the context of Frederick Taylor's Scientific Management movement. Before Gantt, Karol Adamiecki (1866-1933) developed a method for work harmonizing that was based on a graphical analysis. The graphic diagrams used in this method has been known as "Harmonograms" (Urwick, 1963; Marsh, 1975).
- Program Evaluation and Review Technique (PERT) and Critical path method (CPM) are other methods that were developed later and have been applied in managing time in projects. The main difference between PERT and CPM is that PERT operates with stochastic durations, while CPM operates with deterministic durations (Rolstadås et al., 2014).
- Goldratt (1997) developed a method called "Critical chain project management (CCPM) in 1997. This method was based on the management paradigm "Theory of constraints (TOC)". TOC assumes that a few constraints would restrict any manageable system (a unit of organization; for example, a project) to accomplish its goals. Eliminating constrains will contribute to reduce the time usage in projects.

These tools and methods are integrated into the modern practical time planning tools at least to a certain extent.

3.2 Competence development

Acquiring or updating knowledge of time management and time management tools requires focus on competence development. In this paper, we take into consideration a systemic lessons learned knowledge (Syllk) model that was refined by Duffield & Whitty (2015). See Figure 1.

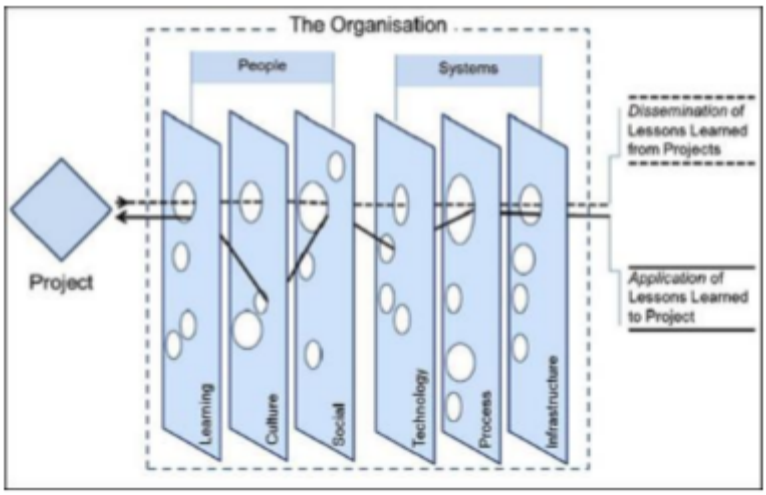

Figure 1: Refined Syllk model (Duffield & Whitty, 2015, page 318)

This model presents a set of organizational elements that affect both application and dissemination of knowledge (lessons learned practices). The elements are: Learning, culture, social, technology, process, and infrastructure. The authors categorize the first three elements as people and the last three elements as systems.

One can distinguish between a systems (or hard) and a people (or soft) approach to knowledge sharing and competence development. The systems approach typically focuses on knowledgeas-data. A common approach is to create knowledge repositories of knowledge items.

Knowledge repositories are electronic databases that are created for access by users. The databases can be filled through collecting and registering knowledge and valuable experiences.

The people approach focuses on human interaction, communication, reflection, sense-making (knowledge-as-meaning), and practice based issues (knowledge-as-practice). This approach includes, among other things, communities of practice (CoP), storytelling and ad-hoc experience transfer (around the watercooler or coffee machine, etc.).

It is to be noted that describing knowledge as data, meaning and practice is a categorization that is made by Spender (2008). This categorization can guide to develop and structure initiatives for competence development.

4. Research methods

The study on which this paper is build incorporates both qualitative methods (interviews, and document analysis) as well as quantitative methods (questionnaire survey).

For instance, when it comes to mapping the current practice (AS-IS study), both interviews and questionnaires were applied. Interviews were conducted with representatives from 9 collaborating companies with a help of a semi-structured interview guide. Each interview lasted 1-2 hours. In total, 13 project managers participated in the interviews. Most of the interviews were conducted on an individual basis. However 2 interviews were group interviews. The questionnaire contained 19 closed questions. These questions were first tested out before sending online to the potential respondents. This testing process can be viewed as a way of making sure the validity of the study. Total number of persons from the collaborating companies who got the questionnaire is 142, and 86 of them answered. Hence, the response rate is 61%.

Using multiple methods to study a single problem or program, such as interviews, observations, questionnaires and documents is called as methodological triangulation (Denzin, 1978; Patton, 1987). Since this paper is based on a study that utilizes different methods – both qualitative and quantitative methods – to look at the research problem, it deals with methodological triangulation.

5. Results, analysis and discussion

5.1 A short summary and reflection of the interview-results (AS-IS)

The results touch upon overall framework, tools, roles and competence development (course, training, etc.) regarding time management in project based organizations.

When it comes to overall framework, the qualitative study shows that most of the organizations mainly use their own project model or quality systems as their framework to manage time in projects. These models focus on issues such as efficiency and decision making. Tools that the organizations use in time management also varies; some organizations apply standard project management tools such as Microsoft Project, and others develop their own tools for their usage. In some organizations (OPAK), the tools were used comprehensively not by project managers, but by project planners or those who assist project managers in the planning process; project managers tend to have only an overall view of time usage in projects. In Statsbygg, speciallyassigned time planners work in large projects, whereas, project managers manage time in smaller projects. In Jernbaneverket, there is a person who is designated to have the responsibility of the toolset – a kind of an advisory position – and gives guidance to the line organization. Organizational roles that are connected to managing time in projects are defined or influenced by contracts and cooperative modes between the involved actors in a project. Statens vegvesen and BundeBygg are examples in this regard.

In addition to using tools, some of the collaborating organizations apply processes, for instance uncertainty analysis processes, experience transfer processes and work processes (regular meetings, etc.) to manage time. This indicates that time management in projects is of both formal and informal nature. Furthermore, this also suggests the importance of considering both the people-factor (culture,

learning and social aspects) and systems-factor (tools and techniques) in managing time in projects (see Figure 1).

Both internal and external training programs / courses are mentioned by the collaborating organizations as their main approach to develop competence in project management in general, and time management in projects in particular. In addition, informal experience transfer as well as utilizing formal systems such as documents and project evaluation reports are considered as sources of gaining knowledge in time management. If we consider Spender's (2008) categorization of knowledge that was mentioned earlier, then this knowledge can primarily be considered as knowledge-as-data. The informal nature of experience transfer suggests that there is a positive organizational culture that promotes openness and willingness to share knowledge and thus contribute to develop competence (of, for example a novice project manager). This informal nature tends to facilitate sharing knowledge in the form of knowledge-as-meaning and knowledge-as-practice.

This paper will first describe a summary of current practices in the organizations. In this regard, it will provide an overall framework, tools and methods, roles and responsibilities, and competence development initiatives.

5.2 A short summary and reflection of the survey-results (AS-IS)

This section of the paper is based on a master thesis (Hoseini, 2015) connected to the "SpeedUp" project, in which two of the authors of this paper were heavily involved. Respondents' work experience connected to their current position varies. A notable portion of them (49%) have 1-5 years of experience. The study shows that time planning takes place internally (48%), and as an internal and external combination (46%), it is of less extent when it comes to conducting time planning externally (6%).

When it comes to acquiring knowledge and competence in time planning, the following aspects were mentioned as most commonly used (in descending order):

- Talking to colleagues
- Read documents, reports, etc.

This result suggest that people-factors and system-factors (see Figure 1) have a considerable influence on knowledge sharing and competence development. Furthermore, external courses (42%) and internal courses (51%) are considered by the respondents as sources of knowledge.

When it comes to tools that the collaborating organizations use in time planning, the following tools were mentioned as being frequently used:

- Microsoft Project (81 %),
- Microsoft Excel (38 %),
- Primevera (25 %)
- Safran (2%).

When it comes to the frequency of using time planning tools, 32% of the respondents use the tools at least once per month, while 27% of the respondents use the tools minimum once in a week. There can be several reasons for using the tools. According to Figure 2 the most important reasons are user-friendliness (25%), company policy (20%) and request from customer / client organization.

Figure 2: Reasons for using time planning tools

The tools are aimed at carrying out various tasks in time planning. The most common tasks mentioned by the respondents in this regard are: Project control (29%), Updating time plan (28%) and detailed planning (27%).

The study also looks at the connection between time planning and delays in projects. Most of the respondents (82%) are agree or partly agree that poor planning lead to delays. When it comes to the extent of delays, 50% of the respondents say that poor planning leads to 1-6 months delay, 26% of the respondents estimate 2 weeks to 1 month delay, and 19% of the respondents mention more than 6 month delay.

Delays in projects can be avoided or reduced by the help of time planning tools in different ways. The respondents mention the following 3 major roles of the tools in avoiding or reducing delays: (It warns when project has a delay (2) By better managing activities and resources (3) It helps better communication.

The study looks at what the enablers of better time planning are. Figure 3 shows the results.

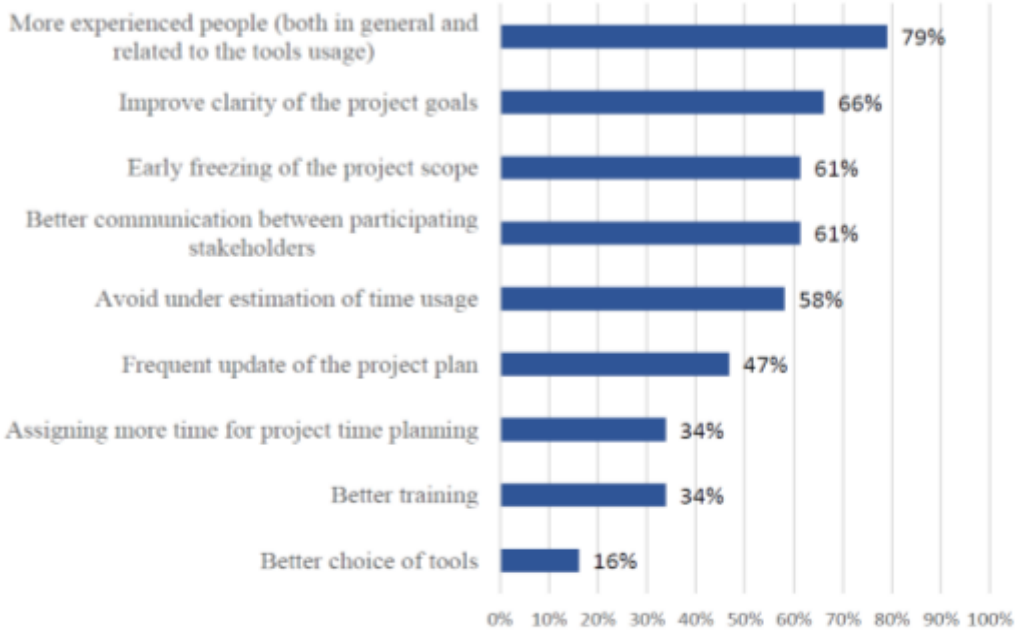

Figure 3: The enablers

In Figure 3, we see that more experienced people is considered as the most influential enablers of better time management. This shows that there is a need to focus on competence development. This does not mean that the already experienced person should do the task all the time. This experienced person can be accompanied by a novice and share knowledge and experience with the novice. In terms of Spender's (2008) knowledge categorization, this situation suggests sharing / acquiring knowledge-as-practice.

5.3 Tools that are currently used in Norwegian project-based organizations

We have seen the AS-IS situation of the collaborating organizations when it comes to their time management practices. In this regard, among other things, the following aspects are described:

- Variety of tools and framework that are used
- Motivation for using the tools
- The importance of having competence and experience in time management, specifically the usage of tools that support time management

These results from the AS-IS study can be considered as a base for deriving suggestions and devising initiatives for improving time management in projects. One such initiatives that was carried out by the "SpeedUp" project is to develop a model / framework for time management in projects (Figure 4), and use this model as a means to gather time management tools that the collaborating organizations use (based on positive experiences of the usage), and present them at the webpage of "SpeedUp" project. This collection of tools, presented in a structured manner, can help others to make use of the tools and improve their time management competence. In this regard, this model can be viewed as both an integral part as well as a concrete result/ contribution of the study that this paper is based on.

Figure 4: A model for time management in projects

This model was developed through discussion between researchers and representatives from the collaborating organizations, and through collective reflection. This process itself is a learning process where people-elements and system-elements (see Figure 1) were involved.

The model starts with focusing on the frame conditions that guide the time planning / management process. This is followed by planning time management and then time planning. The former can be seen as, in a way, planning of the planning of time. The latter is the actual time planning with respect to the project. When a time plan is developed, then it is anchored and presented to relevant actors. As activities according to the plan are unfold, progression is checked and evaluated, and reported. Evaluation and reporting go on continuously. As a part of the output from the progress reporting, revision can be done in order to change time planning. If there is a need to carry out uncertainty on time plan, then it will be done between time planning and evaluating progression. Finally, experience gained from the whole process are captured and shared.

This model functions as a guiding framework for planning managing time in projects. Furthermore, the SpeedUp-team of researchers and representatives from the collaborating organizations gathered relevant tools related to each part of the model from the collaborating organizations and published them on the SpeedUp project's webpage:http://www.prosjektnorge.no/index.php?pageId=830. The tools are presented with their particular purpose, tips and experience of using them and the source of the tools (that is, the organization that developed / use the tool). These tools can be used by anyone who are interested in.

5.4 Some observation and general reflection

The model and the tools were presented and illustrated at a forum arranged by the "SpeedUp" project in August 2016 in Oslo, Norway. Representatives from all the collaborating organizations and researchers participated in the forum. The presentation and the illustration of the tools can be seen as a way of sharing existing knowledge ("best practices") with others. In this regard, Figure 1 presented earlier in this paper can be considered. The forum acted as an arena for knowledge sharing and social

interactions. It provided a conducive setting to discuss issues openly, share knowledge and enhance the collaborative spirit between the participants. This setting can play a pivotal role in developing or strengthening a positive culture for learning and knowledge sharing. As the people-factors depicted in Figure 1 are at place, the systemsfactors such as technology, process and infrastructure are also covered; availability of the model and the tools with relevant information for applying the tools at an open access website contributes to address the systems-factors.

Results from both the interview and questionnaire studies also point out that taking to colleagues and reed reports and documents are main means to learn more about time management techniques and tools. Information provided with the model and the set of tools published at the website would help potential users to contact the respective organizations (that have positive experience in developing/ using the tools and hence gained productivity gains) to get more detailed information, if needed. The collaborative atmosphere developed in the "SpeedUp" project would make the communication between collaborating partners smoother and more effective.

Furthermore, sharing of tools does not necessarily jeopardize competitiveness of an organization that shares its tools with others. A major determining element of competitiveness here is how the tools are actually used. In addition, sharing of tools that enhance time management in projects can also contribute to establish a common pool of known tools. Since many of the industrial partners of "SpeedUp" cooperate among themselves in their (inter-organizational) projects, establishing a common pool of known tools would contribute to improve their common understanding and cooperation in their inter-organizational projects.

6. Concluding remarks

In this paper, we presented firstly an AS-IS study of time management in projects (with a special focus on tools for managing time in projects), and secondly a model for planning and managing time in projects. The results from the AS-IS study can be considered as a base for deriving suggestions and devising initiatives for improving time management in projects, and hence the development of the model. The model includes a list of practical tools (including "best practices") that correspond to each component of the model. We also presented a discussion on competence development that can support sharing and utilization of "best practices".

The model and the tools correspond to some of the important issues that the results of the AS-IS study point out. The model and the tools can be seen as readily applicable practical results that revolve around two main theoretical focus-areas, namely, productivity and competence development.

Further study can include, among other things, measuring the effect of the usage of the tools (both in organizations that already using the tools and in organizations that choose to use the tools). In addition, it can also include evaluation of the process of knowledge sharing and learning regarding the new tools.

Furthermore, the gathered knowledge on the current situation of time management in projects can be assessed in order to identify the maturity of the organizations in time management. This identification at an early stage will be necessary when organizations plan to implement initiatives for improvement in time management. Maturity in time management after the implementation can then be determined

and compared to the initial maturity level. This paper is based on both qualitative and quantitative studies.

There are other research initiatives that are directly connected to time management in projects (for example, a Dutch initiative called "Halftime") and that are indirectly connected to time management (for example, Norwegian initiatives called "OSCAR" and "Involverende planlegging"). A comparison of some common areas / research topics also a possibility for a future study.

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Norwegian contractors' professional ethics and outward ethical credibility – the case of ethical framework

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Abstract

The construction industry is recognised as an important contributor to national economies, typically accounting for 15-16 percent of total annual economic activity. Illegal activities, corruption and unethical behaviour exist within the construction industry. In order to increase the understanding of how legitimate organisations seek to distance themselves from associations to unethical behaviour. Ethical frameworks are summaries of a company's core values and principles as well as a guideline for wanted behaviour. The literature states the importance for organizations to adopt such codes for raising ethical ethos internally, as well as for making an outward statement regarding the company's level of legitimacy.

This paper addresses the following research questions;
1. To which extent do ethical frameworks exist among Norwegian Contractors?
2. What characteristics do the ethical frameworks have?

This study examines the 50 largest contractors in Norway. The data was collected through examination of the contractor's web pages and relevant content available. We also contacted the contractors without an ethical framework publically available. We differentiated between contractors mentioning ethics on their website, those who had published a formal document and those who had both. The findings show that only 19 out of 50 contractors have a publically released ethical framework. This indicates a gap between a needed ethical embeddedness within the industry and the current state. Further, only 13 ethical frameworks managed to clarify the fuzzy line between ethical and unethical behaviour. Ethical frameworks that do not distinguish between ethical and unethical behaviour should not use the word "ethical" or other variations of it. The study examines outward professionalism and ethical ethos for the largest contractors. For the construction industry to develop, it must strive to close the gap between just operating legally, and operating both legally and ethically. Thus, this study contributes to a limited pool of research conducted on ethics in the construction industry. The study does not look at whether ethical framework are implemented as a decision-making tool; it highlights the aspect of providing such tool.

Keywords: Business ethic; Construction Industry; ethical framework; crime; Norway

1. Introduction

The construction sector is a locomotive driving economic growth both on a national and international level. According to Myers (2008), typically accounting for 15-16 percent of total annual economic activity. The sector has been, and still is, a backbone for societies striving for development (Crosthwaite, 2000). Despite the industry's vital role in contributing to a well-functioning society, the industry has experienced cases of corruption, social dumping and collusive tendering among others (Kenny, 2009, Krishnan, 2009). This is backed by statistics from Transparency International, which ranks the construction industry as the most vulnerable sector for corruption among 19 different sectors (Transparency International, 2011). Kenny (2009) outlines the fact that construction involves complex, non-standard activities, in which quality can be hard to assess, as one of the key reasons for this vulnerability. He also mentions the comprehensive net of stakeholders and actors, i.e., clients, consultants, financiers, contractors, suppliers, subcontractors, sub-suppliers, producers, insurers etc., as a contributing cause. Corruption may in fact occur in any phase of a construction project (Tabish and Jha, 2012). A recent study of counterfeited materials within the Norwegian AEC-industry indicated that such practice occurred, but nobody was talking about it (Engebø et al., 2016). Ethics represents a branch of project management research that receives little attention (Walker, 2014). The PM discipline should maintain a strong and enduring interest in ethics and encourage project managers to deliver value in a more holistically manner consistent with being a member of a profession (Walker, 2014).

The term ethics describe what we should do, and what we actually do, when faced with moral dilemmas (Sohail and Cavill, 2008). With ethical behaviour we understand the obligations, duties and responsibilities linked with principles, attitudes and type of character that are binding for people (Charles and Skitmore, 2003). With the terms "ethics" and "morals" having the same etymological root, we, in the following, use them interchangeably. This paper does not seek to dive deep into the fundamental principles of moral and ethical theories, as this falls outside our scope. Rather, we assess representations of acknowledged ethical behaviour in a professional context.

Factors such as increased public sensitivity towards corporate behaviour and negative media headlines raise the importance of ethics and serve as drivers for corporations to establish ethical standards (Chun et al., 2013). In the light of this, the following research questions are addressed in this paper:

1. To which extent do ethical frameworks exist among Norwegian Contractors? 2. What characteristics do the ethical frameworks have?

This study provides a foundation for further research by exploring whether ethical frameworks exist within the industry and what main characteristics that applies for the ethical frameworks.

2. Methodology

The main objective of the data collection was to provide reliable and valid data in order to answer the initial research questions. The data was collected through an examination of the contractors' official web pages, and from an analysis of formal documents addressing corporate ethics. Cases where information regarding the corporation's ethical framework was not available was considered a valid finding in regards to the corporation's outward appearance.

Initially, we searched on the web for information regarding ethics related to the specific companies. This approach did not, however, take into account that some corporations keep their ethical framework for internal use only. To address this, we contacted the contractors without an ethical framework publically available on the web. We differentiated between contractors mentioning ethics on their website, those who had published a formal document and those who had both. All corporations without a prospective ethical framework displayed on their websites were emailed a request in regards to whether they: (1) Have an ethical framework; and (2) If yes, it could be made available for the research project

The examined contractors were the 50 largest contractors in Norway, based on their 2015 revenues as listed by the magazine Byggeindustrien (Byggeindustrien, 2015). The largest contractor had a yearly revenue of 24225 million Norwegian kroner (MNOK) and number 50 had a yearly revenue of 553 MNOK, see figure 2. We experienced clearly that the frequency of contractors that announced their ethical frameworks on their web-pages decreased rapidly when advancing down the list. A sampling size of the 50 largest contractors was therefore considered as sufficient.

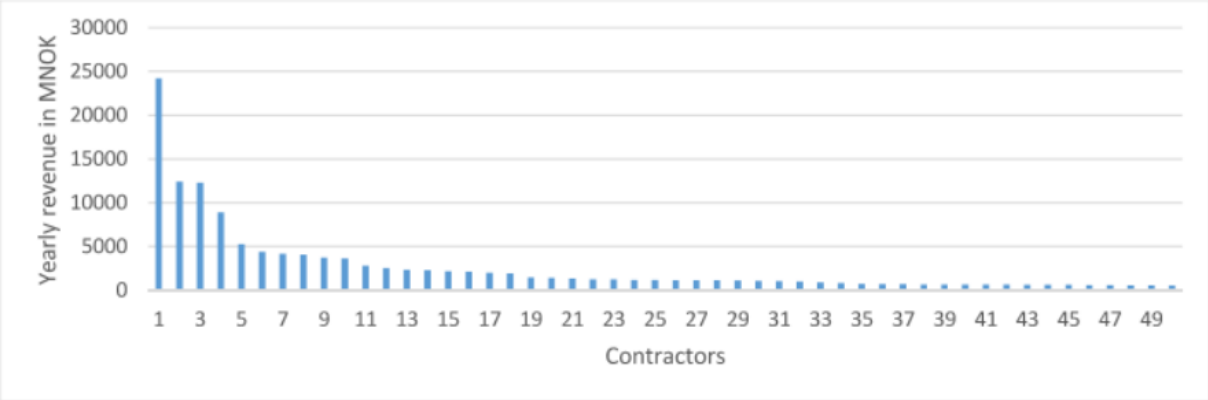

Figure 2: The yearly revenue of the 50 largest Contractors in Norway

Table 1 was adopted to analyse the content of the ethical frameworks. The answers to the questions used for analysis were categorized in a database. This database was constructed to support further collection of ethical frameworks from actors within the Norwegian AEC-industry. The final matrix, consisting of data from the 50 contractors, was analysed to compute a result showing: contractors addressing ethics publically on their webpages; the number of words of the ethical statement; contractors having an official document addressing ethics; contractors distinguishing between legal and illegal behaviour; and the contractors distinguishing between ethical and unethical behaviour.

Questions	Outcome
Is ethics addressed on their web page?	Yes / No
The extensiveness of the webpage concerning ethics	Number of words
Does the contractor have a formal ethical framework?	Yes / No
The extensiveness of the document (number of words)	Number of words
Is the document publicly available?	Yes / No
Does the contractor distinguish between legal / illegal?	Yes / No
Does the contractor distinguish between ethical / unethical?	Yes / No

Table 1: Questions used for content analysis

The analysis adopted a qualitative approach to understand the content of the ethical frameworks examined. Figure 1 illustrates different types of behaviour. This study concentrates on behaviour categorized as unethical, but lawful. This is where employees operate within the law, but in an area perceived as unethical. In the view of the authors of this papers, the purpose of an ethical framework should be to clarify the line between ethical and unethical behaviour.

The distinction between legal and illegal behaviour was addressed according to a line-by-line search for sentences describing how the employees in the corporation should comply with government law and legislations. The distinction between ethical and unethical behaviour are exposed to a subjective evaluation since ethics are not a static concept. In order to be assess whether the content distinguished between ethical and unethical behaviour, the framework had to explicitly state 1) that there is a fuzzy line between what is ethical and unethical and 2) that the employees should stay away from unethical – even if it is legal – behaviour.

An example of a practical nature from ethical frameworks distinguishing between ethical and unethical (that is, how they do it), is the ones who mention the newspaper-test. A champion of the newspaper test is the famous investor Warren Buffet; "if an article appeared in a local newspaper about a decision and action you made, and your family and friends read the article, would you feel good about it?" (Cunningham;, 2015). Ethical framework could distinguish between ethical and unethical behaviour in a manner that is concrete and practical.

This study has some essential limitations. It is limited to an examination of the 50 largest contractors operating in Norway. Thus, the result might not be generalizable to smaller contractors or other actors in the industry. On a methodological level, the study is limited to an analysis of the collected ethical frameworks. The fact that ethics are not addressed on the corporation's web site or that ethical framework was not possible to collect for this study does not necessarily imply that the corporation does not pay heed to ethical issues. A content analysis of ethical frameworks determines, among others, the comprehensiveness and the extensiveness of the content, but it does not validate whether the content is practiced (Kaptein, 2013). Another important limitation is that this study does not look at the correlation between having an ethical framework and whether the organisation enacts ethically. The study does not try to connect content from the ethical frameworks to fundamental ethical theorems. The analysis does not provide an in-depth analysis of how corporations view ethics; what they associate it with; or whether words or phrases collocate in the texts.

3. Theoretical framework

Corporate ethics as a phenomenon has existed for decades. According to Ingason and Jonasson (2013), ethical guidelines are derived from experiences and observations of the long term wider consequences of actions. Ethics is a field, which is constantly evolving. The process is driven by advancement in technology and by a "collective growth in wisdom" driven by information emerging from negative events over time (Ingason and Jonasson, 2013). Ingason and Jonasson (2013) states that ethical issues surface in all projects, specifically related to managerial methods, logistics, strategy, planning and execution in the project as well as at an organisational level. Ethical issues could as well be an aspect in the assessment of sustainability of construction projects. According to Haavaldsen et al. (2014), sustainability should be assessed on an operational-, tactical- and strategic level. Haavaldsen et al. (2014) uses the example of constructing a landmine factory, which could be sustainably (and ethical) on an operational level, but unsustainable (and unethical) on a tactical and strategic level.

The aim of ethical frameworks is to clarify the fuzzy line (see figure 1) between what behaviour the corporation regards as ethical and what is not. By clarify the fuzzy line, the ethical framework contributes to mitigating the chance of employees operating in the zone "lawful, but unethical" (Marked in figure 1.).

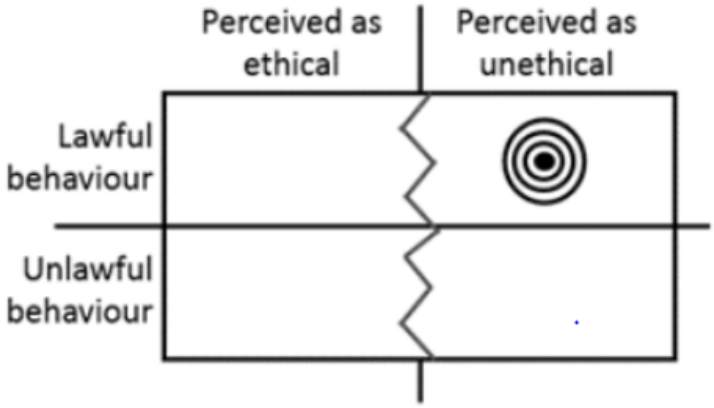

Figure 1 Extension of the law and ethical behaviour (Lohne et al., 2017)

In today's business, it is normal for corporations to have sets of formal documents addressing different aspects, such as (management) rules, behaviour etc. Such documents are often referred to as "business codes". Kaptein and Schwartz (2008) maintain that a business code is a distinct and formal document containing a set of prescriptions developed by and for a company to guide present and future behaviour on multiple issues of at least its managers and employees toward one another, the company, external stakeholders and/or society in general.

The understanding of business codes according to Kaptein and Schwartz is that they serve as a guideline on acceptable behaviour for both managers and employees in general. In this sense, business codes do not need to specifically address ethics, moral or even lawful behaviour. Further, Kaptein and Schwartz (2008) discuss the use of the adjective "ethics", which they believe is superfluous in regards to corporate codes. By not using "ethics", the task of determining whether the codes are deployed to serve only the firm's interests, or also others interests, is avoided (Kaptein and Schwartz, 2008). Caza et al. (2004) connects ethos and virtuousness as a positive deviance of ethical integrity, while dishonesty is

illustrated as the negative deviance of ethical integrity. The normal stance of ethical integrity is to be ethical and dutiful (live by the current ethical and juridical laws and norms). Further, they define ethos as the internal values that characterize an individual. According to the view of the authors of this paper, corporate ethos might thus be described as the values that characterize the corporation.

The term "business codes" is very general, therefore, both corporations and academia apply terms such as "codes of ethics" and "codes of conduct" for documents addressing ethical and moral behaviour. Brooks (1989) defines a code of ethics as a statement of the corporation's values and principles that serves as a theoretical foundation for decision-making. A corporate code of ethics is a formal document which states the moral standards of the corporation (Schwartz, 2005). Further, Schwartz (2005) maps three essential elements that such codes should possess in order to build what he refers to as ethical validity: firstly, participation by employees in the developing process, secondly, coherence with general ethical principles, and third coherence with lived commitments of the corporations employees. While both code of conduct and code of ethics are sometimes used interchangeably, they are, by definition, different. A code of ethics is a statement of the corporation's values and principles that serves as a theoretical foundation for decision-making. A code of conduct is a specification of what the corporation expects from their employees. In his research, Erwin (2011) states that a code of conduct is a document with the purpose of communicating social responsibility and building corporate reputation. Ideally, codes of conduct affect the organizational culture by governing the actions and conduct of employees through the promotion of ethical business practices (Erwin, 2011). A third term used in the corporate ethics literature is "ethics program". Ethics programs can be defined as the formal organizational control system designed to create an ethical culture, to impede unethical behaviour and to promote ethical behaviour (Kaptein, 2009).

There is a vast pool of literature addressing ethics, ethics in business, ethics in organisations and corporate code of ethics. For example, Ho (2010) listed the following names used on codes of ethics; code of conduct, code of ethics, code of practice, credo, mission statement and value statement. This intricate web of different names contributes to confusion when the literature attaches unique definitions to each name. This has resulted in a lack of uniform terminology regarding which name should be attached to the codes. Kaptein and Schwartz (2008) state that the lack of agreement of terminology could be a potential pitfall in research related to corporate ethics because it leads to much confusion. Schwartz (2004) proposes a general definition of a code of ethics derived from numerous definitions in the literature, saying that three common components must be present. The first component is a moral standard that provides guidelines to the employees. The second component is a description of to whom the standard applies. The third component is the written, distinct and formal document itself.

The construction industry, as most industries, faces ethical challenges. Charles and Skitmore (2003) classified ethical impropriety in the construction industry into five main categories: collusive tendering, bribery, fraud, negligence, dishonesty and unfairness. Jackson (2005) lists the following ethical transgressions: alcohol or drug abuse, improper or questionable bidding practices, failure to protect public health, safety, or welfare, and poor quality control or quality of work. These are just some examples of ethical improprieties related to the industry. According to the authors, the main point is that the industry is vulnerable and that there is no standard classification of ethical impropriety.

In light of all the potential ethical improprieties that could affect the industry, some sort of understanding of why corporations need ethical frameworks emerges. Kang et al. (2004) summarize

the role of ethics to be the moral conscience that guides corporate activities. This correlates well with the definition of a code of ethics by Schwartz (2005). Several studies have tried to highlight the importance of corporate ethics. Brooks (Brooks) identified five factors driving the interest in corporate ethics. First, executives want to make sure that corporate behaviour is not left to chance (i.e. no loose cannons). Second, corporate activities could have negative effects on environment, health and safety. Third, society expects corporate behaviour to be accountable, which means negative behaviour can be penalized heavily. Fourth, corporations interact with different interest groups, such as ethically aware investor or customer groups.

The factors above outline why corporations need ethical frameworks and why such guidelines should specify acceptable ethical behaviour. According to Kaptein and Schwartz (2008), corporate ethical frameworks which do not address the distinction between ethical and unethical behaviour should not be using the word "ethical" or other variations of it. Ethical frameworks should outline the corporation's ethical standard and serve as a guideline for employees. Corporations that do not have a business code addressing ethics leave corporate behaviour to chance.

In one of his earlier works, Kaptein stated that a code should demonstrate a corporation's awareness of relevant and topical issues, organizational dilemmas and stakeholder expectation (Kaptein and Wempe, 1998). A study from 2004 collected and analysed the business codes of the, at that time, two hundred largest companies in the world. Within that segment, 52.5% had a business code (Kaptein, 2004). Further, the study identified three distinct clusters of codes: (1) Business principles, (2) Value statements and (3) Codes of conduct. A more recent study looked at the effectiveness of ethics programs (Kaptein, 2015). The study found that organizations that had an ethics program were confronted with less unethical behaviour than those without such a program. The author remarks that: "*For management, the question is not only whether to have an ethics program, but also what components to adopt (the study defines a set of 9 components), and which sequence to follow. This study has addressed these questions and has at least two positive messages. The first is that ethics programs can be effective and the second is that the ethics programs of many organizations in the U.S. are effective*" (Kaptein, 2015). This finding implicates that ethical frameworks have a practical value for corporations who commit to such a framework.

This paper will consequently refer to the term "ethical framework" when addressing codes that contain the three components proposed by Schwartz (2004). The benefit of using such a general definition is that it provides a uniform agreement of the topic. Consequently, this research does not categorize ethical frameworks in to categories, such as "code of ethics", "code of conduct" etc.

4. Results and discussion

The finding shows that 19 out of the 50 largest contractors in Norway present the corporation's ethical framework on their webpage. Four contractors did not mentioned this on their website, but had a formal document addressing ethical framework available online. The remaining 27 contractors were personally contacted by e-mail in regards to whether they did have an ethical framework of some sort. Of these, seven responded. The results are summarized in table 2.

Table 2: Contractors addressing ethics

	Addressed on their website.	Number of words (website)	Formal document	Public available	Number of words	Distinction between legal/illegal	Distinction between ethical/unethical.
C. 1	Yes	941	Yes	Yes	1734	Yes	Yes
C. 2	Yes	555	Yes	Yes	10516	Yes	Yes
C. 3	Yes	445	Yes	Yes	394	Yes	Yes
C. 4	Yes	142	Yes	Yes	1495	Yes	No
C. 5	Yes	239	Yes	Yes	100	Yes	No
C. 7	Yes	470	No	No	n/a	Yes	Yes
C. 8	Yes	267	No	No	n/a	Yes	Yes
C. 9	No	n/a	Yes	Yes	536	Yes	No
C. 10	No	n/a	Yes	No	200	Yes	No
C. 11	Yes	134	Yes	Yes	740	Yes	No
C. 12	Yes	104	No	No	n/a	Yes	No
C. 15	No	n/a	Yes	Yes	2250	Yes	No
C. 16	Yes	1545	Yes	Yes	1500	Yes	No
C. 17	No	n/a	Yes	No	2202	Yes	No
C. 18	No	n/a	Yes	No	394	Yes	Yes
C. 20	No	n/a	Yes	No	1124	Yes	No
C. 22	Yes	266	No	No	n/a	Yes	Yes
C. 23	Yes	990	n/a	No	n/a	Yes	Yes
C. 24	No	n/a	Yes	No	10516	Yes	Yes
C. 26	Yes	114	No	No	n/a	Yes	No
C. 28	No	n/a	Yes	No	1006	Yes	Yes
C. 29	No	n/a	Yes	No	1514	Yes	Yes
C. 31	Yes	36	No	No	n/a	Yes	No
C. 32	Yes	155	No	No	n/a	Yes	No
C. 38	Yes	53	No	No	n/a	Yes	Yes
C. 40	Yes	45	Yes	Yes	776	Yes	Yes
C. 42	Yes	1376	No	No	n/a	Yes	Yes
C. 45	Yes	1478	Yes	Yes	1478	Yes	Yes
Sum Yes (avg.)	19	(492)	18	11	(2138)	28	15
Sum No (Med.)	31	(266)	31	39	(1301)	0	13
Sum n/a	0		1	0		22	22

Regarding whether the contractors had a publicly available ethical framework, 11 had a publicly available documents while six had such a document, but it was not publicly available. An analysis was conducted on 28 ethical framework in form of either webpage-content or as formal documents. To address potential confusion, the 28 is the sum of the following: Contractors having addressed ethics on their website (19) plus those having a formal document (18) minus those who had both (9). The logic is that those having both are already counted for in either of the two previous categories. The analysis indicated that all of the ethical frameworks distinguished between legal and illegal activities, while only 15 distinguished between ethical and unethical behaviour according to the principles outlined by Schwartz (2005).

The findings showed that unison adoption of terminology regarding corporate ethics within the contractor segment existed no. Terms such as 'ethical guidelines, code of conduct, ethics, business ethics, among other variations, were used as the titles of documents ultimately describing the same thing. This finding corresponds well with findings from Ho (2010) and Schwartz (2004). Table 3. Summarizes the name of the texts addressing ethics.

Table 3: Name of the texts addressing ethics

	Title	Number of
1.	Ethical guidelines	14
2.	Ethics and Values	3
3.	Ethics	2
4.	Social responsibility and ethics	3
5.	Code of Conduct	2
6.	Business Ethics	1
7.	Others	3

Extent of ethical frameworks among Norwegian Contractors

19 out of 50 contractors exposed their ethical framework on their web page, and thereby make a public statement of what they regards as their ethical responsibilities, duties and obligations. However, this number might not represent the whole picture of the existence of ethical frameworks for this segment. Whether or not ethics are rhetorically addressed on the corporations websites, does not necessarily imply that they do not pay heed to ethical issues. The subject of ethics may be embedded in less public texts such as contracts or internal ethical frameworks. The remaining 31 contractors were therefore all contacted regarding whether they had an ethical framework or not.

As stated by Charles and Skitmore (2003), the purpose of having an ethical framework is to lay the foundation for good ethical practices and professional behaviour into business. Linking the importance of the construction industry to the economy as a whole, the impacts that decision-making has on the social and physical environment and the vulnerability the industry has to corruption provides a foundation for why contractors should address ethics more explicitly. It is therefore somewhat remarkable that the number of contractors publically addressing their ethical framework was as low as found, especially considering that the evaluated segment of contractors all have relatively large yearly revenues.

The analysis of the existent of ethical framework does not provide an answer to whether the ethical frameworks are practiced or incorporated within he corporations. Corporations without ethical framework could be as aware of ethical challenges as corporations with. Thus, ethical framework could both be a tool for promoting outward image as well as a control system regarding awareness on ethical issues.

Characteristics of the ethical frameworks

The second purpose of this research was to examine which distinguishing features could be attached to the ethical frameworks analysed. The content was not analysed with the purpose of digging into the morale content, or to map the values, principles and rules, or to rate them by their level of ethics. Five characteristics was examined: terminology, accessibility, physical properties, differentiation between legal and illegal behaviour, and differentiation between ethical and unethical behaviour.

Terminology: Half of the ethical frameworks examined were labelled “Ethical guidelines” while two used just “ethics”. It also seemed rather popular to merge ethics with other subjects such as sustainability, social responsibility and business values. Only two contractors used the “Code of

Conduct", of whom both were international contractors. Three contractors had developed their own terminology. These were labelled "People and Handshake", "The real thing" and "Reliability and vigour". While not mentioning ethics in the title, the content resembled that of an ethical framework. For example, the essence of the "the real thing" concept concerning being loyal to own principles and consciousness.

Accessibility: 38% of the examined contractors operating in Norway have content related to ethics on their website. In regards to accessibility, this number must be considered low. In their study of professional ethics in the construction industry, Zarkada-Fraser and Skitmore (2000) found that 45% of their responders from the Australian construction industry worked in an organisation with an existing ethical framework, while 90% of the responders had a connection to a professional institution that had an ethical code of conduct.

Physical properties: The study shows a large spread regarding the extensiveness of the ethical framework. The web content ranged from ethics mentioned in just one sentence to extensive statements attributed to corporate ethics and social responsibility. The same relates to the formal documents subjected to analysis. The documents had a clear tendency to be longer than the web content, see table 2. The extensiveness of the ethical framework might be related to whether they clarify the fuzzy line between ethical and unethical behaviour. It is hard to believe that ethical framework with very little content (11 to 100 words) do manage to cover a sufficient amount of ethics related content in regards of properly address the fuzzy line of ethical behaviour.

Differentiation between legal and illegal: The findings show that all the contractors having an ethical framework distinguish between legal and illegal behaviour. This validated in statements such as "*...we inform our employees about the most important laws and internal rules on a regular basis and oblige them to comply with them." and "...a fundamental requirement is that we follow laws and international conventions*". All ethical framework contained similar statement referring to national laws as well as international laws and conventions. This was not unexpected, since the legal framework applied by the state judiciary are binding for corporations.

Differentiation between ethical and unethical: a main objective for the analysis was to identify the documents that managed to differentiate ethical and unethical behaviour. The study shows that 15 out of 28 documents did so, while the remaining 13 only differentiated between legal and illegal behaviour. The newspaper test was mentioned in several of those. The ethical framework could be described to distinguish between ethical and unethical behaviour. Further, some contractors address the importance of being polite, reliable, and honest in matters affecting the corporation, which is also according to the principles of Schwartz (2005). None of the framework proposes a complete framework that covers every ethical question that their employees may face. In cases where specific ethical issues were addressed, activities such as bribery, making use of wrongfully attained business advantages and the avoidance of fuzzy relationship with customers, clients or partners are the most commonly mentioned.

Instead of proposing extensive frameworks, they tend to propose general or vague guidelines that urges their employees to apply integrity, common sense and critical thinking into their everyday activities. Examples of ethical framework rhetorically clarifying accepted ethical appearance are the following: 1) *"There should be any doubt regarding the integrity of [contractor] employees. [Contractor] encounters their environment with respect and equality. Equality applies irrespective of gender, race,*

religion or political convictions". and 2) "*We plan for safe and efficient operations, always focusing on demanding situations, and never taking shortcuts that could lead to wrong doing or accident. All employees should act and show attitudes that support [contractor]'s role as polite, open, honest and as a professional actor and community builder"*. These statements are relatively broad, but manage to clarify an essence regarding wanted behaviour. Another interesting aspect is that the frameworks tend to link their core values and how these are regulatory compliances with ethical behaviour.

Some of the contractor's state, in their ethical framework, "*we comply with laws, regulations and ethical guidelines…*" without addressing or specifying what the ethical framework actually say. The documents that do not specify such statements further were regarded as not differentiating between ethical and unethical. Several different versions of such statements was uncovered: "We strive for high ethical standards in everything we do."; "The Business principle we apply is that we always will conduct our business within the applicable laws." None of these statements contributes to any clarification of ethical issues past the minimal rule of obeying the law.

5. Conclusion

Extent of ethical frameworks among Norwegian Contractors

Nineteen out of fifty contractors address ethics on their web page and make public statements about their corporate ethics. We found 28 ethical frameworks out of the 50 largest contractors in Norway. Considering that the industry was ranked as the most vulnerable sector for corruption among 19 different sectors, one observation is that there is a need for more transparency and openness in regards to a contractor's stance on corporate ethics. Public announcement of a corporation's ethical stance is an easy measure to display professionalism and responsibility. Websites provide a tool for management in regards of managing impressions and reputation. Thus, it is hard to believe that website statements underrates the corporation's ethical anchorage. In the context of the research results, the segment of contractors could do more to announce that they take ethical responsibility. Such announcements could contribute to an improvement of the individual contractor's reputation as well as the industry. There does not exist a guaranty that corporations that have an ethical framework actually implement it within the corporation. Furthermore, the absence or lack of a formal ethical framework does not necessarily mean that the corporation disregards ethics.

Characteristics of the ethical frameworks

According to the analysis presented in this paper, there is no direct relationship between the comprehensiveness of the ethical framework and whether it addressed the fuzzy line between ethical and unethical behaviour. The most consistent characteristic is the differentiation between legal and illegal behaviour, which all of the identified ethical frameworks does. The findings showed that 13 of the 28 ethical frameworks did not address the difference between ethical and unethical behaviour, they only addressed the difference between legal/illegal. Implicitly, these 13 ethical frameworks state that their employees are just bound by the law, and that unethical behaviour sometimes might be accepted. An ethical framework only addressing legal/illegal behaviour is without practical value, as long as the law already regulates this. The authors agree with Kaptein and Schwartz (2008), who insist that corporate ethical frameworks that do not clarify the fuzzy line between ethical and unethical behaviour should not use the word "ethical" or other variations of it.

Practical implication

On an industry level, actors publically displaying their ethical frameworks contribute to transparency in the industry. One of the functions of a website is to create an outward image for the corporation. Therefore, the content of the website tell something about how the corporation want to appear to the public. This study tells that only 38% of the fifty largest contractors in Norway display themselves as ethical conscious actors. Ethical frameworks do not get sufficient attention within the Norwegian construction industry.

The Project Management discipline should maintain a strong and enduring interest in ethics and encourage project managers to deliver value in a more holistic manner consistent with being a professional member (Walker, 2014). Corporations that implement an ethical framework provide their employees with guidelines for decision-making. While this study does not look at whether ethical framework are implemented as a decision-making tool, it highlights the aspect of providing such tool.

This study is limited to an examination of the 50 largest contractors operating in Norway. Further research should aim at a mapping of the whole industry, with suppliers, clients, consultants etc. Another aspect is to evaluate whether employees in the AEC-industry actually commit to ethical frameworks. This examination study could serve as a basis for further research aimed at in-depth content analysis of different aspects of the ethical frameworks identified, especially how corporations view ethics; what they associate it with; or whether words or phrases collocate in the texts.

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Improving the market up-take of energy producing solar shading: A communication model to discuss preferences for architectural integration across different professions

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Abstract

Electricity producing solar shading provides possibilities for a combined solution for solar shading and building integrated locally produced energy from renewable sources. The multi-functionality of these products calls for collaboration between a range of actors from manufacturers, clients, architects, engineers, and contractors. Two major challenges for the increased up-take of the technology has been identified and is dealt with in a transdisciplinary research project, called ELSA, involving industry and academic institutions. First, the successful architectural integration of solar shading in terms of form, size, colour, detailing etc. in relation to the overall building design will be decisive in order to persuade architects. Second, the development of these multi-functional products to reach functional, technical, economic and aesthetical qualities is dependent upon communication between different professions. As a means to initiate a dialogue between the different professional groups taking part in the ELSA project, a model, the AIQ-model (Architectural Integration Qualities), to assess preferences for architectural integration of energy producing solar shading was developed and tested in a workshop. The results indicate a large consensus across different professional groups when assessing successful architectural integrations. Consequently, discrepancies in aesthetic appraisal of energy producing solar shading should not be the main hindrance for a broader implementation of such solutions. The challenge rather lies in that architectural integration qualities will concur with other important aspects of the multi-functional solution, and not all professional groups will put architectural integration qualities above other functions. The workshop shows that the AIQ model serves its function to initiate and to focus discussions. The value of group discussions to reach consensus was also observed. The AIQ model provide definitions to clarify the judgment base behind aesthetic assessments that was appreciated but all groups but most easily applied by the architects. The model should be further developed to include also other aspects than aesthetics.

Keywords: Solar shading, photovoltaic, architecture, stakeholder, communication

1. Introduction

Although significant improvements have been made to increase the efficiency in terms of energy produced and to reduce the costs of active solar technologies, these are still little used in the building sector (Noord, 2010; Heinstein et al., 2013). International literature underlines that a crucial barrier for the wider implementation can be traced back to the visual expressions of the components and how well the photovoltaic (PV) electricity producing solar cell systems can be integrated in the overall building design (Krawietz, 2007; Kanters, 2011; Farkas and Horvat, 2012; Munari Probst et al., 2012; Heinstein et al., 2013). The architect, as one key actors in the early stages of the design process, will be reluctant to integrate the technology if the visual expression and the possibilities for a successful architectural integration is set aside.

The literature point to several barriers that keep architects away from using the full potential of solar technology in building design. Mastering the best balance between installed power, energy generation and aesthetic appearance of solar technology is not an easy task and the lack of information will be decisive (Zomer et al., 2013). Design supporting methods and tools are not yet well-defined and suitable for architects (Kanters, 2011). Obtaining initial competence in solar technology can also be expensive, especially for smaller architectural offices and smaller projects (Hermstad, 2006). Furthermore, prevailing negative perceptions of and prejudices against these systems among other actors will play an important role (Farkas, 2011). Architects are often in the situation where they must overcome not only their own associations to solar technology, they also need to convince their clients (Hermstad, 2006; Kanters et al., 2013). In addition, solar technology is often introduced late in the design process and as an engineering application, not as a design element (Hermstad, 2006). There is a lack of "architectural language" with respect to PV technology, a necessity to raise interest among architects (Kanters, 2011). Art could be credited as a powerful tool to express new ideas and values, and function as a "mediator" in the process of changing the perception of PV in general (Farkas, 2011).

The complexity and multi-functionality of solar technology in building design, especially if the solar technology will replace other building components, calls for collaboration between architects, solar technology producers, clients, engineers, contractors and end-users (Krawietz, 2007; Hagen and Jørgensen, 2012; Heinstein et al., 2013). The communication process between these actors is a major challenge (Hagen and Jørgensen, 2012). For example, architects and engineers tend to use different language when talking about PV. Architects communicate through "semantic descriptions and visual images" while engineers are used to interact with quantified terms (Hagen and Jørgensen, 2012). Munari Probst et al. (2005) argue that a consistency in the judgements of among architects point to a presence of general integration qualities, defined by architects, and which should be followed in order to successfully integrate PV in building design. In contrast, some authors argue that the development of PV in building design is in need of a common language or tool for communication across professions, that can be comprehensive for different actors (Farkas et al., 2013; Hagen and Jørgensen, 2012).

1.1 Aim and approach

This paper presents research carried out within a trans-disciplinary arena ELSA (*Elproducerande solavskärmning - Electricity producing solar shading*) aiming for improved understanding of mechanisms in market up-take of electricity producing solar shading in Sweden. The ELSA arena consists of representatives from: real estate, solar system manufacturers; architects; contractors;

Swedish organisations for solar technology and solar shading; and the academy (engineering, architecture, daylight, design and innovation). ELSA researches innovation processes with respect to these systems but also engages in prototyping and testing of new products[1].

Electricity producing solar shading combines the solution of shading and locally produced energy from a renewable source, and provides the opportunities to articulate a buildings design. Contemporary architectural ideals favour large windows (Roberts and Guariento, 2009), solar shading should thus be increasingly needed to fight excess heating, but can also be motivated by a strive for more energy efficient building envelopes. In addition, locally produced renewable energy production goes in line with European and national energy policy. Luque and Hegedus (2011) argue that there is a *"logical combination between shading a building in summer and producing electricity at the same time that makes this type of solution increasingly attractive among architects"*. Nevertheless, few examples of combined solar shading and PV is found in northern Europe and Sweden (Gustafsson and Xu, 2016).

The ELSA project takes one starting point on the one hand in the identified need for architecturally integrated solutions and on the other hand in the need for collaboration between different knowledge fields. The design of these multi-functional systems, especially if dynamic, has to deal with varied challenges with respect to wind loads, durability, access for cleaning and maintenance (Roberts and Guariento, 2009) but also daylight, glare and indoor comfort.

This paper presents results from a workshop within the ELSA arena where we explored the appraisal of architectural integration of energy producing solar shading among different actors. A simple model, the AIQ-model (Architectural Integration Quality-model), was developed as a means to support the inter-disciplinary communication about architectural integration and tested among the participants during a half day workshop. Two questions were posed: 1) Do different professional groups differ in their evaluation of architectural integration? and 2) Is the AIQ-model useful as a tool to enhance communication in an inter-disciplinary project environment?

2. The AIQ-model

(Munari Probst, 2009) was among the first to define criteria for successful architectural integration of solar technology, later further developed by Munari Probst et al. (2012). The architectural integration is defined by the position and dimension of the solar system in relation to the architectural composition, the material surface texture, colours, joints, visibility and zone sensitivity, i.e. if the system is situated in a sensitive heritage area or a more "permissive" area. These criteria have been the basis for developing an evaluation model for solar technology in the urban landscape, called LESO-QVS (quality-site-visibility) (Florio et al., 2015), which can assume three different levels of architectural integration: high, medium or low.

A number of other authors provide complementary guidance for evaluating architectural integration of solar technology. The Danish architects office 3XN (3XN, 2014) uses the parameters "Efficiency, Context and Identity", and concludes that the solar technology should either dominate or diminish the architectural values of the building. Hermstad (2006) highlights the importance of including shadow effects from solar technology systems on the façade. Krawietz (2007) lifts up the discussion of creating

[1] http://solartestbed.se/om-projekten/elsa-elgenerande-solavskarmning/

variations of pattern. de Groot (2008) emphasizes that solar technology should be applied "seamlessly" and underline the potential to explore new architectural concepts. Detailing and smooth integration is considered as paramount, not least in the case of retrofitting where the integration of solar technology needs to be *"addressed and solved in a craft logic"* (Bonomo et al., 2015). Important to note is that architectural integration can be in opposition to the ambition to articulate or brand an environmental profile or to showcase innovativeness (Noord, 2010; Heinstein et al., 2013; 3XN, 2014). The symbolic value of PVs and the combination of architecture and PVs makes up an opportunity to support or educate the observers' environmental awareness, or demonstrate the clients' or architect's care about the environment (Farkas, 2011).

Based on these general recommendations for architectural integration of solar technology in building design, and with the inspiration from 15 product specific criteria for defining architectural quality used by the British Design Review (CABE, 2006), a model for evaluating the architectural integration qualities (AIQ) was designed. The model was developed in an iterative process involving a test panel in which the authors, a number of practicing architects from the ELSA project and of some architect students took part.

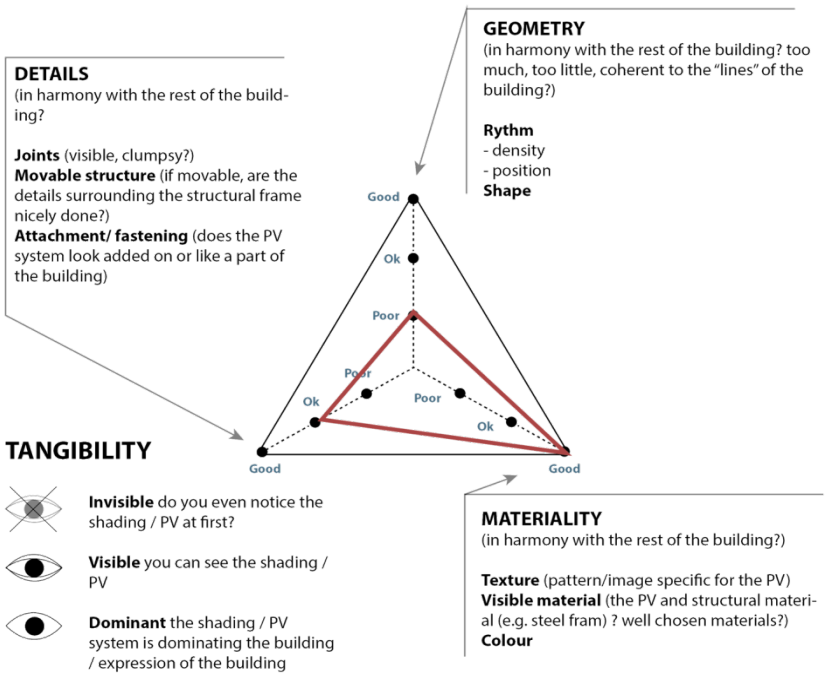

Figure 1: The AIQ-model, the triangle and the "Tangibility eye"

The AIQ-model is visualised as a triangle where each corner, representing geometry, materiality and detailing, is assessed with the prospect of answering whether the solar shading system is well integrated in the overall design. The model has three rating levels: poor, ok and good (Figure 1). Geometry assesses sight lines, shape, rhythm, density and position. Materiality assesses textures, patterns, colours and reflections. Detailing assesses attachment, structural elements, size and precision in design and production. Furthermore, the visibility of the system is assessed using an eye symbol evaluating if the solar shading system is dominant, visible, or invisible. High visibility can be judged as negative in a sensitive area but clients can be positive to high visibility if they wish for visibility for their investment

in solar technology. The AIQ-model, in its present state, only considers external aspects of architectural integration not how the solar shading is perceived from the inside of the building.

3. The workshop

In March 2016, a workshop was carried out in order to explore architectural integration preferences among 18 participants representing all professional groups in the ELSA arena. Four of those were workshop leaders and did not participate in the test but acted as note-takers and leaders. All discussions were also recorded for enhanced documentation.

Figure 2: In the first step, each participant should make an individual judgment of the architectural integration quality of nine selected buildings with solar shading.

The workshop was carried out in three steps. In step one (15 minutes) each participant evaluated nine buildings with solar shading individually from a selection of photographs of the building presenting details as well as the whole building, and by using the AIQ-model (Figures 1 and 2).

In Figure 3, pictures of the nine building are presented. Buildings 1, 3 and 7 are retrofitting projects and the solar shading has been installed after the buildings were completed. For the rest of the projects, the solar shading has been designed as part of the original design. All but one of the buildings, example 4, are fitted with photovoltaic. Although not being energy producing, example 4 was included since the design of the solar shading was regarded as architecturally interesting by the research leaders and judged and possible to complement with photovoltaics.

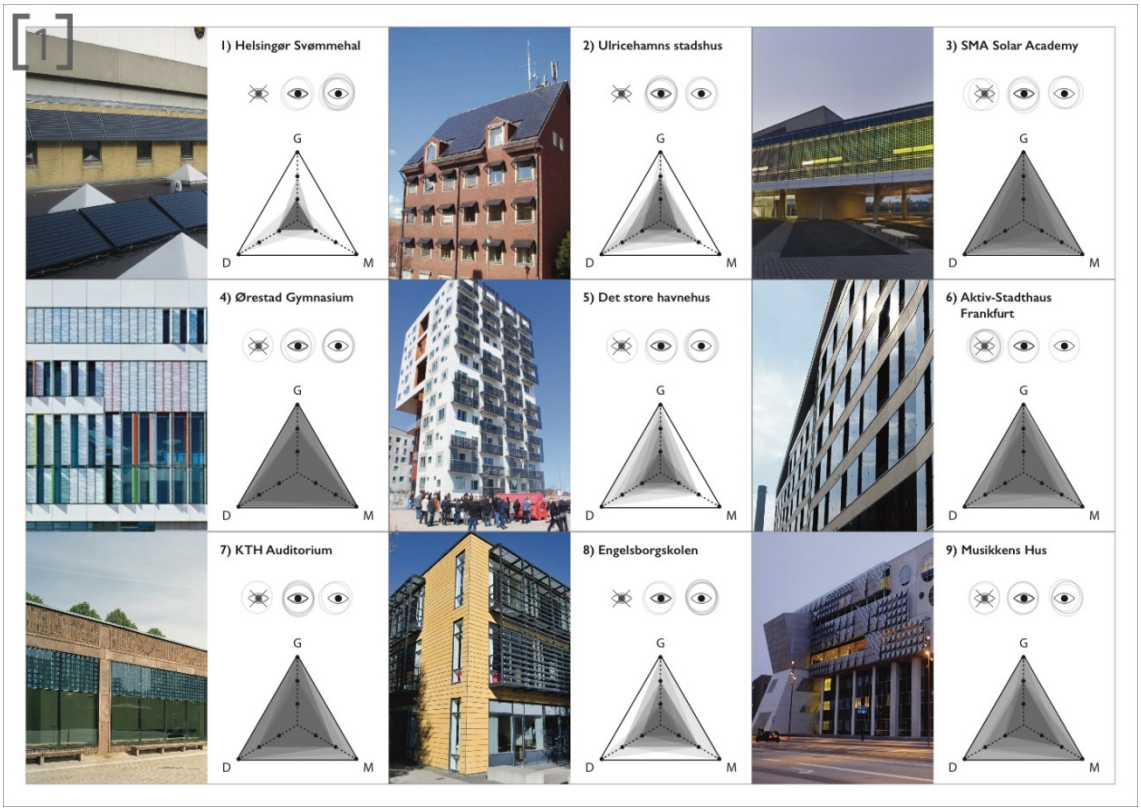

Figure 3: Aggregated results from the individual evaluations in step 1.

In step two (20 minutes), the 14 participants were divided into three professional groups for a group evaluation. Group one, the "installers", was formed by five representatives from manufacturers. Group two, the "clients", was formed by one property owner, one representative from a solar energy lobby organisation and three researchers in engineering having the function of clients for the prototyping in the ELSA project. Finally, in group three, the "architect-designers", three architects, one architect/daylight expert and one product designer participated.

In step three (20 minutes), inter-disciplinary mixed groups with one or two from each profession were formed for a new group evaluation. The aggregated results of the evaluation of step two and three are presented in Figure 3. At the end, all groups joined for a final discussion about the outcome, experience and value of the exercise.

4. Results

In the following we give an extract from the discussion made in step two, the professional groups. The discussions in step 3 and the following general discussion is presented in the paragraph 6.

There was a large agreement in the group "installers" that the "cap" solution in **building one** was badly integrated in the overall design. *"Terrible"* was an expression used. However, one participant said that the building wasn't that elegant to start with and the cap solution did not make such a big difference. One participant in the group found that the original building might even be enhanced by the solar shading. The group "owners" also found the solution *"terrible"* and *"clumsy"*. *"It changes the building for the worse, it is completely dominating the building"*. The "architect-designers" were not consistent in their view of the "cap" solution. Some said that the solar shading was *"very ugly"*. *"It is a bad*

building from the start, then this over-dimensioned shading bluntly screwed to the building. It is not good". However, one participant found that it somehow still fitted with the building and that the shading *"wasn't that horrible".* He argued that the cap fit with the geometry of the building and probably was a very economical solution.

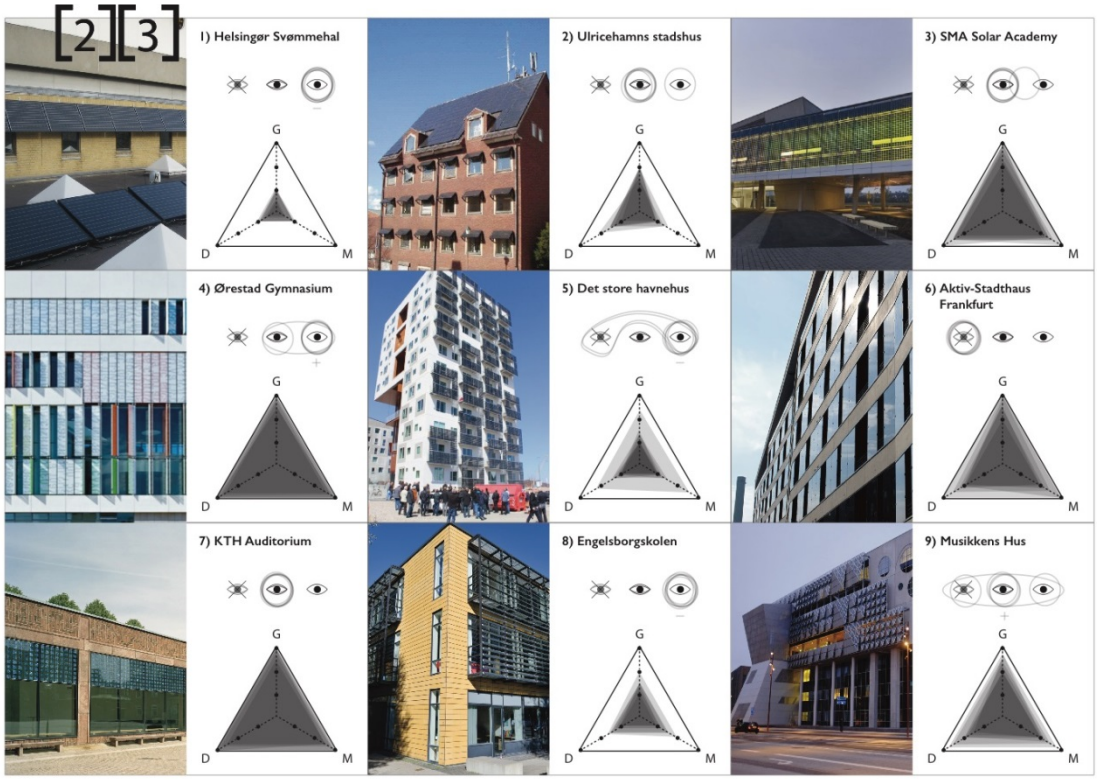

Figure 4: Aggregated results from the group evaluations in step 2 and 3

The reactions to **building two** were more positive among the "installers" and "architects". These groups reasoned that the marquis solution fitted the building. The "installers" discussed that the photovoltaics on the roof draw too much attention, which pulled down the overall impression. One participant in the installer group declared that *"If I know that it produces much electricity, then I am more positive".* One of the "installers" discussed the function of the shading. He declared that in order to be efficient as solar shading, a larger part of the window need to be shaded. The "owners" were divided about building two. The property owners in the group were very negative towards the geometry and the detailing: *"sad"* was one reaction. *"Terrible it destroys the whole building",* said another. *"It fits even worse than number one".* The two solar researchers in the "owner" group were more positive. The "architects" though that the solution *"worked",* that the geometry was ok, the problem was the material, the detailing, and the PV roof.

The "installers" agreed that the solar shading in **building three** seemed to harmonise well with the building, but it was also designed as part of it making the task easier to fulfil than in retrofitting. The "installers" had doubt about the effect in terms of produced electricity. The "owners" generally liked this system, *"damn good",* but one of the solar researchers through it made the building appear "heavy" and that thin film PV would have been more appropriate in this case. The "architects" discussed that the solar system was clearly visible and *"a design feature".* Most of the architects liked it but it was not their favourite among the nine examples. The daylight designer reflected upon the possibility that the inside would lack of daylight: *"I would not like to work there. It would feel too cramped".*

There was a large agreement among the "installers" that **building four** exemplified a very well integrated solar shading system. *"It is evident that somebody has been thinking here"*. The participants could easily see a thread in the design thinking. One comment was given about how this design probably could be very interesting at night. The "owners" were divided. One of the solar researchers was doubtful about the solution while the rest of the group gave top ratings. *"It makes you happy"*. *"It is dominating in a good way"*. The "architects" found the shading system very dominating *"It IS the building"*. They reasoned about the visibility. It is evident that the system is very visible but it might not be obvious for the public that the function is solar shading.

Building five was subject to lively discussions among the "installers" that had very opposing views. The installation is very visible, something some of them found attractive others not. *"Do we need to reach a consensus?"* Some disliked it. *"Why?"*. *"I don't like this. It looks as it has been added on. It does not harmonise with the building"*. Others in the group liked the design and found it intriguing. *"I find it cool. A lot of design but not so practical! Half of the windows are still completely unshaded. But I don't have a problem with that, I like it"*. The "owners" didn't like the dominating feature. *"Worse the longer I look at it"*. *"Looks like somebody shoot it on the building with a machine gun"*. The "architects" thought it was dominating but not in a good way. *"It looks glued on"*. The daylight designer once again noted that it would probably be very dark inside the building. The visibility of the system was judged as invasive but it is still not evident that this is a solar system.

The "installers" reaction to **building six** were positive. *"A bit better than good"*. The solar shading harmonises well with the overall design of the building. *"Seems like a cost-efficient solution"*. The "owners" also liked it but one of the property owners didn't like the detailing, especially the attachment which he thought pulled down the overall rating. The "architects" were positive. *"They have tried to make something out of the attachment and they should be praised for that"*. *"Full marks – a very nice example"*.

The retrofitting solution in **building seven** was generally well appreciated by the "installers". *"It enhances the façade at the same time it melts in with the brick wall"*. *"It is timeless"*. The design was judged as probably being more dominant from inside the building. The "owners" were generally positive and gave the building top notes. One in that group thought that: *"The building wasn't nice but the solar cells fits in"*. The architects found it *"almost beautiful"*. The blue photovoltaics marries well with the brick wall. One architect found it lacking in detailing. Another one exclaimed: *"How can you get stuck on the detailing. This is almost a piece of art!"*.

Building eight was also subject to some diverging views among the "installers", but the groups agreed upon a negative view. The system seemed rational but at the same time not so intriguing or visible. One called it *"German"*. However, the system was found to fit rather well with the overall design. *"The funny thing is that I actually think it harmonise with the building"*. Another comment was: *"you are probably never able to see the sky from the inside with this system"*. The "owners" found the system dominating and could not make out if the system was part of the building or attached afterwards. They didn't like the detailing although the geometry was found ok. One in the group made a comparison to a prison. The architects thought it looked like a cage. They didn't appreciate the detailing: *"It is too evident, heavy, clumsy, you can see some cables"*. They also found the design "closed": *"You would feel rather trapped behind that system, almost like a burglary protection"*.

Building nine was also subject to diverging views among the "installers". *"I like it, it is cool. It is more like a piece of art than solar shading". "It for sure does add something".* The fact that it was something of an art work actually made solar system less visible. Another participant found it to abstract *"This is not for humans".* The "owners" also found that even though highly dominant and visible, the function of solar shading and PV was rather invisible. *"It is more of a general decoration". "This really makes you think, but I find it funny".* One owner was negative especially towards the detailing. Some of the "architects" liked the building, others found the facade to *"messy"* which *"pulled down the overall impression".* The architects in general found the expression dominating and a bit confusing, and they doubted if the system actually serves as solar shading or if it is purely decorative.

5. Discussion

The workshop showed a much larger consensus across the professional groups regarding the perception of architectural integration of solar shading with PV than we had expected. None of the groups liked the simple "cap" solution in example one, while the design solution of examples four and seven was the most appreciated. The two examples five and nine with unconventional design solutions gave rise to the most vivid discussions.

The group of "installers" was the group with the most vivid discussions. They had especially opposing views on building number five and nine (Figure 4). The installers were often harsh in their negative judgements. They did not always refer to definitions in the AIQ model when making their evaluation but seemed to refer to personal judgments.

The "architects-designers" were in general more positive in their evaluations, although they did not always agree. They discussed with articulated arguments, referring to the definitions in the AIQ-model, which seemed to bring them closer to a group consensus. One of the participants in the group expressed her surprise about the positive views in the architect group. She had expected the architects to be harder in their judgments and harsh in their comments towards other architects. In response, another one in the group said that he had the feeling that this forgivingness might be reflect that the architects knew how difficult it is to deal with these questions in practice.

The "owners" held the most low-key discussions. The two property owners in that group were among the most negative in the whole workshop, also towards building two and seven for which the other two professional groups held more positive views.

Although a bit difficult to use for all groups, the AIQ-model was considered a support for the discussions. The architects had the advantage of being used to the terminology in the AIQ-model. For those not trained as architects, the concept of "materiality" was difficult to relate to. Instead, the non-architects seemed more prone to use personal expressions in their evaluation. One participant in the "owner" group said that he had preferred to rely more on his first impression and gut feeling than to try to look for specific aspects such as geometry, materiality and detailing. On the contrary, another participant in the same "owner" group thought that the model enriched the discussion as it forced them to express *what* and *why* they liked something or not.

Our results can be compared to an earlier larger European survey among architects, engineers and manufacturers about their perception of architectural integration of building integrated photovoltaics

(Munari Probst et al., 2005). The study was a questionnaire filled out individually and without any AIQ-model to guide the respondents. Contrary to our study, the European study state differences in perception across the professional groups. They also found a large consistency within the group of architects. The authors conclude that the consistency among the architects confirm *"the existence of general integration principles, not necessarily appreciated by some engineers"* (Munari Probst et al. 2005, p.2). Munari Probst et al. (2005) thus argue that these general integration qualities, confirmed by the architects' perception, has to be followed in order to develop successful solar systems.

Our study shows consistency across professional groups. Furthermore, our participants in the "architect" group was not that aligned in their views. Thus, our results thus go against the idea of a prevailing architects' view of architectural integration, and the idea that other professions do not appreciate the same aesthetics. Our conclusion is that the differences between the professional groups rather lie in education, culture, language and the way the they evaluate and articulate their argumentation. The professions have different languages as stated by Hagen and Jørgensen (2012) but these differences could be bridged by introducing all actors to the same language. This could be done with a developed AIQ-model and supported by characterisation exercises, which is part of architects training, for also other professional groups in the building sector.

The groups discussion in itself appears as important to reach a better consensus in the groups. All participants found the workshop enrichening to the continued inter-disciplinary work in the ELSA project. We found a larger consistency after the group evaluations (Figure 4) compared to the wider spread of judgment in the individual evaluation (Figure 3). The lack of groups discussions in the European survey (Munari Probst et al., 2005) could explain the discrepancy they found in perception among professions. The workshop thus confirms earlier studies (Hagen and Jørgensen, 2012) that point to the value of collaboration between professions in the development of successful integration of PV in building design along with the value of a tool to support communication between the professions in inter-disciplinary environments.

Finally, there is room for further improvements of the AIQ-model. Some participants found the AIQ-model too simple. Instead of the three level point system, also used in LESO-QVS (Florio et al., 2015), a five level system including the level "excellent" would have worked better. Furthermore, colour could have been singled out as one assessment criteria instead of being part of materiality. The participants agreed that a more complicated model would have demanded more time for the workshop. One participant also drew the attention to the fact that some questions for the workshop were confusing. For example, the question: *"Is the solar shading dominating?"* The ambiguity of the question was demonstrated by the fact that some participants judged a system as dominating while others found it to be invisible. Although very dominating, a system can be perceived as well integrated and thus invisible, for example as in building four.

Maybe the largest deficiency with the AIQ-model is its mono-disciplinary nature. The group discussions revealed that other functional, technical and economic factors will be part of the overall evaluation of the energy producing solar shading and may compromise the importance of architectural integration and aesthetics. For example, one participant in the "architect" group found it difficult to give an opinion on only exterior aesthetics when she suspected that the function of the system was bad regarding daylight inside the building. The same kind of remark was given by one participant in the "installer" group, who declared that he would have been more positive and forgiving towards the un-

aesthetic solutions in some cases if he knew that the system produced a lot of electricity. Discussion revealed that while the architects are interested in extending the number of innovative products, the participating PV manufacturers were more interested in the standardisation of design in order to scale up productivity and market shares.

6. Conclusions

The aim of this paper was to explore differences in perception of architectural integration qualities of energy producing solar shading in building design across different professional groups. A model to evaluate architectural integration qualities was developed as a tool to communicate about aesthetic values of such systems. The results of a workshop within the inter-disciplinary research project ELSA demonstrate a large consensus among the different professions when evaluating the successful architectural integration of energy producing solar shading. The conclusion we can draw is that diverging views on the aesthetics or architectural integration would not be the primary cause that impede a broader implementation of energy producing solar shading. Instead, the challenge lie in the fact that aesthetical integration qualities will concur with other aspects such as function, efficiency, energy production or economy. While architects might not want to comprise architectural integration qualities, other professions might value other aspects higher.

The workshop show the usefulness of groups discussion and tools that can enhance the communication between professions. This could potentially benefit the development and broader implementation of energy producing solar shading in building design. The AIQ-model helped the participants to articulate architectural integration and gave rise to interesting discussion appreciated by all workshop participants. Although architects had the best conditions to use the model, the other professions also found the model helpful to focus the discussions. A major limitation of the present AIQ-model is that while the design process for multi-functional energy producing solar shadings will be challenged by inter-disciplinary perspectives, the AIQ model is limited to valuing external integration and aesthetics. This experience should be the starting point for the continued development of inter-disciplinary communication tools.

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Liquid integration and Modern Methods of Construction: eddies of house-building in the UK

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Abstract

Off-site construction in the UK is increasing yet the overall number of houses built is far from targets set by the UK government. Despite a growing recognition that increased integration between house building professionals is needed to enhance the number and quality of houses built with Modern Methods of Construction (MMCs), little emphasis has been given to how integration between multiple subcontractors - carpenters, plumbers, and electricians – occurs. This paper draws on interviews with employees of a small house building firm, the supplier of the open panel timber-frames, and subcontractors. Foregrounding how particular challenges of taking up off-site methods of construction are resolved turns the attention away from the constraints and/or benefits of taking up off-site methods of construction, to how on-site integration occurs when using off-site methods of construction. The paper develops the concept of liquidity to describe integration in off-site construction whereby house building occurs through collaboration between firms and personal. A range of metaphors develop the concept of liquidity in different ways – it is suggested that eddies of integration provides a unique approach of researching integration in supply-chain partners.

Keywords: supply-chain integration, off-site construction, supply-chain management, liquidity, timber-frame construction

1. Introduction: liquidity and integration

1.1 Dam integration

> *"I think the whole industry's attitude is that people don't want to innovate in this industry because the skill's been there and we've done it this way for thousands of years, why change? And it is, change is so hard in this industry…." (Timber-frame designer)*

Modernising house-building through off-site methods of construction (OSM) is often positioned as the principal solution to increase the 'flow' of house building in the UK. The benefits of offsite construction to the UK's commercial construction sector are well rehearsed: faster construction times, higher build quality, less risk, reduced snagging, and a reduced requirement for skilled labour (Blismas et al. 2006). While higher energy efficiency requirements and a housing requirement of more than 220,000 annually have also repositioned off-site construction as a viable method for housebuilders (Wilcox et al. 2014), the uptake of OSM throughout the UK and nearby countries varies. For example 5% of construction in England uses MMC in comparison to Scotland where 75% of construction occurs through MMC and 92% in Sweden (Steinhardt et al. 2013).

A lack of particular drivers (Steinhardt et al (2013), co-ordination between supply-chain partners, and conservative approaches to construction (Barlow, 1992) are given for the relatively low uptake of MMC in England. As the above quote summarises, transitions to modern methods of construction (MMC) in UK house-building tend to be portrayed as an industry problem in which 'the industry' as a whole inherently constrains adoption. This paper argues that such a focus neglects to consider the saliency of existing ways of working among the supply-chain to the adoption of off-site methods of construction. More specifically, that transitioning to MMC is not an absolute shift — different from ways of working that already take place – since flows of integration between firms and/or professionals continue to occur. In this sense the uptake of MMC occurs through continued collaboration across firms through the activity of building houses.

Little attention has been given to how integration - between supply-chain actors - occurs, and may occur differently when taking up MMCs. This paper tackles this problematic by focusing on the on-site implications of MMC. We use metaphors inspired by fluid heuristics (such as the wing dam in figure 1) and a case study of the uptake of MMC in a small house-building firm to explore how integration in the uptake of MMC can be framed. Various dynamics of coordination and flow - that we term the liquidity of integration – are used to aid this endeavour. The paper begins by providing a brief overview of some approaches to integration before turning to how approaching integration as fluid may aid future conceptualisations of supplychain management.

Facilitating fair relationships between main contractors, subcontractors and suppliers, for Dainty et al. (2001) is needed:

> *"If significant performance improvements are to be realised within the sector, the mutual benefits of supply-chain management must be extolled to SME's in order to engender their trust" (Dainty et al. 2001; 171).*

For Dainty et al (2001) potential advantages of off-site construction are dispersed unequally across multiple SME's, whereby subcontractors are not treated fairly, and where more education and training relating to overall build programs with off-site methods of construction is needed. Despite the potential of off-site production to overcome skills and material shortages, improve thermal efficiencies, speed up construction, and open up design opportunities (Blismas et al. 2006), small to medium housebuilders are yet to fully embrace off-site construction. However, while larger house builders have more capacity to integrate overall supply-chains more attention is needed to further understand possible issues that constrain SME's when taking up off-site methods of construction (Dainty et al. 2001).

In both acknowledging and moving beyond these approaches to understand how integration may occur, this paper emphasises the fluidity of integration on-site whereby a multitude of actors integrate and solve on-site problems. These examples both retain the momentum of separate firms – such as business models – and create new 'solutions' to pertinent onsite puzzles.

The aim of the paper is to analyse how integration occurs and to explore how integration with multiple actors and firms is conceptualised. The paper takes as a starting point that integration is multiple and malleable – it does not – take 'a' shape but is dynamic across sites and over time. In order to do so, the use of the metaphor of liquids - which unlike "solids, cannot easily hold their shape" (Bauman 2000: 2) is useful.

1.2 Fluidity and Integration

The concept of fluid integration has received some attention in theories of supply-chain management in terms of fluidity of markets (Klug 2013), transactions, and reductions in build out durations. Theories of fluid integration here are premised with an ambition to either increase or improve integration between suppliers and manufactures through transitioning from transactional to relational exchanges (Pohja 2004). Here, chains are repositioned in an attempt to engage actors contractually, or adapt how information or products flow between them (Dainty et al 2001).

Many have taken on board Bauman's (2000) recommendation that attempts to gain or increase controls neglects the fluidity of social integration and have furthered his work by contextualising how relations vary with specific dynamics. In an interview (Kilminster & Varcoe 1992) Bauman recognises how conceptualising fluidities in relation to specific dynamics – such as eddies – can help understand social integration.

> *"I came to the conclusion that sociology is not a discursive formation. If it is a discursive formation, it is one which is made of holes only—of apertures—so there is a constant input of material from outside, as well as output. I am rather inclined to see sociology today as an eddy on a fast-moving river, <u>an eddy which retains its shape but which</u> changes its content all the time, an eddy which can retain its shape only in as far as there is a constant through-flow of water."* (Kilminster & Varcoe, 1992: 213)

Despite focusing on the discipline of sociology, theories of construction management may be enhanced through foregrounding how social integration is conceptualised. These fluid yet dynamic forms of integration – as this paper illustrates – may further understandings of how house builders use off-site methods of house construction in the UK.

1. Fluid metaphors of integration

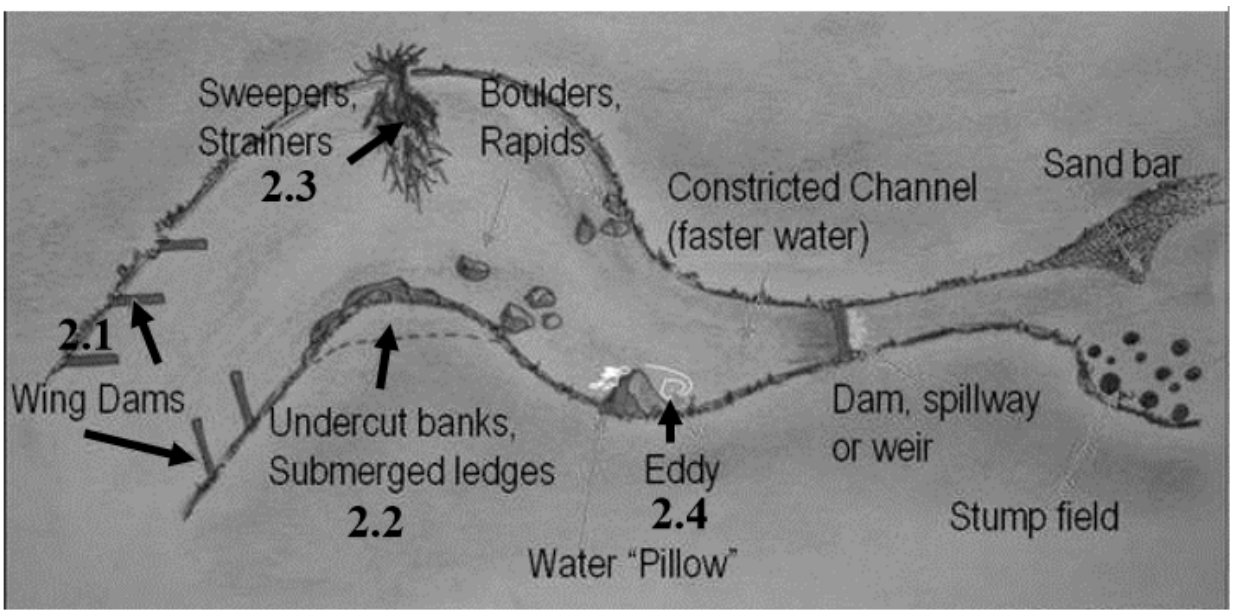

Figure 1: Liquid Metaphors (adapted from Watson 2011)

The representation of river hazards above provides the narrative order of the paper and assisted us to frame different dynamics of integration. The paper begins with exploring how supplychain integration can be conceptualised in terms of the first four hazards in the above figure. We begin by exploring how strategies of increasing the uptake of off-site construction have been approached in terms of guiding the flow of construction in a particular direction. For example, a wing dam is a structure built into a stream to deflect the current, and thus helps to highlight implications of approaches to integration that focus on industry wide transitions. Subsequent to illustrating approaches to construction management through the first four heuristic devices – wing dams, undercut banks, strainers, and boulders – the paper turns to an overview of the empirical case and how the heuristic devices of eddies helped us to account for integration between supply-chain actors .

2.1 Guiding integration: wing dams

Attempts to guide the flow of UK house-building industry towards MMC's have been made to decrease house building shortages. Most recently policy advisor Farmer challenged the construction industry to "Modernise or die" (Farmer 2016). In this sense the 'industry' is the barrier which needs guiding to increase the uptake of MMC. Housebuilding professionals hold back the uptake of MMC due to their lack of innovation through working in silos (Barlow 1992).

The second fluid dynamic of the paper (see 2.1 on figure 1) the 'wing dam' helps to illustrate how positioning integration as a barrier to modernity neglects how integration already occurs and could occur differently. The assumption is that there is a constant homogeneous flow that can be either

changed with a swift transition or that house-builders need 'guidance' to direct their attention in a different direction. A focus on guiding an industry as a whole or guiding house builders choices neglects how integration occurs through different currents – to mean different ways of working. The paper now turns to the heuristic device of undercut banks to highlight how strategies and capacities of taking up MMC vary depending on the size of the firm.

2.2 Surviving integration: undercut banks and ledges

The adoption of off-site construction methods has predominantly been by larger housebuilders whose business models reflect the economies of scale required to fully capitalise on the manufacturing processes (Pan et al. 2008; Pan & Goodier 2012). For example, large scale housing developments with standard repeatable design components provide a better business case for prefabrication than small housebuilders whose business model focusses on small developments of between 5-10 bespoke units. The size of housebuilders relates to capacities to take up MMC, and to survive to wider environments whereby small project-based firms remain more open to external fluctuations than large firms (Barrett and Sexton, 2006). In terms of the fluid heuristics in figure 1, capacities to take up MMC are bound up with firm level internal and external dynamics that include strategies of surviving unexpected situations such as economic down turns. Larger and small house builders have different capacities to avoid and survive undercut banks and ledges. They also take up MMC in different ways – smaller sites with different arrangements and varying relationships with actors in supply-chains.

In contrast to a dam whereby the uptake of MMC would flow constantly and could be turned on and off like a tap, the fluid heuristics of wing dams explicate integration as being relative to internal and external – firm level - strategies. The following section now turns the attention to how the uptake of MMC not only varies between differently sized firms but also across firms working on the same project.

2.3 Straining integration: strainers

> *"A strainer is defined as anything that swift water can flow through, but that a swimmer, kayaker or boat cannot. Some examples include cars, trees, man-made obstacles and debris. Strainers are life-threatening obstacles that should be avoided whenever possible." (Watson 2011)*

As a liquid heuristic, strainers help to explicate how transitioning to MMC impacts trades differently. In contextualising integration as relative to specific currents –not only to a specific scale of flow but also to specific trades, Dainty et al (2002) importantly illustrate the complex – and often unequal forms of integration – that than can occur with when SMEs build with MMC, which can lead to distrust between contractors and supply-chain partners. For example, 'subcontractors' are often not treated fairly in terms of profit margins nor is adequate attention given to how particular scopes of work are impacted by changes in build programs. The lack of attention given to how the uptake of MMC strained by unequally dispersed integration – some trades integrate easily while others fail – is surprising when taking into consideration how electricians, joiners and bricklayers are the professions in the shortest supply (Pan & Goodier 2012). The focus – implicitly at least – is that integration is 'blocked' by particular currents between firms and has led to a fragmented construction industry.

The paper began by unpacking and challenging the idea that wholescale shifts toward modern methods of construction are possible. This relied on and reproduced an assumption that there is a constant flow of integration between construction firms regardless of their size or arrangements with partners. This acknowledges how integration in house building occurs through currents. Wing dams – the first fluid heuristic of the paper - furthered the argument by acknowledging how currents - such as business models or ways of working – guide firms in particular directions - strategies of staying afloat reproduce internal and external fluctuations. Integration can also be strained with the uptake of MMCs whereby benefits are unequally distributed among construction partners; particular trades may be adversely affected and longstanding relationships between firms and supply-chain may deteriorate. The fluid principle heuristic of the paper 'eddies' is introduced in the findings section which proceeds an overview of the case.

3. Findings: eddies and integrating windows

In the previous section we unpacked how the uptake of MMC varies across sizes of firms and contractual relationships between them. The following – findings – section takes an approach that furthers exploration into relational accounts of the uptake of timber-frame by foregrounding integration through multiple currents highlighted in the activity of integrating windows into timber-frame homes. In this sense the strength of integration or relationships between suppliers and builders did not help understand our case. Instead we focussed on how integration occurs within dynamic currents.

As defined by the Oxford English Dictionary, an eddy is "A circular movement of water causing a small whirlpool". As a metaphor of integration between supply-chain partners, eddies are insightful as they focus on the circular way in which upstream and downstream currents come together. In any instance no stakeholder is prioritised over another. In the sense of the metaphor of an eddy, house-builders, suppliers, plumbers, carpenters, ground workers, and electricians all collaborate to build houses. As was apparent in our case study, the personnel and materials involved in the construction of timber-frame homes was neither constant nor standardised but was part of fluctuating environments – whirlpools – and the currents they carry. MMCs required skills, materials, and methods of organisation that did not have a 'main current' of construction. In this sense currents are not only co-ordinated but also rely on existing dynamics such as those described in the previous section, and an acceptance that problems will have to be solved on site. Currents are neither here nor there, alien or familiar, but intersect through activities on-sites which are themselves part and parcel of wider environments.

3.1 The case: Percy's Yard

The empirical data was collected over a year long period through extended periods of observation, analysis of project documents such as programs of work, and interviews with supply-chain to capture experiences of working with an offsite construction method of construction. By exploring how multiple actors and firms integrate through the construction of four timber-frame houses, and by drawing on notions of integration as being fluid – in a variety of forms – specific instances of on-site integration of MMC were captured. Observations that integration could be framed through the metaphor of an eddy emerged through research, analysis, and collaboration between researchers. Here theories of integration were placed alongside ethnographic notes and interview transcripts.

The case centred on a small housing development in South East England built with open panel timber-frames. Both the manufacturer and the house-builder building the timber-frame were reliant on pre-existing collaboration within firms and their experience of working with building professionals more broadly. The professionals involved, the timber-frames used, and the site that the homes were built on was not however set in stone, it was an outcome of fluid yet dynamic integration.

The initial strategic aim of the house-builder to adopt timber-frame was to capitalise on more stringent performance requirements of new homes needed for a particular site, the site was however delayed by extensive planning procedures, and the timber-frames were used on a different site 'Percy's yard' where planning permission was already in place. Becoming the home for timber-frames regardless of formal requirements for the performance benefits that timber-frame carry, Percy's Yard helped to unravel incentives for integrating different how integration without – direct - incentives occurs. The paper tackles how using timber-frames had implications for supply-chain partners shortly, before doing so it is worth reinforcing how firms relied on and reproduced currents of supply-chain integration.

3.2 Cross-firm collaboration

The 'house-builders', the materials used, and the professionals involved were arranged by drifting environments - house building is already 'modern'. Bespoke homes – the housebuilders – started up with employees that had worked together for a previous firm which went out of business (in 2008) when a number of construction firms were unable to stay afloat or retain all existing staff members. This 'economic downturn' as it was described by managing directors of the two firms led to adaptations of personal for GG and the creation of Bespoke Homes. The timber-frame advisor working on Percy's Yard 'Dan' had been also been made redundant in 2008 and had started working for the company again in 2010 before becoming a managing director during the duration of our case study.

Experience of working together on previous projects, for the managing and the site-manager of Bespoke Homes, and experience of working with other house-builders for Dan was highlighted as being crucial when using MMC for the 'first' time. While Bespoke Homes had not built houses with timber-frame before, and Dan had not worked with Bespoke Homes before, the site-manager and the managing director had built some flats using timber-frame while working for a previous firm. Previous experience was highlighted as being crucial when using MMC not only for GG and Bespoke Homes but also the subcontracted supply-chain.

When interviewing the managing director at the start of the project, he explained how he was going to use scaffolders, brick layers, and electricians that had experience of working with timber-frames, and nodded to the importance of using timber-frames on a previous project to 'get an idea about what it was about'. Quenching his thirst to try timber-frames in the previous project overcame concerns relating to timber-frame in the past which he may added have stemmed from the TV documentary World in Action which heavily criticised the build quality of some timber-framed buildings. A timber-frame estimator at GG also reinforced the assumptions "flying around" about timber-frame and the importance of trying it for the first time. The following quote from her and a subsequent quote from a sales director emphasise the importance of "giving it a go":

> *"Once they've tried it they love it, they just need to give it go" (Sally, Timber-frame estimator for GG)*

"We find it difficult to get our foot in the door" (Charlie, Sales Director GG)

In talking through previous experience with house-builders Sally highlighted how difficulties occur when "John from the Pub", pointing to the lack of appropriate skills that are sometimes drawn on, but raised issues of collaboration between suppliers and housebuilders as preventing the uptake of MMCs. She explained how questions are rarely asked by house-builders about changes to overall build programs, and very rarely do follow on trades enquire about working with timber-frames.

Charlie, in explaining how attempts to have demonstration events - in which a timber-frame structure was available for viewing – were unsuccessful due to not representing how they "become houses" in the sense of not illustrating brickwork or and how the houses would be configured with wires and pipes. While the demonstration projects were unsuccessful due to being separate from building sites that they will necessarily be part of: they did not illustrate how the frames work with other technologies such as pipes, wires, and bricks. For Charlie, assumptions about the buildability of the frames are only fully understood when building with the frame itself. In a similar yet contextualised strategy, Dan took the site-manager and the managing director to a live site. Despite this excursion to further understandings of the frames becomes houses, the site manager was not entirely convinced that Percy's Yard but be completed without complications, not because of the timber frame itself but because of years of experience that told him how 'we'll just to wait and see what happens' (Site manager). When asked how using timber-frame will change how he manages the site, he explained:

> *"I think the whole process is slightly different from the starting point, obviously the brickwork round the outside is basically the same but I think from there on in everything else on the inside is going to be a bit of a new experience" (Site manager)*

In anticipating the changes that need to occur when constructing with timber-frames for the first time, the site manager postulates how the "whole process" will be different, while as he noted before there be numerous other supply-chain – with more experience of timber-frame - to available to help. In his words:

> *Unlike me I think they've [the subcontractors] probably all worked on timber framed construction anyway because - whereas this is a first for us - I think I can't say for sure but I'm about 95% sure that they will have all experienced a timber framed construction before. Yeah, so they will know the ins and outs of it probably better than I will. (Pete, site manager)"*

In this sense MMC are not entirely separate from current ways of working nor are they completely reliant on specific information, construction is always a collaborative exercise that involves frequent unexpected challenges .The following excerpt from ethnographic field notes made while observing the negotiation of window sizes and expectations of shrinkage illustrates this:

> *On arrival to site today the site manager continued to be committed to overcoming issues of the compression rates of the timber-frame and the openings for the windows. The "window men" apparently still want much larger tolerances and want the spacing at the top rather than the bottom of the openings. In contrast, the timber-frame suppliers had advised him to have the spaces to account for the tolerances at the bottom of the window openings. For the window suppliers such tolerances had proved successful on a previous site they've worked on and they*

wanted to stick to these to avoid complications. The site manager seemed complexed yet comfortable with this situation; he simply stated "we'll sort something out"….

When asking the site manager was asked how he overcame the conflicting advice regarding the window openings. In response the site manager explained how, after consulting some friends who had more experience than him with timber-frame structures, decided to "go for somewhere in-between" and "cross his fingers" (site manager). This decision was not as laissez faire as these quotes may convey and the window dilemma continued. Challenged by the material specifics of timber – it shrinks after installation as the water content changes – the site manager drew on methods of problem solving he knew well – and while he took on board the opinions of the supply-chain involved, he also attempted to imagine where the coursing of the brickwork would lie in relation to the shrinking timber-frame. By marking the timber-frame with lines where the brick coursing would eventually be he made an informed decision about where the size of the windows and where the openings would be not for the window opening that he measured, but for all the windows – except for the bays - on the site .

"*Y: Yeah. You know it's packing out windows as well, the windows didn't come in at the, the window openings didn't come in at the right size, so we had to go around and put half inch ply on the, on the bottom so the window will fit in properly, yeah.*

I: How did you eventually decide on half inch, was that?

Y: Oh well that's something Pete sorted, I don't know if that was working for brick courses that needed to be done, I don't know, but it's just silly little bits and pieces which you've got to, well next time I will allow for these bits and pieces really."

The above passage from an interview with a carpenter is illustrative of installing a window was only possible with adaptions to previous ways of working across supply-chain partners. And while reasoning may remain at the firm level – in this example Bespoke Homes – the decision came from - and the implications of doing so -are dispersed across multiple supply-chain. Future scopes of work will incorporate the "bits and pieces" when working on timber-frame. At the same time working with timber-frame changed how his approach to house-building: repeat visits were needed, more time was spent "cleaning up after people" by installing noggins for plumbers that would not have been needed if the internal wall was a block structure.

4. Discussion and conclusions

The above findings have provided varying examples as to how integration between supply-chain actors has occurred and has also reflected on the potential implications of approaching integration as fluid. This demonstrated an alternative approach to the heuristic of chains whereby firms are firmly tied together and that there is a constant flow between construction supply-chain actors. By highlighting the importance of currents between partners, this study has experimented with different fluid dynamic heuristics to provide new avenues of insight into how these currents come together - liquid integration involves the mediation of multiple professionals and firms. In this sense, methods of integration already occur to 'iron out' how construction happens, and it is important to think through how these adaptions are salient to MMC. Before discussing how the metaphor of an eddy opens up this challenge, we reflect briefly on the metaphors of the dam, wing dam, undercut banks, and strainers.

At the start of the paper we discussed how framing integration with MMC as being absolute is problematic – the relative lack of MMC in house-building within England was due to a lack of drivers or supply-chains avoiding MMC due to an inability to respond to, or lack of, incentives. More substantially, this approach dissects MMC from existing ways of working, and leaves little room to further understandings of how the uptake of MMC differs depending on varying sizes of firms and their relationships with supply-chain partners. The metaphor of the wing dam helped to unpack how the industry as a whole cannot be 'guided', and the metaphors of undercut banks and strainers pushed back on the idea of integration that simply does not happen or that can be guided holistically. Undercut banks – as a metaphor – helped to account for the importance of SME specific strategies that cross internal and external boundaries to avoid unintended situations. Integration with MMC is also strained through unequal relationships between supply-chain partners – this was revealed through the metaphor of strainers. Eddies – as a metaphor of integration – furthered conversations in this area by showing how MMCs are facilitated by and reliant on particular whirlpools that circulate across supply-chain. Here, integration was malleable, integration did not and does not flow in any particular direction but spiralled through activities. According to which there will never be one form of integration or problem solving but a reworking of intersecting forms of collaboration. Focusing on the circular ways in which firms come together helps to redirect approaches to supply-chain integration away from connections between firms toward how forms of coordination and performance intersect through activities over time; staff and firms come and go, as do strategies of integrating supply-chain partners change (demonstration projects and visits to live sites), window sizes and spaces are adapted through collaboration across actors, and routines are adapted as new ways of working emerge.

Emphasising dynamics between firms and their partners helps to move beyond holistic approaches to MMC, whereby the uptake of MMC for the whole industry is constrained by a lack of innovation, or lack of integration between supply-chain partners. Instead we focused on integration as reworking existing arrangements and the performance of materially mediated activities over time – in what we termed eddies. To mean that new challenges and arrangements between supply-chain actors frequently occur but are never tackled without prior experience of the activity. As Kreiner (1995) points out:

> *"…the fact that projects occupy only a bracket in time and thus have neither history nor future, allows evolutionary processes little scope for improving performance. Thus, such improvements may await new ways of framing the issues of project management."(Kreiner 1995: 345)*

Thinking though how activities emerge over time with varying supply-chain actors begins to explore different ways of framing supply-chain integration. Drawing on the fluid dynamic of an eddy helps to explore how integration spirals through whirlpools of activities over time and provokes further approaches that account for 'liquid integration' across supply chain actors.

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Information Flow Between Design and Production

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Abstract

This paper addresses problems in the information flow between building design and production in a building project with Design-Bid-Build (DBB) contracts, and propose a set of solutions to these problems. The following three research questions are answered: Which communication channels are used? Which characteristics do the communication channels have? Which actions can improve the information flow between design and production? Information can disappear in communication between design and production, leading to errors or deficient descriptions for the production. Existing literature does not fully describe how this can be corrected in DBB contracts. The purpose of this paper is to improve information flow between design and production. An expansion project at Oslo Airport is selected as case. This project has been chosen because it is an extensive building project with DBB contracts and complex communication patterns. In order to attain a certain representativeness of the effects from DBB contracts the selected research methods are extensive literature review, document study and semi-structured interviews with 13 workers from respectively design, construction management and production in three of the contracts. The paper presents both the formal and informal communication channels used in the case project and the strengths and weaknesses of these channels. It also presents actions that can improve information flow between design and production. The expansion project at Oslo Airport is the only project investigated. The project is vast, so the paper encompasses only a few of the project's contracts. The complexity of the project might complicate the representativeness. The paper highlights important areas for organizing communication between design and production in a building project. Good information flow between design and production contributes to a lean execution of building projects, both with respect to end value and productivity.

Keywords: Information, flow, communication, design, production

1. Introduction

Effective flow of information is important for all organizations in the Architecture, Engineering and Construction (AEC) industry. The AEC industry can be seen as dynamic and fragmented (Zhang, 2011). The number of actors involved in a typical project makes it complicated to maintain good communication. Furthermore, building projects often have thousands of employees working in different teams, at several locations and at different times.

The largest building projects in Norway typically use Design-Bid-Build (DBB) contracts (Lædre 2006). DBB-contracts are administrated by the project's owner or owner representatives hired to ensure that the owner's interests are maintained (Lædre 2006). Design and production are two closely related parts of a building project, even though they are usually executed by different people (Meland 2000). Design-Bid-Build (DBB) contracts differ from design-build (DB) projects in that it the design and production are carried out in different contracts. The owner has the responsibility to coordinate the contracts, and so the owner becomes an intermediary between design and production (Lædre 2006).

Communication between different contractors and the design team usually flow through the owner in DBB contracts. That makes good communication one of the biggest challenges for the owner's representatives at the construction site. The owner employs various communication channels for information flow between parties to face this challenge (Røsdal and Ørstavik 2011). Oslo Airport is a public costumer, which according to Bhatia and Drew (2006) often have less focus on lean construction than private costumers. Costs and quality are important aspects in lean construction, but public costumers often have other interests such as social value, which are harder to measure.

Much literature regarding communication, information flow, design and construction exists, but there seem to be a knowledge gap regarding information flow between design and construction (Emmit and Gorse 2006). The authors have not found any literature that in depth studies information flow between design and production in DBB contracts, a knowledge gap that is addressed in this paper.

The paper examines one of Norway's largest on-going building projects at this date; the Oslo Airport Expansion project. The following three research questions form the basis for the research:

1. Which communication channels are used?
2. Which characteristics do the communication channels have?
3. Which actions can improve information flow between design and production?

2. Theory

Communication theory is not a coherent field and numerous different theories exit. Craig (1999) have investigated the different research approaches to communication theory and proposed seven different theoretical traditions who all have a different view on communication. The seven traditions proposed by Craig (1999) are divided according to their underlying conception of communicative practice and is divided as following: Rhetorical, Semiotic, Phenomenological, Cybernetic, Sociopsychological, Sociocultural and critical. To be able to further understand and advance into the communication theory all the traditions have to be taken into consideration. The objective of this article is not to advance into communication theory but rather to understand the information flow between design and construction.

Communication in the cybernetic tradition can be described as a transmission of information and knowledge between people, and is essential in complex building projects. Reinertsen (1997) states that most important quality of communication is not to increase the flow of information, but rather to reduce the need of information. This means ensuring that information reaches only the team members actually needing the information for their specific purposes. Speed and quality of the communication is much more important than the quantity of information (Reinertsen 1997).

Though being closely related, the design and production work are mainly carried out by different people with different knowledge and at different times. This creates a critical and difficult intersection between design and production (Røsdal and Ørstavik 2011). In this paper we consider design to be the group that consist of designers, engineers and the design manager. We consider production to be the group that consist mainly of on-site workers and their managers. Dainty et al. (2006) stress the importance of the communication channels imposed in the contract. The communication channels should provide good co-ordination between the different parties, make sure information regarding changes reaches all involved parties and create good communication between management and craftsmen within the contractor firms. Cockburn (2003) employ the term "communication effectiveness". Channels with high communication effectiveness, such as face-to-face conversations, transfer information faster than ineffective channels, such as one-way, written communication. Face-to-face communication has several attributes that create a good communication flow, like the use of body gestures and real-time question-and-answer. Written communication, such as e-mail, typically lacks of many of these attributes. According to Dainty et al. (2006), communication in the construction industry is traditionally seen as flowing through the lines given in the projects' organization charts, and through given, official communication channels. The communication flow in the project will equally depend, however, on relations between individuals, and communication might often occur through unofficial channels outside of the organization chart, both internally in a firm or between parties (Dainty et al. 2006).

Communication channels can be either asynchronous or synchronous (Hrastinski 2008). The communication is synchronous if a receiver can reply or comment immediately after the message is given. Such synchronous communication is current in face-to-face- and telephone conversations. According to Hrastinski synchronous communication provides a high level of motivation and commitment, precisely due to the fact that the receiver is able to answer quickly. Asynchronous communication, on the other hand, occurs in email correspondence and other written communication channels. Such communication lead to more reflected answers and make room for more time to process information.

Communication can be named as either informal of formal (Emmitt and Gorse 2003). Informal communication is information flow outside of the routes given by the organization. Differences between formal and informal communication channels can be associated with the degree of control, as the informal channels usually are largely unstructured. They are still used because they can be seen as shortcuts in getting information (Emmitt and Gorse 2003).

Meetings are often used as communication channels in building projects. Martin and Poulsson (1996) distinguish between transferring information and communicating in meetings. One party in the meeting might give information to others, or the parties can have a conversation and develop the information together. The authors state that the latter gives the best communicational value.

Sødal et al. (2014) state that communication between design and production might benefit from multi-disciplinary collaboration through the different project phases. The authors are of the opinion that there are no distinct disadvantages with early involvement of contractors in building projects. According to West and Gransberg (2014), such early involvement is, however, difficult to achieve in DBB-contracts compared to other project delivery methods. They state that other alternative delivery methods have several benefits because of contractor preconstruction involvement. According to them, contractor design input enhances constructability and innovation, and might even lead to lower costs. Emmitt et al. (2004) state that early design cooperation between design and construction gives the parties a sense of "ownership" and that communication as a consequence typically improves. The findings of this paper reveal contractor involvement in design to be a significant challenge.

3. Research methodology

The paper uses the Oslo Airport Expansion project as a case project. This is an extensive building project using DBB contracts. The research is based on an extensive literature review, a document study and semi-structured interviews with 13 project participants from – respectively – design, construction management and production at the Oslo Airport expansion project.

The case project is chosen mainly because of its high complexity – permitting to elucidate the factors examined – and because the main author has had a summer internship at the project, where he experienced communicational difficulties. Three contracts, out of a total of 93 in the project, are studied for common and varying features regarding information flow between the design team, owner and contractors. The research is carried through with a qualitative approach to reveal subjective opinions from the interviewees, who are employed at varying parts in the design, owner and production organizations, and might have varying needs regarding communication.

The literature review followed the steps specified by (Blumberg et al. 2011), 1) building of an information pool, 2) application of a filter to reduce pool size, 3) a rough assessment of sources to further reduce pool size, 4) an analysis of the literature in the pool and 5) the refinement of filters or stop search. Errors and omissions might occur where literature is misinterpreted, contain incorrect information or has low relevance to this paper.

The description of the official communication system used in the case project is based on a document study of the contract, which is available online. The main purpose of the document study was to reveal the formal communication channels and how they should be used in practice. Errors and omissions might occur where the contract is misinterpreted or important information overlooked.

In-depth interviews were carried out with employees from three different contracts in the building project. The main author had a summer internship working with the contract in case 1 prior to the research, and considered the information flow in the building project as fascinating, which is why the case was selected. The client's construction manager suggested the interviewees from this case. He also suggested the other two case contracts. The client's construction managers in case 2 and 3 suggested the interviewees from these contracts. The interviewees were employees from the engineering group, engineering group leaders, contractor management and contractor middle management. The client's construction managers working with the contracts in case 2 and 3 were not permitted by their superiors to participate in interviews, although informal conversations were made with them regarding

communication and information flow, as a supplement to the interviews. This denial was due to a general policy from the Oslo Airport, had decided to reject all requests regarding student thesis so close to completion date of the project. They wanted their employees to pay full attention to the project.

All interviewees were asked the same questions in order to make the answers more comparable. It was in the interviewer's interest to get the interviewees to talk about subjects they found important, so the questions were short and somewhat open for interpretation. Variation in experience and dissimilar interpretation of the questions may have caused results to seem more severe or less significant than they are in reality Errors and omissions might occur where the answers are misinterpreted.

The paper is limited to three case contracts from one building project, and mainly apply to information flow in DBB projects. The case project is a public building project, which might have other needs regarding communication than private projects. Since the case contracts are of somewhat dissimilar sizes, and at different stages in the process, they might have varying needs as well. They are also late in the production phase, so the needs might vary from earlier in the project.

The second research question mainly focuses on the formal communication channels, which for this project are ProArc (a drawing distribution software), forms and meetings respectively. Table 1 lists these channels' strengths and weaknesses. Arroyo et al. (2015) state that including both strengths and weaknesses will lead to a double counting of attributes to alternatives. However, since the intention is to see how the communication channels supply each other, and not to determine one, superior channel, attributes can be found under both strengths and weaknesses in the tables.

4. Findings

4.1 Formal communication channels in the project

The communication plan set by Oslo Airport is meant to support their visons, values and goals for the building project, as well as to strengthen Oslo Airport's competitive position and insure a good operation of the airport throughout the project. The communication system consists of drawing distribution through a computer software, meetings and forms for internal and external communication. The document study reveals that the design basis is distributed through a document management system called ProArc, which is an acknowledged documentation software for document control and distribution of drawings. The contract also mentions several types of form templates. There are different forms for different situations. The forms' main purpose is to document communication regarding uncertainties in drawings or changes in the product. Meetings are also arranged for synchronous communication between design and production. In case 1, the leader of the engineering group attends the weekly pre-construction meetings. Case 2 don't have regular meetings for direct communication this late in the project. Case 3 allows for direct communication between design and construction in weekly drawing examination meetings, with representatives from the engineering group, the owner and the contractor.

4.2 Strengths and weaknesses in the communication channels

The interviewees were asked which communication channels are used between design and production in the Oslo Airport expansion project. The most used channels were found to be ProArc, forms, meetings, e-mail, phone calls and informal face-to-face conversations.

Drawings, BIM models and descriptions are distributed through ProArc. The engineers send drawings to the engineer group leader, who forward them to a document center. The document center controls the drawings and distribute them in ProArc. The contractors get immediate access to these documents when they are added in ProArc.

Forms are mainly used for changes or questions regarding the design basis. In case 1 and 3, the forms are sent from the contractor to the owner, who passes them on to the design team if they are unable to answer. In case 2 the forms are sent directly from the contractor to the leader of the engineering group, with the client's construction manager on copy. Forms are sent back and forth by email, and then logged and stored in ProArc. Case 1 and 2 uses forms as a communication channel, but case 3 rather use them as a method of documenting a conversation subsequently.

As a supplement to ProArc and forms the owner arranges regular or special meetings with the contractors and/or the design team.

The interviewees where asked to express their opinion on ProArc, forms and meetings. The strengths and weaknesses extracted from the interviews are shown in Table 1. The plus sign indicates strengths, and the minus sign indicates weaknesses.

Table 1: Attributes of the formal communication channels

ProArc	*Forms*	*Meetings*
+ *Gives a tidy overview of the drawings.* + *Good traceability in the communication.*	+ *Two-way communication.* + *Good traceability in the communication.* + *Good for resolving extensive problems.* + *Good preparation for meetings*	+ *Two-way communication.* + *Good traceability in the communication.* + *Good for resolving extensive problems.* + *Good preparation for meetings*
- *The software is cumbersome.* - *Insufficient in urgent situations.*	- *Time consuming and cumbersome.* - *Poor response time.* - *Might be poorly formulated.* - *Very inefficient for resolving small problems.* - *Insufficient in urgent situations.*	- *Time consuming and cumbersome.* - *Poor response time.* - *Might be poorly formulated.* - *Very inefficient for resolving small problems.* - *Insufficient in urgent situations.*

The interviews reveal that the employees of the building project also use informal communication channels, mainly emails, phone calls and face-to-face conversations. These channels have several attributes that make them undesirable in the project, according to the interviewees. They have little or no traceability, which might cause information loss, misconceptions and quarrels. They are still used occasionally because they are less time-consuming than ProArc and forms.

4.3 Suggested actions for improved information flow

The interviewees were asked which communication channels they prefer, and the answers had significant variations. The contractors' foreman and construction supervisors seem to prefer effective communication channels such as informal face-to-face conversations, on-site meetings and phone calls. They are not very fond of written communication channels such as forms and emails. Effectiveness was stated to be important to the project managers in the contractor firm. They wanted the communication to be traceable, though, so they preferred formal meetings with minutes. The owner's representatives maintained that it is preferable if information flows through the official communication channels; ProArc, forms and formal meetings. Their least preferred method of communication was phone calls. All representatives from the design team liked to communicate with written messages through email or forms, since this provided them with the opportunity to consider their wording carefully before sending the message.

Several of the interviewees from the contractor firms states that the formal communication system focuses too much on traceability and documentation in the communication, and too little on effectiveness.

The study revealed that direct communication between design and production is allowed through certain channels in all the case contracts. In case 1 and 3, the design teams and the contractors meet up weekly at the regular meetings. The construction supervisor and the foreman from the case contracts stated that one meeting per week between the two parties is adequate. The interviewees from case 1 stated that the weekly pre-construction meeting satisfies the need of direct communication between design and production, as long as the leader of the engineering group is present. The client's construction manager described it as very effective that the engineering group can answer questions regarding drawings immediately. The leader of the engineering group himself maintained that most of the meetings treat matters where he lacks interest and knowledge. On the other hand, it provided insight in the production progress. This generally proves useful in planning the design progress. The contracts in case 2 and 3 do not include representatives from the design team in pre-construction meetings, mainly because they communicate directly through other channels. The leader of the engineering group in case 3 would prefer if he attended at least some of the pre-construction meetings to get more insight in the production progress.

The interviewees from case 3 has seen good use of the weekly drawing examination meetings. The structural engineer in case 3 stated that these meetings gives the parties knowledge of upcoming work, and helps prevent problems in production. Such problems might create higher costs and reduce the quality of the product.

The interviewees stated that direct communication outside of meetings creates a chaotic information flow where information disappears. Direct communication with email has occurred in urgent matters, but only with permission from the owner and with the owner on copy. In case 2 the owner is less strict with direct communication between design and production. Since the client's construction manager has to retransmit most of the forms to the engineering group anyway, he has allowed the contractor to send it directly, with the owner on copy. The leader of the engineering group in case 2 maintained that this is a way to communicate directly without losing the owners supervision, and claimed that this has worked well in this contract. No other interviewee in case 2 mentioned this as being a source of

communication problems. The client's construction manager in case 1 however claimed that the owner's representatives often can answer forms without help from the engineering group, and thinks that direct communication with forms would lead to unnecessary extra work for the engineering group.

The building project include a high number of complex components and structures designed by contractors and suppliers. The leader of the engineering group in case 2 thought that contractors should be engaged earlier so they can co-operate in team with the engineering group. The leader of the engineering group in case 1 also saw benefits in pre-construction contractor involvement.

5. Discussion

5.1 Formal communication channels in the project

The formal communication system between design and production seems to consist mainly of drawing distribution through a computer software (ProArc), forms for written correspondence and meetings (Figure 1). Informal communication channels, such as email, phone calls and informal face-to-face conversations, are primarily used as a supplement to the formal channels. In urgent matters, the informal channels might, however, be used to transfer new information.

5.2 Strengths and weaknesses in the communication

The communication channels seem to have great traceability, which is important in vast building projects. Unfortunately, high traceability in communication channels seem to lead to inefficient flow of information. The easiest traceable channels used in the project, ProArc and forms, are also inefficient. This is especially unfortunate for the workers who want effective channels. When formal communication channels have low efficiency, informal communication seem to be used more frequently. It seems like easier software for drawing distribution and better procedures for sending forms would improve the effectiveness and reduce use of informal communication channels. The interviewees also mention other weaknesses in the communication channels (Table 1). Some of the weaknesses in ProArc can however be disregarded by use of forms. ProArc is a one-way communication channel, but the contractors can communicate back though forms or meetings. Several of the weaknesses of forms are also eliminated by communication through meetings instead. Forms are for instance very inefficient for solving small problems, which can be solved in meetings instead. Still, several of the weaknesses remain, which may lead to use of informal channels, such as telephone, email or informal face-to-face conversations. Use of informal channels may reduce or remove traceability and tidiness of the communication.

Distribution of drawings through ProArc and correspondence by use of forms seem to be the key channels for a traceable and tidy information flow at the case project. These channels are however asynchronous and inefficient. Meetings, which supplement ProArc and forms, are more effective and synchronous face-to-face communication, and still have traceability. The high demands regarding traceability in the project seem to give much time waste.

5.3 Suggested actions for improved information flow

The case study seems to indicate that the communication channel preferences varies between different roles in the project. Workers close to production prefer effective communication channels, and do not seem to care much about traceability in the conversations. This might be because they are paid more for working fast and want to resolve matters quickly. Traceability is very important for the management from the contractor firms and the owner, probably because they are blamed if agreements cannot be traced in conflicts. Design prefer written communication. Many of the questions from production might be regarding drawings that were made long time back, so they can be difficult to answer right away. This might be the reason why employees from the design team like to prepare themselves before answering.

Direct communication between design and production is seen as valuable in all cases, but it is implemented in different ways. The most used methods are pre-construction meetings in case 1, directly sent forms in case 2 and drawing examination meetings in case 3. Pre-construction meetings are mainly process related meetings between contractors and owner's representatives, but by including a member of the engineering group, he can answer drawing related questions immediately. Drawing examination meetings are meetings between contractors and the engineering group, so they can discuss new drawing basis. Meetings seem to be a popular channel among the interviewees. Oral messages, and the fact that two people can communicate directly, gives high effectiveness and a low amount of noise, without losing the owners insight. The owner and the contractor in case 1 see great value in the attendance of the leader of the engineering group in the meetings, and the he gets insight in the production progress. Drawing examination meetings might not be as a good source of information for the design team though. The meetings are valuable for the contractors and the owner, but little information is transferred back to the design team, especially regarding building progress. Drawing examination meetings might however give better answers to the contractor, because it seems easier for the engineering group members to answer questions than in pre-construction meetings. Drawing examination meetings usually treat new drawings that are still fresh in mind, and since it is known which drawings will be discussed it is easier to prepare. In pre-construction meetings, the leader of the engineering group might get questions regarding drawings made several months back, and it seems more difficult for him to predict the meeting topics. Neither pre-construction meetings nor drawing examination meetings seem to give much room for two-way communication, but is rather used as a channel for information flow. None of the interviewees mentioned meetings arranged between design and production for cooperative planning, which according to the literature review is propitious for achieving common goals.

The literature study revealed that contractor pre-construction involvement is difficult in DBBprojects, compared to alternative project delivery methods. This seem to be confirmed in the interviews. The main problem in the case project seem to be good co-operation between the design team and contractors. According to the literature review, the best solution comes if both cooperating parties contribute in the planning. This would be easier to accomplish if the contractors were involved earlier in the project.

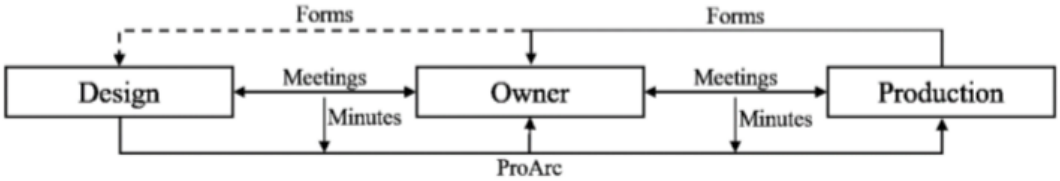
6. Conclusion

The paper has studied information flow between design and production in DBB contracts in three case contracts from one building project. It answers three research questions, namely: 1) Which

communication channels are used, 2) Which characteristics do they have and 3) Which actions can improve information flow between design and production. The findings mainly apply to that project, but lessons learned in the three studied contracts should have value for similar projects as well.

According to the interviewees in case 1, information mainly flows as shown in Figure 1. The figure does not include informal channels such as email, telephone, informal face-to-face conversations and other formal meetings, which are mostly used as supplement to the formal channels.

Figure 1: Formal communication channels of the case project (illustration by authors)



It seems like the formal communication system is too cumbersome and should be more adapted to the needs of the contractors, with higher efficiency, to improve information flow overall. Direct communication between design and production seem to work well if the owner's supervision is maintained, for instance by sending forms with the owner's representative on copy. This shortens the communication chain, and make forms more efficient. Meetings with representatives from the engineering group, the owner, and the contractor seem to be effective communication channels between design and production. Two types of meetings, that certainly improve information flow, are mentioned in the interview; pre-construction meetings and drawing examination meetings. The interviews seem to indicate that pre-construction meetings with a participant from the engineering group is a good method for meeting the engineering group's needs. Drawing examination meetings seem to be advantageous for the contractors. A good approach might be to arrange weekly pre-construction meetings with attendance from the leader of the engineering group, and drawing examination meetings when new drawing basis is delivered. The preconstruction meeting will give the design team insight in the production progress, which makes it easier for them to know when new drawings are needed. Drawing examination meetings is helpful for the contractor to clarify the drawing basis close upon production.

One of the biggest challenges in DBB-contracts seem to be co-ordination of design basis made by the engineering group and the basis made by contractors and suppliers. Contractors should be involved earlier and participate more in the design phase of the project.

Parts of the knowledge gap is covered in this paper, but for further research we recommend looking at the paper's limitations. One aspect that is revealed in this paper is the high demand of traceability in the communication at the case project. It would be interesting to study information flow in public projects further, to determine if there are evident differences to the private sector. Public project owners could be compared for common and dissimilar characteristics in the formal communication systems implemented in their building projects. We also recommend looking at differences between information flow in DBB projects and DB projects.

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Does Lévinas help us to trust?

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Abstract

Drawing on my personal experiences in the German construction industry, I seek to explore the relationship of trust, responsibility, and ethics from a Lévinasian perspective. Often responsibility is related to some form of accountability and business ethics to codes of ethics or ethical principles. However, drawing on the work of Emmanuel Lévinas one must question these principles and understand responsibility and ethics differently. To Lévinas ethics and responsibility stem from the encounter with the other, the ethical approaching of the Other. To him, ethics cannot originate from any general principle but must come before any theme, category, or principle. Therefore, he locates ethics and responsibility beyond any concept. To my understanding trust too belongs to this pre-conceptual realm.

As the owner of a medium size construction company, I explore my business environment, in particular, my professional conduct, using auto-ethnography to better understand the relations between trust, ethics, and responsibility and their manifestation in business practice.

Lévinas' understanding of ethics and responsibility before any concept requires an ultimate epochè. Therefore, all concepts, even the concept of language, must be dismantled. My difficulty is then to name, to describe something which is beyond fixed language. Therefore, my writing needs to be evocative rather than analytic.

I try to explore how ethical business practice accounts for the situation and the very way of interacting with business partners. I seek to understand ethics, responsibility, and trust beyond static principles. In that way, I try to show how one can maintain trust as a way of interacting. To maintain trusting relationships, one needs to employ first and foremost an attitude of care and forgiveness. Such an attitude, prior to concepts and principles, helps to deal with the inherent change and volatility in construction projects. This rather adaptive way of approaching trust might be helpful for actors in the industry.

Keywords: Trust, Forgiveness, Ethics, Auto-Ethnography Emmanuel Lévinas

1. Introduction

For almost 18 years I run my own construction company. I do employ 35 workers, most of them bricklayers and carpenters. We – as company – build the structures using brickwork and concrete. In my position as owner-manager, I have to deal with many stakeholders involved in the construction projects we are working on. Essentially, I am required to negotiate with most of them to advance our common projects.

Projects in the construction industry do often evolve throughout the design and construction process. Throughout this process new demands emerge, designs get amended, schedules change, etc. Very few project get built as they were initially planned. This constant change to the project requires some flexibility and adaptiveness from the stakeholders involved. It is flexibility with regard to how their contracts are lived, how they react to changing demand, how they try to solve problems, how they work together, how cooperation is lived.

Far too often I wrestle with the question of whether I should act trustingly or rather embrace a tight control regime. I wonder whether it is beneficial for me to trust or are the risks of betrayal just too high. I started off exploring my experiences in business with a broad focus on negotiation. I like to cooperate with others rather than fighting over everything from resources to prices. It is this wish to cooperate and the close link between cooperation and trust that made me focus on trust more and more.

In order to understand this relationship better, I try to explore the relationship between trust and control first from a philosophical perspective, then I delve into Lévinas thought, because his thought treats the relation between the self and Other extensively. Later, I seek to translate these insights into and connect to my business practice in the construction industry. Exploring Lévinas' work seems to be a worthwhile endeavour, since engagements with his work with regard to trust are few in number (e.g.; Peperzak, 2013) and to my knowledge, there is little done to translate insights gained from Lévinas about trust into managerial practice.

2. Auto-Ethnography

I am auto-ethnographer. Auto-ethnographers write about their personal experiences. Often, I sit down in the evening and write about the day. Sometimes it is just short notes sometimes longer stories. This writing is my means of recording what happened that day. I often focus on a single event, I write how it did unfold, what happened, what I thought at that moment. Sometimes I stop here with a description of one or two events during that day.

However, quite often it is only the start of a process. The event triggered some feeling, so I seek to explore these feeling. And then I recall earlier events maybe weeks, maybe years before. Often, I write and rewrite, inflate and shrink the stories. Then I try to connect these events to my readings in the literature. I ask how connect these events to theories. The writing does often begin quite focused on a particular event, but it becomes messier the longer I write.

Emerson, Fretz, and Shaw (2011) talked about a sense of significance which the ethnographer needs to develop. When I choose the event to write about it is often the events that impressed me most that day. However, while writing some detail, some side-note becomes more important. Reflecting in the light

of my readings gives some interpretations often a new twist or turn. It is this open process of wondering (or perhaps wandering) that make auto-ethnography so valuable for me. This way of making sense of my life is not a straightforward process. One has to imagine it as a constant back and forth between the stories and the interpretations. It is essentially a hermeneutic circle in which an understanding gradually emerges (Iser, 2000). But the process of understanding is, as it is inherent in hermeneutics, never complete and finished (Iser, 2000).

I may have, therefore, disappointed readers who sought for detailed procedure how I collected my field-notes and made sense of them. The procedures are less important to my approach I rather follow Richardson and Adams St. Pierre (2005) and understand my writing as a method of inquiry. Not a stringent regime of writing is important but curiosity about my experiences and their meaning and a constant scepticism about my understandings.

In conversation, we may sometimes hate the "yes, but …". However, this "but" is key to reflexivity in auto-ethnographic accounts. It is questioning how I as researcher or me as a practitioner (with some vested interests) influenced my interpretation and how did researching influence me. After each new insight, each new understanding pops up at least one "but." As soon as I think something I may question it – Lévinas (1974, p. 168) talks about scepticism which "follows" thinking "like a shadow" –which forms the bedrock of reflexivity. Reflexivity as scepticism is a substantial part of my 'writing as inquiry'. Then any description, any claim, any understanding is followed by a new question – 'why?', 'how?', or just a blatant 'really?'.

These questions help to unfold how I as a businessman of 15 years in the industry, as one being tired of exhausting conflicts, as one being stressed out by different demand are looking at my own experiences. I have an interest in people trusting me and me trusting people. Without a great deal of trust, I would not be able to cope with my life. That fact frames my research. Does it render my approach as invalid? No, it does not, it sets out a subjective framing that I try to make explicit so the reader can take it into account and read my work in the appropriate way.

I research my experiences, which is certainly a limitation of auto-ethnography, even worse I take only a look on my very close business environment which further limits my vision. Hence, my work is very strongly influenced by what I am. However, the narrow focus allows me to look close, to dig deeper. This is where auto-ethnography can contribute most – by close examination, by introspection. I can far more easily explore my emotions and thoughts than that of others. "Such introspection offers intimate knowledge" (Pelias, 2013, p. 387) which other methods have difficulties to yield. But still, I present here my interpretations of events, in the light of the theories I reviewed, yet others may come to a different reading of the events I encountered. Even I may understand them differently later.

3. Trust

Although I started off with a broad interest in how to make negotiations less competitive and more cooperative drawing on the work of Fisher and Ury (1981), throughout my ethnographic journey, I focussed more and more on trust. It is this hermeneutic process that leads me to understand that trust plays a central role in cooperative negotiations. Therefore, my interest shifted to the quest of what trust is and how I may be able to enhance and maintain trust in my business relationships. This interest in trust is the point of departure for this paper. Therefore, I may begin with demarking the territory.

In order to cooperate, we need to trust other. My experience in the construction industry suggests we are well advised to build well-working trust relationships with the persons we work together on our project. It is not the question whether we trust because a complete lack of trust would prevent us from getting up in the morning (Luhmann, 1973; 1975) let alone seeking to build a house. Trust is so prevalent in our personal relationships that we often do not recognize it, although if it declines, we become aware of its importance.

To trust means to me to belief in the goodwill, the benevolence of the person I am interacting with. On the basis of trust, I hand over discretionary powers of things valued to the other person (Baier, 1986). To trust another person is not based on a calculation (Williamson, 1993) it is rather the very point where rationality fails. When we cannot calculate when rational prediction fails to answer the question whether the other person in front of us is going to do what is in our best interest we are supposed to trust. At the end of rationality, we need to take the 'leap of faith' and trust (Möllering, 2006)

What do we mean when we say we trust? To Baier (1986) to trust is to hand over discretionary powers over things valued. Take this example, some time ago a client handed me over the keys for his house to do some work while he and his family left the house for vacation I would argue that he trusted my staff and me. He might have believed that we were capable and willing to fulfill the given task. At the same time, he believed that we would not abuse our powers but act benevolently towards him (Mayer, Davis, & Schoorman, 1995). The power he gave us – my staff and me – made him vulnerable to our action and in particular to ill-will and betrayal. That is the central distinction between the concept of reliance and control. I can perfectly rely on a machine to work properly, but the machine does not have the power to betray me nor does the machine have any good or ill will (Baier, 1986). Therefore, trust is a concept that only applies to the relation of humans.

It is this feeling of vulnerability that makes me sometimes feel uneasy when I trust the person. And it is the possibility of being exploited, betrayed or disappointed which does prevent me from trusting altogether. I am able to limit the vulnerability to other's action. For instance, I may impose sanctions or measures of deterrence within a contract so that if the other party does not comply it gets punished. That works to some extent, but the force of such control mechanisms are limited. These measures work as guarantees for compliance, but no guarantee is watertight (O'Neill, 2002a). When I just consider the complexity of my construction project and their ambiguous nature I must fail to design control mechanisms beforehand when the design of the building is not even finished when we start to build it. We cannot control a process completely from which we do not know the outcome nor how the process might evolve. It is this ambiguity that requires me to trust. I do not know completely, I, therefore, cannot control and must take the leap into the unknown – I must trust. If I would know, if I did control, it would not be trust it would be reliance.

However, a common response to a lack of trust is ever more control. Although it is the case that some control works as a springboard for trusting (Rousseau, Sitkin, Burt, & Camerer, 1998); too much control, in fact, suppresses trust (O'Neill, 2002b). Even worse, control is often very resource consuming. In the end, control does not seldom cost more than a breach of trust would (Weibel & Martens, 2016).

But a utilitarian view on trust – as means to save cost – could miss the point of what trust actually is and therefore how to enhance trusting. It would make trust a variable in a calculation. However, the

utilitarian view of trust is contrasted by an understanding of trust as "in a certain sense blind trust" (Giddens, 1990, p. 33) and 'quasi-religious faith' (Simmel, 1907). Therefore, "[t]rusting someone thus involves more than a necessary or inevitable result of the correct evaluation." (Peperzak, 2013, p. 24) Trust is then something different than reasoning. Drawing on Løgstrup (1997), Frederiksen (2014, p. 35) regards trust "trust as a fundamental category of social life" and separates trust and calculativeness as two different modes of interaction. If calculation is ontology and trust is something different, it leads me to the very basic quest of what is being and is there something else.

Some time ago I came across Emmanuel Lévinas' work through the help of a senior tutor. Lévinas has dealt with the question of the origins of being, of ontology extensively. Lévinas (1961) says that our categories are limited and the limited totality of our understanding cannot account for our relationships fundamentally different others. Williamson (1993) and Frederiksen (2014) demonstrated the same limitations of calculation. Therefore, one has to look beyond calculation, beyond ontology to understand trust. Lévinas has not dealt with trust as such, but his thinking goes beyond ontology towards a relationship to the Other which is not based on rationality but an ethics of responsibility (Lévinas, 1974). There are two important reasons why to explore Lévinas' thought: It is this combination of beyond rationality and ethics of responsibility in Lévinas work and that his thinking is based on a relation between the Other and Self – the interpersonal level I am interested in.

4. Lévinas Thought

"*But being must be understood on the basis of being's other."* (Lévinas, 1974, p. 16)

To Lévinas we are first of all subjective. Our consciousness only develops because we are encountering others. Central to his thought is the 'Other'; which is another person. This person's otherness, alterity, is not about personal traits. It is not about race, gender, profession, blue or green eyes – it is that this Other is just not me. All the traits fall into my categories – I know how blue looks. But I do not know how it looks for the Other simply because I am not this person. (Lévinas, 1961)

This other person escapes my grasp. I can never entirely translate the Other into my categories. The Other "infinitely overflows the bounds of knowledge." (Lévinas, 1962, p. 12) This overflow, this very inability to grasp the Other connects to the observation that incomplete knowledge of the persons I am interacting with is impossible (e.g.; Baier, 1986; Möllering, 2006; O'Neill, 2002a). Therefore, I need to trust. Yet it goes even further.

Encountering the Other(s), we form our own consciousness. We translate our sensing – feeling, seeing, smelling, etc. – of the Other into our own categories. Lévinas calls these categories the Said (Lévinas, 1974). The Said, however, is produced by Saying. To Lévinas Saying and Said have a completely different meaning (Davis, 1996). Saying is to Lévinas responding to the Other. It is giving signs – in form of literally saying something to the Other or communicating in any other way. The meaning I address to the Other's utterances is then the Said.

The responding to the Other is already there before I am conscious. It is Saying before I am aware of what I say. Through this process I create meaning; it is the creation of the Said, which is my categories and concepts. The Said is ontology, is being; Saying is pre-ontological, is being's other. It is primordial sociality, prior to any concepts in the realm of being. Saying is beyond being. Because we create our

own being only through the encounter with the other, it is exactly this encounter with the Other in which I become infinitely responsible towards the Other. Without the Other, I could not become my own self. Hence, this approaching of the Other, responding to that other person is in the first place an ethical relationship (Lévinas, 1974).

But it is a responsibility distinct from what we often understand of the word. It is responsibility before any concept. It is not to be understood as "[s]omebody is responsible for something to somebody […]" (Waldenfels, 1995, p. 40) That would imply to give reason for my actions, but that is what Lévinas seeks to avoid. He rejects responsibility as subjected to reason because "[t]his interpretation of the world of words and things, however, presupposes that there is only one order to which our saying and doing can be coordinated or in which it can be incorporated [...]." (Waldenfels, 1995, p. 41) To Lévinas responsibility must come from beyond reason. Reason is always part of a totality. Lévinas wants me to move beyond that, to be good before I reason. I have to be good and benevolent to the Other before I think about it. It is therefore not accountability as it is used in contracts. It is responsible responding – responsible to and for others.

If, however, responsibility would be understood as accountability, subjected to reason, responsibility would be part of ontology; it would presuppose and all-encompassing totality, not allowing for the Other. But the Other in its alterity escapes, I cannot understand the Other's "saying and doing in a non-ambiguous way." (Waldenfels, 1995, p. 41) Hence, "the response does not primarily refer to something which is said and done but rather to something which has to be said and done." (Waldenfels, 1995, p. 41) To be responsible in Lévinas' sense means to care for and to be open towards the Other.

Every person that I interact with is essentially the Other in Lévinas' terms. This person is beyond what we can essentially grasp. The Other "escapes my grasp by an essential dimension, even if I have him at my disposal. He is not wholly in my sight" (Lévinas, 1961, p. 39). I cannot ever know the Other, and I am far less able to control the Other. I must trust for the very sake of interacting – for the sake of becoming my own self.

5. Trust as ethical condition

"I am commanded, that is, recognized as someone capable of realizing a work. […] But for this command to not involve humiliation […] the command I receive must also be a command to command him who commands me. It consists in commanding a being to command me." (Lévinas, 1954, p. 43)

It is inevitable for me to interact with others and therefore I am required to trust them. In approaching an unknown Other, I must believe that she or he does not hurt me. Therefore, I think trust belongs to the ethical approaching of the Other; trust is Saying. To Lévinas ethical approaching of the Other, in showing responsibility for and to the Other, but I also command the Other implicitly. Yet, it is not reciprocity, whether the Other follows my command is entirely the Other's affair (Lévinas, 1982).

I may illustrate this back and forth by this little episode:

> *"On a sunny June's morning, I walked through the rather small building site with my foreman. My company worked on this building site for a couple of weeks already, and we were about to finish our job there. Then my foreman said something like, "we haven't touched this part of the*

building, but I have to show you." My foreman already told me about the cracks in the old column, but when I saw them myself, I knew we had to do something about them. The cracks, two of them, were some 50 cm long and almost 1 cm wide. That in the middle of a column of 40 by 40 cm. I jokingly said to my foreman that "the column is not collapsing only because it is used to withstanding the load." I called the architect from the building site to tell him about the cracks. He already knew about them and knew that we had to fix the cracks. He asked for a price, and I told him a rough estimate. Without long hesitation, he told me: 'Do what you think is best.' That was it."

We had not touched the column nor were we in any other way accountable for the cracks. My foreman saw them, and he knew that something should be done about them. Telling me and subsequently, the architect about the cracks is taking responsibility for the cracks without being accountable for them. The foreman used the phrase that something has to be done about them. But still, there was no way to claim that we were accountable to do something.

But more interesting is the response of the architect. He gave us wide-ranging discretionary powers. 'Do what you think is best" is letting us chose on his behalf. It might even imply that he thought that we knew better than him what to do. We took responsibility for the cracks and got rewarded by being trusted. We did implicitly demand that from the architect. He did respond exactly in the way I 'demanded,' but one should be careful not to call it reciprocity. Whether the Other follows my command is entirely up to the Other. "Reciprocity is [the Other's] affair." (Lévinas, 1982, p. 98) Hence there is no way of claiming trust from the Other. It would make little sense since a conscious decision to trust someone is impossible. One "cannot trust at will" (Baier, 1986, p. 244). It is impossible to choose to trust.

6. Relaxation of control

It is here that it becomes evident that I am powerless when it comes to trust. I cannot choose to trust someone nor can I force or coerce someone else to trust me. I offered the architect to trust me, because I assumed (or better my foreman) responsibility for the cracks. He did trust me, but if he were not, I could not have done anything. He was 'not at my disposal' (Lévinas, 1961), even if I were to die for it I could no claim reciprocity from the Other (Lévinas, 1982).

Although the relation to the Other is asymmetrical, it is still one that is significantly formed by mutual trust. It is the Other that cannot live without others around him too. The Other needs to trust in the community. "At the very heart of this community […] is the ethical relation." (Large, 2015, p. 44) The Other might behave unethical towards me, but at some point, the Other must be ethical. Otherwise, he or she ends up in solitude.

Therefore, I cannot say for sure whether another person might respond to my ethical approaching but at least quite a lot of persons will do. And more importantly, if I were acting unethically towards all Others I would end up in solitude. I could not live that way. We see that in business life very vividly. We can argue with some persons, and I certainly do that. I must admit that it is sometimes unethical what I am doing. But at the same time, I need partners I to have a working relationship with. I need to trust them, and I need them to trust me otherwise, I would live in a world of enemies.

At first sight, it looks as if I could not cope with the demands that stem from permanently controlling people. I will never get watertight guarantees (O'Neill, 2002a) nor am I able capable of completely controlling others. It looks as if I were too limited to do so. It is though deeper rooted. Given Lévinas account, the very way I control other persons – through my knowledge, through the Said – is based on the ethical relationships I maintain. When control is based on something which is beyond control – the Saying – I should be careful not to spend too much effort in a task which in final consequence must fail.

More important, though, control is always violence towards the Other I am interacting with. When I try to control the Other, I translate this other person into my categories. I do not preserve the Other's alterity. I try to make him or her the same to me because I seek to subdue the Other to my categories. But the alterity of the Other is a great gift for me. The Other comes up with different ideas, different thoughts and new inspiration I could not have on my own – the Other's world is different. I need the Other to develop myself. It is that we – the Other and me – become one for a task we could not fulfill on our own (Peperzak, 2013). I need the Other to contribute, and the Other needs me. Without him or her, I would live in deafening silence (Large, 2015) – creativity would come to a grinding halt. Hence, I not only must respect the Other, but I am also required to preserve, to embrace her or his otherness. I must be prepared that the Other thinks, responds and acts differently from what I expect or want. I must anticipate forgiving him or her.

7. Responsibility and Forgiveness as Key to Trust

"Here we have a reversal of obligation. It is the offended party who worries about the forgiveness, for the sake of the offender, and decided to appear before the person who insulted him." (Lévinas, 1968; 1977, p. 22)

Forgiveness makes it possible for me to trust you in the first place. The other is another person and not me. Therefore, the Other thinks and acts differently. The architect when telling us to "do what we think is necessary" he implicitly opened the space to forgive us to some extent. He did not specify what we were supposed to do about the cracks. He left it to us. Hence, there was a range in which we could move without being blamed for anything. When I trust my foreman to do the work properly, I must be prepared that he does it not in the way I would have done it (or liked it to be done – I am an engineer and not bricklayer. Hence I cannot do his job). In other words, I must be willing to forgive. If I cannot forgive, trusting would become an issue of huge distress for me.

I would constantly fear to be disappointed. I would permanently seek to ensure that things are done in the way I would like them to be done. The margin of discretion left to the trusted would be minimal. And even that small range of free decision would cause me sleepless nights. A lack of forgiveness on both sides – on the side of the trusting for unwanted outcomes and on the trusted's side for criticism – is likely to destroy relationship rather fast .(Baier, 1986)

If I am able and willing to forgive, on the other hand, I can be relaxed. I can rest assured that I will be able to cope with the future outcome of my trusting. If the trusted delivers what I expect, then fine, I am a lucky person. If the trusted does not, I am going to forgive him. It is here that Lévinas opens two alleyways. "There are two conditions for forgiveness: the good will of the offended party and the full awareness of the offender." (Lévinas, 1968; 1977, p. 25) But since I am responsible for the Other I have

to take care. That means, in essence, I may seek to make him aware of what has gone wrong, to make him conscious how I expected the Other to act.

Even if awareness is lacking we are not lost, since "[o]ne can, if pressed to the limit, forgive the one who has spoken unconsciously." (Lévinas, 1968; 1977, p. 25) If we cannot bring our point across, we are still in the position to forgive. For the future task, it does, however, mean that we have to think again. Either I can live with the way the Other does it – I forgive in advance – or I give the task to someone else.

Drawing on the cracks-example again: I knew the architect for a while. He knew what my engineering capabilities are. Hence, he could leave his expectation open – "Do what you think …" Leaving it that open does, however, imply a mixture of flexible expectations or anticipated forgiveness. It is a hermeneutic circle of trusting and getting feedback in the form of fulfillment in whatever way of the tasks given. And it is my responsibility to figure out what to expect; I am the one who had given the task. I may amend my expectations or help the Other to do what I want.

I am not talking about controlling the Other I talking about the ongoing process of communication. I must engage in an ethical saying towards the Other. In that, we produce the Said as a framework within which we work. However, I must be aware that this framework is incomplete. It will never resemble the infinity of the saying. I can never know for certain what the Other is going to do.

It is not trust that we have to build; I think trust is already there in human beings. It is rather the framework of interaction that we need to build. It is as Weick (2006) outlines a movement between structure and entropy. Life to Weick has a tendency towards entropy. However, in order to organize our lives, we need some structure, but not a total structure. That would stifle our lives; we would not have the air to breath. We need here and there some guidance but enough freedom – entropy – to create new things. The Said gives us the structure, but we need the Saying to create something new.

For that reason, I need a mindset that allows the Other to be not me but a truly another person. I must not seek to control her or him. I may implicitly command the Other but would I apply forced influence on this person, I would rob the Other's otherness. In consequence, I can only change myself, I can think differently, I can act differently, yet I am responsible.

After some altercation between some members of staff in my company, I complained to my father about it. He just said, 'people behave like that, that has always been the case."

He did that not in a mood of resignation but in his forward-looking way. It sounded to me like an urge to get used to something I cannot change, should not even attempt to change, just get along with it. They are going to lay down their animosities. It sounded to me as if I should not worry about it too much and forgive them for their fight.

To me, it is the construction industry's ambiguous nature that makes trust so important in our industry. There is no single project I was involved in which was finally build as it was designed in the very beginning. During the process of designing and building something – from the first idea to the finished building – the design is all too often changed. That is the very nature of our business; there are too many stakeholders involved, and projects are too complex as to render it possible to finish the design

in before commencing the construction process. Hence, we ought to deal with the ambiguity of our profession in a responsible way. For that, ethical behaviour, ethical as outlined by Lévinas, is crucial in order to make the building work run smoothly.

Some years ago, when I argued with a client, an architect I knew for a while said, 'Never stop talking. It the only way out of a conflict.' I assume he was not aware of Lévinas' notion of saying, however, talking – saying – is the creative power that may resolve conflicts by creating something new. In his mind, it was some unknown option which might work for both conflicting parties.

However, saying is far too often not seen as an option. Ethical behaviour is often regarded as weakness. The very contrary picture I see on huge public construction sites all over Germany. Devastating competition forces contractors use almost all means to make the project profitable. Once the ethical attitude of the persons in charge is bent in favour of opportunism, it becomes a viscous spiral of contractual fighting. It does, therefore, most the time end in litigation. I doubt this atmosphere does serve the persons involved nor the image of the industry as a whole.

8. It's me who trusts

"One recognizes morality by its gnawing sense of unfulfilledness, by its endemic dissatisfaction with itself. The moral self is a self always haunted by the suspicion that it is not moral enough." (*Bauman, 1993, p. 80*)

It is on the one hand terrible to realize how large the responsibility is that bears on my shoulder. It is infinite. But on the other hand, it is all in my hands. I can choose to act ethically; I can choose to act trustingly. It is entirely up to me. It is my deliberation whether I seek to be ethical or selfish. Nobody else can decide that for me nor should someone else do that. I am the one who makes it possible to the other to trust me. Only I can offer me as a trustworthy person.

Acting ethically and trustworthy has certainly its limits. I need to care for myself. "Only a subject that eats can be for the other[…] (Lévinas, 1974, p. 64). I have to take care of myself in order to be able to act ethically. I also have not taken the Third – the other Other – into account here. I may choose towards which person I act responsibly. Yet, my aim is still clear: caring for and forgiving the Other, as opposed to a tit-for-tat strategy, is perhaps the only way of avoiding ongoing conflicts, making relationships work and projects a success. I should try my best to be an ethical person.

However, since it is already something I cannot fulfill entirely, I am in the position to forgive me for not being as ethical as I should. Still, I should not rest and strive for acting ethically, acting trustworthy. It is an 'utopianism' (Wright, Hughes, & Ainlley, 1988) but it is worthwhile to follow. I only have to consider the implication of the opposite. I could not live in an environment of only enemies. Therefore, it is better for me to act ethically (as far as I am able to) and 'command' others to trust me.

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Downfall in the Oil Price; Challenges and Opportunities for the Construction Industry

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Abstract

The effects of declining oil and gas prices are being felt by economies around the world specifically oil-producing countries. The petroleum industry being the most important industry in Norway, not only contributes to the wealth in the country, but is also a very important driver for the innovation and technology development in other sectors especially the construction sector. Therefore, the current global economic situation and its impact on major oil and gas capital projects have made construction productivity improvement more and more important. Nevertheless, according to the Ansoff's theory of weak signals, strategic surprises, such as downturn in oil prices, do not appear out of the blue; rather they may be detected with the aid of pre-emptive signs, which may be referred to as early warning signs. The purpose of this study is to investigate whether an early warning system could have predicted the extent to which the oil crisis would affect the construction industry in Norway, allowing the industrial actors to react strategically ahead of time in order to exploit the opportunities created due to this situation and maintain and improve productivity under these circumstances. This is done through identifying the possible key leading indicators which could be measured in early phase of the downturn in oil capital, in order to discover these early warning signs. The next step is to verify how early a potential disruption could be predicted based on these indicators and how the industrial actors could accordingly react to this situation. This research is based on literature study including scientific publications, newsletters, white papers and available data obtained from selected news volume. The research results contribute to better understanding of the benefits of early warning systems in order for the main actors within the construction industry to effectively manage disruptions in the related industries.

Keywords: Construction industry, Downturn in oil prices, Early warning system, Opportunities

1. Introduction

Norway is a small open economy, but according to the Ministry of Petroleum and Energy, it is today the 7th largest producer of oil and the 3rd largest producer of gas in the world. The petroleum sector accounts for 21.5% of its Gross Domestic Product (GDP), and almost half (48.9%) of total exports. In 2013 Norway was ranked the 15th largest oil producer, and the 11th largest oil exporter in the world. It is also the biggest oil producer in Western Europe (Buvarp, 2015). This leads to the country being vulnerable to the volatility in the oil pricing. Just to illustrate, in the course of the last two years nearly 30,000 people have lost their jobs in oil and gas as a consequence of falling oil prices and a delay in investing in productivity growth in the sector (Mohsin and Holter, 2016).

The construction industry is one of the industries which has been strongly influenced by the fluctuations in the oil price. This is due the fact that the building and construction industry is sensitive to fluctuations in the market, and is often the industry that registers the first signs of major changes in the economy (Ministry of Trade, Industry and Fisheries, Norway, 2001). The falling oil prices have posed a major challenge to the growth of the construction sector in a number of oil-producing countries specifically the Gulf countries (Nagaraj, 2015). This article looks specifically to the effect of the oil price on the Norwegian construction sector from a proactive management perspective. This is done through early identification and response to the signs of major changes within the sector. These signs are referred to in the literature as "Early Warning Signs" (Nikander, 2002). Identification and reaction towards these signs leads to more successful proactive management of the situation created due to the major changes.

The purpose of this article is to review selected data and information, extracted from various sources, in the early phase of the downturn in oil capital in Norway, in 2014, and investigate the potential value of an early warning system for construction project managers to proactively act on economic disruptions, such as down fall in the oil price, in order to exploit the possible opportunities lying under these situations. This will be done through introducing a list of key leading indicators which if measured and taken into account timely, can show indications of the future developments within the construction industry. Note that despite the importance of geopolitics in the oil and gas sector, discussion and analysis on the geopolitical factors which impact the oil price are out of the scope of this paper. The scope is narrowed down to the impacts of the downfall in oil price on the construction industry in the Norwegian national level.

The research questions covered in this article include: 1) What is the effect of downfall in the oil price on the construction industry and 2) What are the leading indicators which can give an indication of the potential effect on the construction industry, in the early phase of the development of the construction sector towards its current situation?

2. Theoretical background

2.1 The effect of the downfall in oil price on the construction industry

The significant fall in oil prices since mid-2014 has influenced the construction industry around the world in different ways. In this study, the construction sector is referred to as the sector which comprises the construction and maintenance of houses and commercial buildings, and the development of roads, airports and facilities related to defence, energy, oil, gas, railways and tramlines. According to the UK

economic outlook, the construction sector in UK could gain significantly from a reduction in the oil price (Pwc Network, 2015). This is due to the rise of business investment following the rise in intermediate demand and consumer spending, thus the construction industry becoming the key beneficiary. The CECE Annual Economic Report (2015) also states that since 2014, growth has finally returned to the European construction sector. This should even accelerate further in 2015. One of the drivers of this growth is mentioned to be the purchasing power gain due to the decline in oil prices. Another overview of the European construction market also indicates that this market has started growing since 2014 and will continue the growth in the next 5 years. For example, the Norwegian construction sector output is forecasted to grow by 5.04% in 2020 which will double comparing to 2014 which is 46 Billion Euros (Buildingradar, 2015).

Although the construction sector is highly sensitive to fluctuations in the market, the downfall in oil price has not highly influenced it in a negative way, this could be due to the fact that only 25% of enterprises in the building and construction sector have petroleum related sales (Brander et al., 2013). There could be also other reasons such as lower construction costs which make it cheaper and easier to move supplies and other necessary materials to construction sites and transport of stones and waste (Construction Monitor, 2015). A third argument can be the weakening of krone due to the downfall in the oil price which according to the Norwegian finance minister *"even though a lower oil price represents a problem to the oil and gas industry, the krone now represents improved competitiveness for the rest of the Norwegian industry"*. In addition, while unemployment is rising nationwide, it is falling in those parts of Norway that aren't dominated by the oil industry (Mohsin and Holter, 2016).

Nevertheless the information presented above are all published following the fall in the oil price in 2014. This study tends to investigate the potential value of an early warning system for construction project managers to proactively manage disruptions within the national market, in order to exploit the opportunities and maintain productivity.

2.2 Strategic Early Warning Systems (SEWS)

A central premise of this study is the theory of weak signals, first introduced by Ansoff (1975). Ansoff's idea was to seek an improvement to the strategic planning method, as it did not function satisfactorily when sudden changes or unanticipated discontinuities occurred in a business environment. Ansoff also uses the term "strategic surprise" to describe these discontinuities. A concrete example of this discontinuity is the oil crisis in the 1973 when the members of the Organization of Arab Petroleum Exporting Countries (OAPEC, consisting of the Arab members of OPEC plus Egypt and Syria) proclaimed an oil embargo. By the end of the embargo in March 1974, the price of oil had risen from $3 per barrel to nearly $12 globally; US prices were significantly higher. This had many short-term and long-term effects on global politics and the global economy (US department of state, office of the historian, 2013). In these cases according to Ansoff (1975), the usual approaches for trend monitoring and planning based on them was not sufficient. Ansoff indicates that strategic surprises do not appear overnight; there are always signals or symptoms of surprises to come. This theory has been strongly criticized by other researchers. Makridakis and Heau (1987) in Nikander (2002) stated that this theory has remained an academic idea. Webb (1987) in Nikander (2002) also indicated that it is crucial to investigate whether these signals actually exist. However there are also some other researchers that confirm the existence of these signals (Betts, 1982; Mintzberg, 1994).It is interesting to point to the work done by Weick (1979) which indicates that "organizational sense making" provides insight into

factors that surface as organizations address either uncertain or ambiguous situations. This work, although is not directly related to Ansoff's theory of weak signals, but alike the weak signal theory points to the importance of human actions in prevention or management of critical situations.

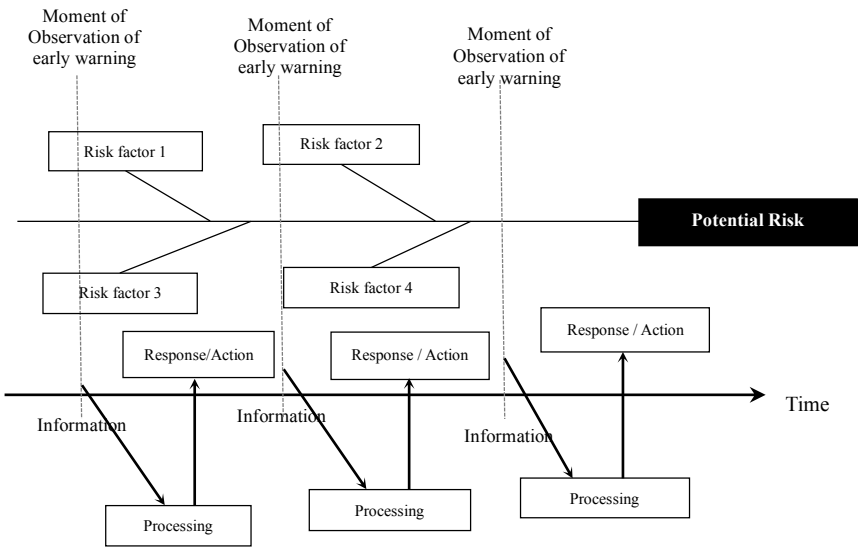
It is worth mentioning that there are many other fields which directly or indirectly deal with the concept of EW signs. The published information on the EW concept of possible problems covers a large range of areas from health related aspects to technical areas such as risk and safety and financial and economical fields. Due to the importance of EW signs a number of EW systems have been developed within these fields. Examples are the economic distress indicators model (Kaminsky and Reinhart, 2000; Zhuang and Dowling, 2002; Cheang, 2009) in the field of finance and Resilience based EW indicator (REWI) (Øien et al., 2010) in the field of risk and safety.

This study is based on the assumption that weak signals /early warning signs do exist and with hindsight it is often possible to point out the most likely factors leading to a future development, either of positive or negative nature. The early warning phenomenon is closely linked to the risk management concept via the concept of "risk symptoms" (Nikander, 2002). However it is according to Niwa (1989), the information provided by an Early Warning (EW) about the time available before the risky event becomes real, is not the same thing as the probability of materialization of a risk. These two concepts do not substitute each other and are not opposite factors. Rather they supplement the total knowledge. Based on these definitions an EW sign is defined as following (Hajikazemi, 2015, p.12):

"*An EW sign is a specific element, happening or event which shows that the risk event will actually realize. The EW sign does not provide information on the exact time of the materialization of risk; neither does it reveal its expected magnitude. Rather it acts as an alarm which triggers action in order to either prevent the realization of the potential problem or possibly lessen the undesired consequences*."

It should be noted that by risk, the authors mean both upside and the downside of the risk. In fact a risk can be turned upside to ones advantage by the opportunities it provides. Figure 1 presents the interconnectedness of the concepts; risk factor, potential risk, EW and response.

Figure 1. Interconnectedness of concepts (Hajikazemi, 2015)



In case of strategic discontinuities or surprises, a Strategic Early Warning System (SEWS) allows organizations to react strategically ahead of time by detecting EW signs which can be perceived as important discontinuities in an organizational environment. The EW information, at this point guides and empowers people to take actions when a crisis is close to happening. Effective early warning systems embrace all aspects of emergency management, such as: risk assessment analysis, which is one of early warning system's design requirements; monitoring and predicting the intensity of the development about to happen; communicating alerts to authorities and to potentially affect; and responding to the situation (Grasso and Singh, 2011). In this article, the main risk under study is the growth within the construction sector in Norway The aim is to investigate the contribution of a SEWS for more effective proactive management by the construction project managers. The authors believe that the SEWS can be used as part of the strategic planning method that the project managers can use to make flexible long-term plans. This can be done through scenario planning. According to Ringland and Owen (2007) *"Scenarios do not predict the future, but they do illuminate the drivers of change: understanding them can only help managers to take greater control of their situation."*

3. Research approach

The information which builds the foundations for this article has been gathered through studying published literature within scientific journals and conferences and also selected news volume which mainly focus on the downfall in the oil price and the effect on the construction industry worldwide. In addition, a number of Norwegian governmental documents which include the budgeting plans and records, have been studied. This has been followed by several structured discussion sessions where the authors, who have in total over 30 years of experience working in both the oil and gas and the construction sectors in Norway, have analysed and discussed the gathered information. The main focus of this research is to investigate if the signs of the development in the construction industry were identifiable in the early phases of the development process, which in our case is in mid-2014. The authors have endeavoured to combine the findings from the literature and their personal experiences in order to illustrate a case which is of interest for the actors within the construction industry. This has been done through development of two different scenarios regarding the possible influences of the oil price on the developments within the construction industry. The scenarios are validated by studying trends and other indications from the time prior to the realization of the upside risk, in order to illustrate that the identification of early indications of the current development within the construction industry would have been possible in advance.

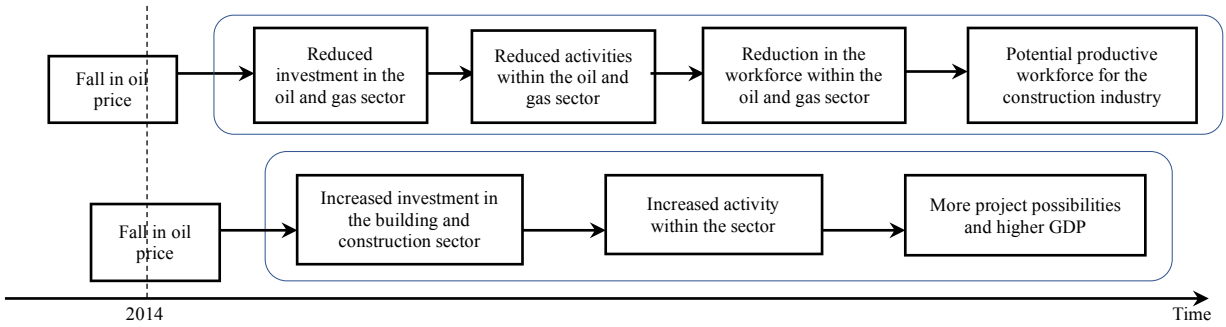
The research approach applied in this study was inspired by Siggelkow (2007) who indicates that *"it is much harder to make a paper interesting whose findings or conclusions only address theory. A paper should allow a reader to see the world, and not just the literature, in a new way"* (p. 23).

4. Early indications of the potential opportunities for the Norwegian construction industry

As earlier mentioned, the decline in the oil price has not had severe negative consequences for the construction industry in Norway. This sector has rather experienced a growth since 2014 when the downturn in oil price occurred. A clear example is the approximately 200% growth in the total turnover in Veidekke, a leading Scandinavian construction and property development company with about 6,400 employees, since 2014.

This can be due to different reasons which were partly described in section 2.1. In this section, two different scenarios will be presented as the reasoning for the growth within the construction sector, following the downfall of the oil price (Figure 2). The next step is to investigate if there are any indicators which if monitored prior to 2014, could show indications of the development of the construction industry towards the ending points of these scenarios.

Figure 2. Two scenarios for effect of the oil price on the construction sector

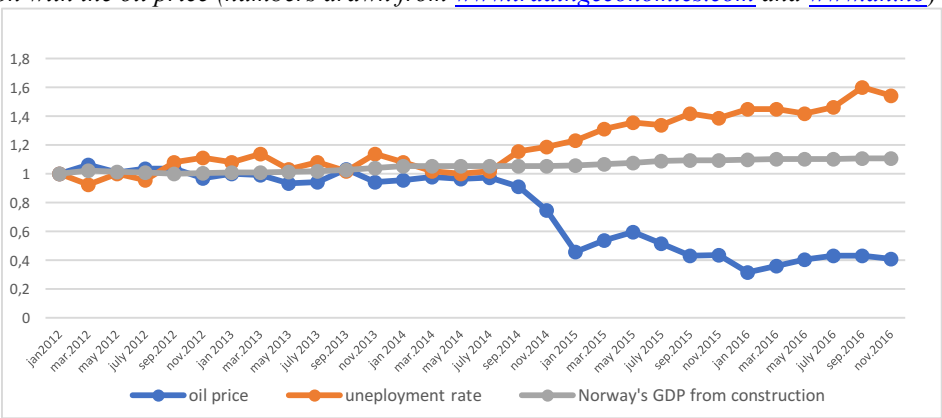


Scenario 1: The fall in the oil price has resulted to reduced governmental investment in the oil and gas sector, thus reducing the activities and projects within this sector, leading to a high unemployment rate. The skilled resources will thus be available in the market, creating an opportunity for the construction sector to hire productive and skilled workforce.

Scenario 2: The fall in the oil price, although hurts the economy in every oil producing country, but is a testament for to the strength of the Norwegian construction industry that the country's GDP from construction not only hasn't declined since mid-2014, but has grown significantly. This is due to increased investment within the construction sector. Figure 3 shows the growth of Norway's GDP, from construction, alongside the growth of unemployment rate, in comparison with the changes in the oil price.

The question now is, was it possible for construction project managers to, by foresight, get an idea about what plausible futures would look like, prior to and in the early phases of the down fall in the oil price? Are there any leading indicators which in case monitored, could have given an indication of these scenarios becoming real?

Figure 3. Growth of Norway's GDP from construction and the unemployment rate within the past 5 years in comparison with the oil price (numbers drawn from www.tradingeconomics.com and www.dn.no)



Scenario 1

The decrease in petroleum investments in Norway, had already begun before the end of 2013 (Statistics Norway, 2016). This, in addition to the fact that the oil production in Norway was experiencing a constant decline since 2001, could appear as an early indicator for the potential developments within the construction industry due to these facts. However, it should be noted that the decrease in the petroleum investment was not foreseen and stated by the authorities at that time. The "National budget report" published by the Norwegian finance department in 2014, stated that:

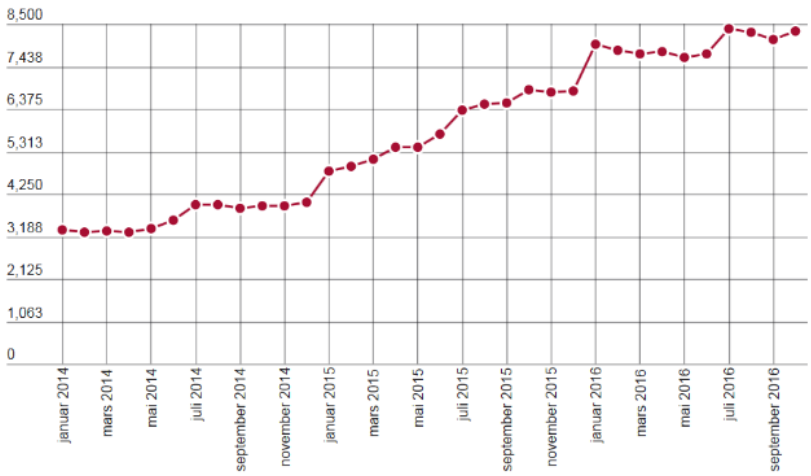
"Petroleum investment growth will continue this year and next year, although the growth rate is expected to be somewhat more moderate in 2014 than in the preceding years."

The National budget report in 2015, affirmed that there would be a decline in the petroleum investment. This was a rather new statement which was not foreseen and mentioned in the previously published reports. Today, it is predicted that there will be continued fall in investments in petroleum industry until end of 2018, thus the same situation in sense of growth and profitability, remaining for the construction sector.

The number of unemployed engineers experienced a constant growth from early 2014 (See Figure 4). This number has grown by 1.48% up to this day (Andersen, 2016). This number was also an early indication for the potential opportunity of productive and skilled workforce which the construction sector could benefit from.

In 2014, the National budget report stated that the private sector had accounted for about 75% of the increase in employment in 2013. It also stated that the employment growth had been especially strong in the building and construction industry, in offshore-related parts of manufacturing industry, as well as in some service industries. Looking at the trend of unemployment growth in Norway, in general, and the growth of the workforce within the construction industry, could already demonstrate the potential which lies within the construction industry to benefit from the unemployed workforce within the oil and gas sector.

Figure 4. Number of unemployed workers within engineering and ICT fields from January 2014 to October 2016 (Andersen, 2016)



Scenario 2

Industries for which fuel is a direct and significant cost will see a positive effect from lower oil prices (Garrison, 2015). The companies within these industries, not only will benefit from declined costs associated with transporting materials, but will also benefit from broader economic gains from higher consumer consumption and healthier state and national budgets (Garrison, 2015).

The Norwegian government in early 2014 announced that it will invest 508 billion Norwegian Kroner (NOK) (85.3 billion USD) on transport for the next 10 years, 311 billion NOK (52.2 billion USD) will be spent on roads, 168 billion NOK (28.2 billion USD) on railroads and the remaining on other transport facilities. Key projects under the New National Transport plan were the construction of a highway E39, the upgrade of Oslo's rail network, the construction of an underground railway tunnel through Oslo, and the construction of road between Kristiansand and Trondheim (Reportlinker, 2014). This could also be an early sign indicating the high potential for higher activities within the building and construction sector.

In the following section, the operational aspects of an EW system for identifying the potential opportunities under the conditions described above, will be discussed.

5. Discussion

The purpose of this paper, is to investigate on possible early signals which provide indications of the development of the construction sector, as it is today, following the downfall in the oil price. Looking at Figure 1, the potential risk (in our case an upside risk) is the positive developments within the Norwegian construction industry and the risk factors are the elements which lead to these developments over time. The oil price dropped in mid-2014 and considering the development trends within the construction sector in Norway, any signal identified at (or around) that point of time, is regarded as an "early" indication.

The authors propose two scenarios for the possible effect of oil prices on the Norwegian construction industry. Evidences have been found within public documents and reports published in 2014, which verify these scenarios. The intention is however first and foremost, to select possible leading indicators which in case measured and monitored early, within the development process, can provide information to the construction project managers in order to better exploit possible upcoming opportunities. Secondly, this information should be employed in order to establish an early warning system (see figure 2) which will facilitate the systematic use of the gathered information in the favour of exploiting possible opportunities within the construction sector.

The operational aspects of the EW system suggested by Grasson and Singh (2011) include: Monitoring and predicting (the signals), communication the alerts and responding. According to the two scenarios proposed in the previous section, monitoring the following leading indicators, can provide indications of the possible development within the construction industry:

1. Investments in the oil and gas sector
2. Unemployment rate
3. Investments in the building and construction sector

The challenge lies in the source of information and, reliability of the data and the accuracy level of the predictions based on the gathered information. The successful proactive manager applies observation and monitoring in order to gather intelligence about these areas – the earlier, the better. The second step includes communication of the alerts between the strategic decision makers within the project and project organization. This is then followed by responding to these alerts, which is in fact the stage where the strategies will be developed based on the communicated signals. Nevertheless findings by Ansoff (1984) which was later further developed by Hajikazemi (2015), indicate that there are possible filters which a message or piece of information should go through before arriving to the firm from the environment of that firm. These filters can either restrict or ease the processing of the information. In other words, identifying the EW signs is of little or no use if they are not effectively responded to and an effective response calls for overcoming the complexities of human behaviour in responding to these signs. This calls indeed for further research and investigation.

Having discussed the operational aspects of a possible EW system and the challenges, the authors will endeavor to answer the research questions outlined earlier in the article.

What is the effect of downfall in the oil price on the construction industry?

The trends show a covariation between the oil price and the GDP from the construction industry in Norway. The GDP has grown as the oil price has gone down. Although it is not a proven causality that the downfall in the oil price has led to the positive developments within the construction industry, the authors believe that due to the two scenarios described in the previous section, there can be a true correlation between these two elements. Note that however important it may be, the price of crude is never the single factor driving events.

What are the leading indicators which can give an indication of the potential effect on the construction industry, in the early phase of the development of the construction sector towards its current situation?

According to the scenarios mentioned, monitoring the investments in the oil and gas sector, the unemployment rate (especially among engineers and skilled workers within the oil and gas sector) and the investments in the building and construction sector can aid project managers and strategic decision makers for development of their strategies for the future. The follow-up of these indicators and certainly other possible leading indicators, at any point of time, can provide valuable information which can be the basis for strategy development within building and construction project organizations.

It is worth mentioning that in the short run, although the fall in oil prices has been problematic for Norway, but is has not led to a catastrophe. This might be is due to Norway's big advantage, which is the US$860bn (£565bn) Norwegian Government Pension Fund Global into which the oil money is deposited, which is a phenomenal economic strength for a country with a population just over 5 million (Buvarp, 2015). However, there is no guarantee that the oil price will go back to its unnatural high level again. Therefore, it is crucial for other sectors, and especially the building and construction sector to be proactive in developing their strategies according to the changes within the global oil market in order to maintain a sustainable business.

6. Conclusion

The purpose of this paper was to study the impact of the downfall in the oil price on the Norwegian building and construction sector. The authors have investigated on possible early indications of the potential opportunities for the Norwegian construction industry, and proposed two scenarios based on which strategic decision makers within this sector can develop their future strategies.

This study indicates that establishing an EW system which contains three stages including, monitoring leading indicators of future developments, communicating the alerts and responding to them. This system can be applied as an effective tool for proactive management of disruptions.

Further studies that investigate more thoroughly the long-term effect of the fluctuations within the petroleum market on the building and construction sector, alongside real case studies within this sector, are likely to be of great interest in the near future.

Another interesting approach for further studies is to connect early warnings with the growing interest in big data analytics. On a worldwide basis, the total amount of digital data created and replicated each year is expected to increase exponentially up to 2020 (Tien, 2013). Data with higher levels of variety, volume, and velocity of data exchanges are becoming available. In combination with higher-performance computing and machine learning, this development supports analytics of evolving situations. This can be done in real-time, or with short time lags. The access to real time or almost real time information makes it possible for a company to be more agile than its competitors (McAfee and Brynjolfsson, 2012). There is a potential to develop models for early warning in different areas, including the one discussed in this paper. Big Data can be used to make more precise predictions, which can lead to better decisions. Data and applications related to different engineering disciplines, such as energy, have been analysed in isolation previously. There is a potential to combine different types of data. Big Data can give new information and knowledge for decision-making (Jagadish, 2015). McAfee and Brynjolfsson (2012) found that the more companies characterized themselves as data-driven, the better they performed on objective measures of financial and operational results.

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Effective knowledge transfer in construction worksites – a case study among construction workers and site supervisors in Finland

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Abstract

Construction industry is typically operated by project based organisations, where several actors from different companies are working together temporarily in a certain time period in a certain construction worksite. It has been both practically and scientifically acknowledged that this poses challenges to knowledge transfer especially because the actors and sites are constantly changing. These challenges have been widely studied, but majority of the research has concentrated on the management and organisational level, i.e. on project organising and management (see e.g. Kamara et al 2002a, Rezqui et al. 2010). It is, however, equally important to understand the challenges of knowledge transfer at the construction worksite.

To fill the research gap, this paper concentrates on the knowledge transfer in construction worksites during the actual construction of the facility among construction workers and site supervision. The purpose of the paper is to investigate the factors that enhance or inhibit effective knowledge transfer in a Finnish construction worksite. The study is conducted by adopting case study based research approach (Yin 2008, Eisenhardt 1989) and the research material is collected in a construction worksite of a Finnish main contractor in southern Finland. Material consists of 10 interviews of construction workers, site supervision and the supervision of subcontractors.

The study is leaning on existing knowledge transfer literature and a theoretical framework has been built based on a literature review. The research material is analysed by utilising a loose theoretical framework, where issues influencing on knowledge transfer are considered in four categories; personal factors, organisational factors, network related factors and informational factors (see. e.g. Goh 2002, Riege 2005, van Wijk et al. 2008, Kanto et al. 2014).

The results indicate that familiarity and trust between the people is a major factor enhancing the knowledge transfer among the construction workers, site supervision and the subcontractors. Besides, established processes and IT-systems have a positive effect on the knowledge sharing. Especially, among the construction workers, it should, however, be recognized that their motivation to spread and receive information is in connection with its convenience and easiness as well as with the personal interest. Besides, the employees do not have access to the IT-systems and -devices, which somewhat inhibits knowledge sharing.

Keywords: Knowledge transfer, construction industry, construction worksite

Introduction

Definitions of knowledge and knowledge transfer

In recent years, knowledge has become one of the main success factors in organisations and this notion has generated several studies on knowledge management and knowledge transfer. The increasing pace of technological change, the growth of the amount of the information available and increasing competition have made the companies consider their knowledge management activities (de Kretser & Wilkinson 2005).

The definition of knowledge in organisation is typically broad: many phenomena, including routines, practices and technologies can be seen as knowledge (Rerup and Szulanski 2004). Kogut and Zander (1992) distinguish between "information" and "know-how" as two types of knowledge. By information they refer to "what something means" and by know-how "knowing how to do something". Knowledge can also be divided to tacit and explicit. Explicit knowledge can be expressed in numbers and words and thus it is easy to share systematically. It can be, for instance, in the forms of manuals or reports. Tacit knowledge, on the other hand, is difficult to formalise or express as it refers to skills, expertise and ideas that may not be codified (Polanyi 1966).

Huber (1991) defines knowledge management as a process of acquiring, creating, sharing, utilising and storing knowledge that facilitates the organisation to perform successfully. Knowledge transfer, on the other hand, is considered to be the most important aspect of knowledge management in organisations (Dave & Koskela 2009). It refers at its simplest to transferring source knowledge successfully to a recipient (Cummings & Teng 2003). In organisations, knowledge transfer typically refers to the process through which one organisational unit or an employee passes its or his experience to others by exchanging knowledge between or among individuals, teams, groups or organisations (Argote & Ingram 2000, Duan et al 2010).

Challenges of knowledge transfer in organisations

Organisation need to facilitate the knowledge transfer between the employees and units as it is a key to effectiveness and business performance (van Wijk et al. 2008). It is not, however, always simple and the challenges of knowledge transfer have been investigated in numerous studies. Some of the most notified knowledge transfer challenges in previous studies include absorptive capacity, the nature of knowledge, organizational culture and organizational structure (see e.g. Cohen & Levinthal 1990, Easterby-Smith et al. 2008, Tsai 2002).

Based on a literature review, factors influencing on the effectiveness of knowledge transfer in organisations can be divided into four categories; individual factors, organisational factors, network factors and informational factors (see. e.g. Goh 2002, Riege 2005, van Wijk et al. 2008, Kanto et al. 2014). These categories may be partly overlapping and at least, are interconnected with each other, but they offer a loose framework to investigate the challenges in a construction work-site. All these will be taken a look next to give an overview of the theoretical background of the study.

At the individual level knowledge transfer is affected by a person's ability to absorb knowledge and his/her motivation to spread and receive information (Goh 2002, Yang & Maxwell 2011). Besides, the

communication skills of a person have a remarkable role in his/her ability to share knowledge (Riege 2005) Also the perceived costs of sharing the knowledge compared to the benefits for providing the information for the individuals should be considered when knowledge transfer is hoped to be enhanced in organisations (Cress & Kimmerle 2006, Yang & Maxwell 2011).

Also national culture can be a potential barrier of knowledge transfer as well as age and gender differences and differences in experience levels (Riege 2005). In addition to those differences in people's background, also low social identification has a negative impact on the knowledge sharing. These two issues may be partly interconnected as diversity of employees can naturally, among other factors, have an effect on social identification (Willem & Buelens 2007).

At the organisational level, incentives should be planned to encourage knowledge transfer (Kim & Lee 2006). Incentives do not have to be monetary, using recognition as a reward is often considered as one of the most powerful (Dainty et al. 2005). Furthermore, organisational characteristics such as size and age of the organisation may have a role in the knowledge transfer as ageing organisations have been argued to become more inert and big organisations to become too complex for fluent information sharing (Nidhra et al. 2013). Also organisation structure, such as the amount of hierarchy, bureaucracy, formalization and centralization, has an effect on the knowledge transfer. All of these are argued to have a negative impact on knowledge sharing inside an organisation (Kim & Lee 2006).

Organisational culture is also affecting on the effectiveness of knowledge transfer as it includes the main values and norms of an organisation. The existence of strong collaborative and cooperative culture increases the knowledge transfer between individuals and groups. Besides a culture of continuous improvement and learning encourages to gather relevant information and to use and share that information in problem solving and implementing innovative solutions and practices. (Goh 2002). Culture determines for instance if openness and knowledge sharing is valued in the organisation or is it more important to hold onto the individual powerbase (Yang & Maxwell 2011). Besides, a culture of openness and collective ownership encourage knowledge sharing and acquisition as it increases trust between the employees. Trust, on the other hand, is considered to be a key enabler of knowledge transfer because most people will not risk sharing what they know without it (Dainty et al. 2005, Goh 2002).

At the organisational level, it is also important to ensure that there are no time-constraints for knowledge sharing. There should be time for reflection and learning to ensure effective knowledge transfer, which rarely occurs if daily working responsibilities do not allow engaging in knowledge sharing activities (Dainty et al. 2005).

In the network level social networks, tie strength and trust are the most important factors that typically increase knowledge sharing both within and across organisations. Besides, the power relations between network actors and the position of the actors in the network can influence on knowledge transfer as sharing of knowledge may be viewed as a loss of power (Easterby-Smith et al. 2008, Nidhra et al.2013, van Wijk et al. 2008).

Similarly, as in the organisational level, in the inter-organisational network reciprocity of knowledge transfer, shared vision and teamwork also influence positively on the knowledge transfer. Long-term

collaboration typically helps in developing open and knowledge sharing oriented networks (Dainty et al. 2005, Easterby-Smith et al. 2008).

Inter-organisational knowledge transfer can also be analysed at other than firm level. Due to the focus of this paper, individual level is the most interesting also in the inter-organisational knowledge sharing. How the interpersonal interactions take place between the donor and the recipient firm has a major effect on the outcome of the transfer (Easterby-Smith et al. 2008).

Lastly, it has been noted that the nature of knowledge to be transferred has an impact on the efficiency of the process. Tacit, ambiguent and complex knowledge is argued to be more difficult to transfer and assimilate (e.g. van Wijk et al. 2008). Knowledge ambiguity makes the knowledge difficult to imitate, but it also inhibits knowledge transfer within and between organizations (Coff et al., 2006).

Information technology is frequently considered to be the solution to intra- organizational knowledge transfer problems (Goh 2002). IT that is utilised in the knowledge transfer should be easy to use and efficient in order to minimize the challenges of information sharing (Yang & Maxwell 2011, Argote et al. 2003). If there is a mismatch between individuals' need requirements and IT systems and processes, knowledge transfer is likely to become more difficult. The lack of experience in using IT systems can also be a barrier to effective knowledge transfer as it may increase reluctance to use those systems (Riege 2005). Poor communication may occur due to the lack of effective mechanisms and processes to encourage knowledge transfer. Establishing and maintaining open communication channels is crucial in enhancing knowledge sharing and also in generating open organisational culture (Dainty et al. 2005).

Knowledge transfer in the construction industry

In the construction industry, work is conducted in projects where multiple actors from different organisations with various special skills and competences work together, which poses challenges for knowledge transfer. The industry has been under a pressure to improve its efficiency as customers have demanded better products with fewer resources. It has been acknowledged in the construction sector, that effective knowledge management and knowledge transfer can bring the desired innovation, improved efficiency and business performance (Kamara et al 2002b, Yusof &Bakar 2012). To obtain these benefits, knowledge transfer must be supported by organisational culture, business strategy and individual motivation (Forcada et al. 2013).

Knowledge management and knowledge transfer has been studied in the construction industry, but the research has concentrated on the project and organisation management and on the use of IT in knowledge transfer (see e.g. Kamara et al 2002b, Rezqui et al. 2010). Few studies have investigated how knowledge transfer and sharing could be improved among the employees in the construction project environment (see Dainty et. al 2005). Employees' perceptions on knowledge transfer have not been paid attention, even though effective knowledge transfer at the construction worksite is an important prerequisite for the success of the construction project.

In this paper, the focus is on knowledge transfer of the employees at the construction site. Following Kogut and Zander (1992) knowledge, in this study, includes both the practical work- and organisation related *information* and the *know-how* related to people's own work. The knowledge to be transferred in the construction work-site thus includes the information related to the current work-phase,

information related to the organisation (e.g. personnel issues, news from the management) or to the future work- sites and the know-how related to person's own work.

The theoretical background of the study will offer a loose framework for the empirical work, where the aim is *to investigate the factors that enhance or inhibit effective knowledge transfer in a Finnish construction worksite among employees, work-site supervision and supervision of the subcontractors.*

Figure1: Summary of the factors affecting on knowledge transfer in organisations

Methodology

Case description

The case in this study is a construction site a big Finnish contractor, who offers construction services of residential and commercial premises as well as civil and environmental construction. The contractor is constantly investigating in various development projects to improve the effectiveness of worksites. Along with the BIM development and supply chain management, they are planning to invest in improving the knowledge and information sharing by organising a pilot programme of mobile device utilisation in the worksites. It was therefore interesting to study the current state and challenges of knowledge transfer at the construction work site also to find out the starting point for the pilot.

In the construction site investigated, two apartment buildings and a parking building is being built. This worksite is a part of the development of whole new residential area in southern Finland. The two apartment buildings consist of over 100 apartments of different size and they will be finished by the end of 2016. In addition to contractor's own employees, there are several subcontractors operating in the worksite in various tasks and work phases.

Data collection and analysis

In the study presented in this paper a case-study based research approach has been adopted (see e.g. Yin 2008, Eisenhardt 1989). In general, case studies are the preferred strategy when "how" and "why" questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context.

The data was collected through interviews at a Finnish construction site on May-June 2016, when altogether ten interviews were conducted. Three of the interviewees were site supervisors, three construction workers and four subcontractor supervisors from four different subcontractor firms. Interviews were conducted as theme interviews, where no strict list of questions were used. Instead, the aim was to discuss about collaboration, knowledge sharing and openness in relation to the daily work of each interviewee. Besides, some background information was gained in meetings with the vice president of R&D, a development engineer, a project manager at the head quarter of the contractor. The memos of these meetings were also utilised as a research material.

The material was analysed based on the developed theoretical framework, but the analysis also included inductive elements (Koskinen et. al 2005, see also Becker 1998). In short, this means that theory was only loosely steering the empirical work and issues outside the framework were allowed to raise and discuss.

Results: Knowledge transfer in the construction worksite

In this chapter the results of the study will be presented and discussed separately among construction workers, site supervisor and supervisors of subcontractors. The factors affecting on knowledge transfer in all four categories presented previously will be considered in every three personnel groups.

Construction workers

Among the individual factors, motivation seems to be the major factor both to inhibit and increase knowledge transfer. For the construction workers, their own work and the tasks related to it are interesting, but there is no motivation to acquire or share information about other things going on at the construction site. The big picture of the construction site is not seen to be interesting, even though it might be useful to be aware of certain general site information. Therefore, the site supervision should pay attention e.g. to the delivery of general organisational information.

Motivation to find or share knowledge is also very small, if it is considered to be troublesome. Therefore, if knowledge is hoped to be shared in the organisation, it should be made very easy and convenient. For instance, physical distance hinders information sharing, as employees do not want to spend time on walking long distances in the work site to find right persons. Or at least this trouble is not taken if it does not have some actual and immediate benefit related to the current work.

The hierarchical organisation structure also seems to effect on the employees' initiative, as the knowledge is expected to be delivered by the site supervision. Construction workers are not keen on looking for the information by themselves, but majority of the knowledge needed is gained in the weekly meetings with the site supervision. Some work related questions may need urgent help from the site supervision, but the distances in the construction site may be long and it takes time to walk to the site office to ask something. The use of mobile devices could therefore enhance the knowledge flow between supervision and construction workers.

Site supervision

Site supervision has a good motivation to find and share information and it is considered to be easy, thanks to various information systems and data banks. The whole supervisor team is typically moved from site to site and the team is therefore quite established and the people know each other. This is considered to be important and it is also easy to share information or ask for help

At the organisational level, the site supervision does not recognize major problems in knowledge transfer. The organisational culture is considered to be open and the regular meetings and data banks are ensuring the knowledge transfer. The practices are established also with the subcontractors. They are long-term partners and the co-operation is easy and fluent.

Thanks to the appropriate IT-systems and intranet, information sharing is considered to work well also through the whole organisation. Even though the organisation is big, the site supervision believes that they have access to all the organisational information they may need and if not, they can ask for it easily. Besides, the supervision believes, that their practices to spread the information for the employees and the subcontractors at the work site are working well. Weekly meetings are considered to be good channels for work site related information sharing and work related information can be spread and shared also on a daily base when needed.

Subcontractor supervision

For the supervisors of subcontractors, the main challenge is to balance between several simultaneously ongoing construction projects. Knowledge sharing or transfer is not seen to be problematic, but the amount of information is sometimes difficult to handle. Physical presence at the sites is considered to be important to ensure knowledge transfer, even though it is difficult to arrange or requires constant travelling from site to site. Also the use of laptops or tablets is seen to be problematic, when the days are spent at the sites or travelling. Therefore, the problem of knowledge handling and storing has been solved in various ways. Some of the supervisor store the files of each work site in their car, so you can choose the right file when arriving to a certain work site. Others prefer to update the information concerning different sites to their laptops after working hours.

At the network level, the knowledge transfer is seen to be fluent and the partners are well known. Long collaboration relationships are typical and all the relevant actors and people seem to know each other. Regular meetings help in coordinating the activities and sharing the information.

Conclusions

Knowledge transfer and sharing is argued to be the key to effectiveness and business performance. Effective knowledge transfer can bring advantages also in the construction industry, where pressures to improve efficiency have arisen. In the study presented in this paper the aim was to investigate the factors that enhance or inhibit effective knowledge transfer in a construction site during the construction of a facility. These were investigated among construction workers, site supervision and subcontractors' supervision by conducting interviews at a construction work site in Finland. The main findings of the study are summarised in figure 2.

The results of the study indicate that especially familiarity and trust between the colleagues and team are important factors that enhance knowledge transfer both inside the contractor organisation and among subcontractor firms. Besides established processes and IT-systems have a positive effect on the knowledge sharing.

Majority of problems in knowledge transfer occur due to the lack of interest and motivation of construction workers. Their motivation to spread and receive information depends on it convenience and easiness as well as on their personal interest. If knowledge transfer is considered to be difficult or the knowledge to be transferred is not regarded as personally interesting, information is not shared or received. Furthermore, the hierarchical organisation structure is causing the lack of initiative among construction workers; they expect supervision to provide the information needed instead of actively seeking the information themselves.

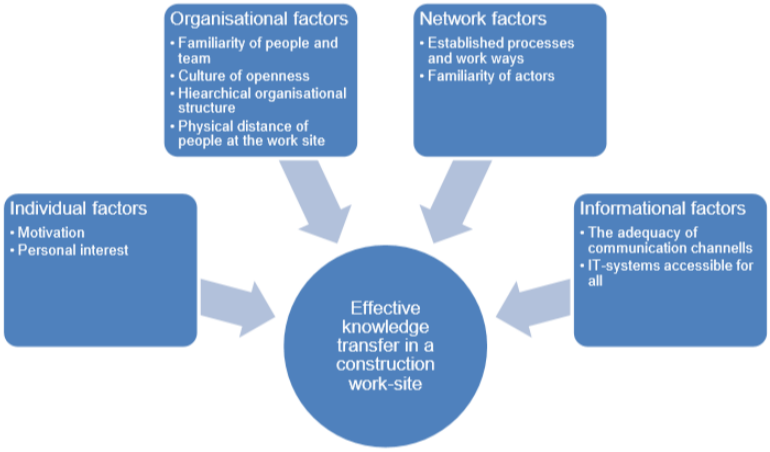

Figure 2. Elements of effective knowledge transfer in a construction work-site

Physical distance is another main factor affecting on the effective knowledge transfer in the worksite. In large construction worksites, people may work far away from each others, which poses challenges for the effective knowledge transfer. For the subcontractors' supervision, it is especially demanding to ensure enough physical presence in various worksites. It is not always possible to meet face-to-face and the construction workers do not have mobile phones or other devices for work-related contacting, which somewhat inhibits knowledge sharing. Based on the findings it can thus be argued that the use of mobile devices in the worksite could make knowledge transfer easier and thus increase the construction workers' motivation to share information.

The results also indicate that site supervision does not recognise all the motivation problems of employees related to the knowledge transfer; neither do they consider the employees' troubles of sharing the information without appropriate IT devices. As a conclusion, there is therefore an actual need to increase supervision's awareness about the employees' perceptions and, through that, to improve employees' possibilities for knowledge sharing.

Based on the findings of this study, research about how mobile devices can be utilized in the construction worksites in order to improve knowledge sharing among all the people working at the worksite will be interesting both scientifically and practically. Also, some pilot programmes are

currently taking place in Finnish construction companies, and results from these will be interesting in terms of improved knowledge transfer.

The results also indicate that, knowledge transfer in the construction worksites includes certain challenges and it thus requires additional research. As the results of this study are qualitative in nature, they cannot be, as such, generalized. It is, however, clear that the by studying construction worksites, understanding about the construction worker's reality can be increased. This may offer new perspectives also to the current challenges of construction industry.

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The influence of construction project actors' motivation on externally initiated systemic innovation

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Abstract

Urbanization and climate change are central challenges for urban development today, why a need for substantial innovation, e.g. systemic innovation, can be identified. The large amount of interdependent actors and their fragmented processes are among the key factors that hamper innovation in the construction industry. Two key actors in the industry, property developers and contractors, can be identified as important when developing innovation, due to their central roles in the construction project process. Therefore, it should be important to make them dedicated towards innovation, i.e. create motivation. This is in line with research on successful innovation development highlighting the importance of commitment and collaboration.

A need seems to be present to create motivation towards innovation for key actors in the industry. Based on this, the purpose of this paper is to explore how motivation of key actors can influence development for systemic innovation in the construction industry. To explore this, a case study of the urban development project Stockholm Royal Seaport and its developed building logistic center was analyzed, adopting a model for receptive change context. Tentative findings suggest that actors' motivation for innovation is important for the development. Developers' possibility to influence through procurement strategies, to increase awareness and collaboration, can be used to create motivation for contractors.

Keywords: systemic innovation, urban development projects, motivation, receptive context, procurement strategies

1. Introduction

The urbanization and climate change are two central challenges for urban development projects (UDPs) (Wiseman, et al., 2014). This calls for wide ranging innovation that involves all key project actors, i.e. systemic innovation, to achieve the needed renewal in the construction project process. The main part of innovation in the construction industry is driven by material suppliers and public initiatives (Seaden & Manseau, 2001; Holmen, et al., 2005; Winch, 2010). However, externally initiated innovation must be adopted by key actors in the industry, e.g. contractors and property developers, who in this paper will be seen as the users of systemic innovation. Effective development of systemic innovation is difficult in the construction industry on account of the many interdependent actors and their fragmented processes (Winch, 1998). Because of this, it is important to explore what influence a systemic innovation. Larsen (2011) emphasizes the importance of considering actors' awareness and influence during innovation process. Something this paper has taken inspiration from, by looking at how actors' motivation influences innovation.

The innovation context has been argued as important to consider in complex systems, which the construction industry is commonly regarded as. The innovation context, both internal and external, has been widely discussed. Pettigrew et al. (1992) introduced the concept of 'receptive' versus 'non-receptive' contexts for change. They introduced eight features which can help outline the receptiveness for innovation for an organization. These features will be used in this paper to investigate the receptiveness of a systemic innovation in the construction industry. By investigating the context for systemic innovation the motivation of the innovation for the different actors will be discussed. The features for a receptive context was developed investigating the health-care industry, why some of the features will be adjusted to fit the construction industry characteristics.

More specifically, the purpose of this paper is to investigate how actors' motivation of an externally initiated systemic innovation influences its development by investigating the receptive context. An illustrative example of such innovation can be found in the on-going UDP, Stockholm Royal Seaport (SRS). This paper uses a case study from SRS as its empirical foundation with focus on the development of a systemic innovation, a building logistic center (BLC). An assumption made prior to analyzing the case study was that a context which is receptive and can influence motivation for actors are important for development of systemic innovation. A theoretical implication from this paper suggests that developers can influence systemic innovation development through their procurement strategies, focusing on creating a receptive context were actors' motivation can increase. A practical implication is to increase the understanding of systemic innovation in the construction industry and the importance to include the users in innovation processes.

2. Context for developing innovation in organizations

2.1 Influence for innovation

As touched upon in the introduction, the construction industry has difficulties being innovative and forward-thinking (Holt, 2015; Styhre, 2010). The involvement of multiple interdependent

actors in construction projects seem to complicate and hinder innovation, since negotiation between actors will precede all major changes (Winch, 1998). On the other hand, innovation does of course

occur in the construction industry to various extents. Gann (2000) describes the industry as having functions that can generate innovation within projects; the difficulty lies in spreading them and making the improvements last. Gann suggests developing systemic innovation with recognizable cost and time reduction in stages, to showcase the possibility of innovation. Adopted from Mlecnik (2013), systemic innovation is here defined as innovation which depends on coordination and collaboration among several key actors during the innovation process, as opposed to independent innovation that can be developed by a single actor in isolation. In other words, systemic innovation success is dependent on interorganizational networks. Furthermore, innovation will foster and spread change in a system (Slaughter, 2000), in this case in a UDP and potentially in the whole industry. Mlecnik (2013) further describes the construction industry characteristics as compatible for systemic innovation, in terms of the high interaction between actors and the project based organizations. The result, however, will depend on how the coordination and collaboration is executed.

Influence through awareness and communication has been highlighted as important for innovation processes (Larsen, 2011). On an actor level, influence for innovation can be found through incentives that create gainsharing (Winch, 1998). Winch (1998) discusses different procurement strategies which influence gainsharing; while traditional competitive procurement hampers gainsharing, partnering can encourage gainsharing and in turn innovation. Current research agrees with this, claiming that partnering and especially long-term partnering is found to be crucial to gain lasting innovation which can be transferred across projects (Ingamansson Havenvid, et al., 2016; Holmen, et al., 2005). Dubois and Gadde (2002) came to a similar conclusion stating that standard offerings in traditional procurement strategies will hamper innovation. These traditional procurement strategies, often focused on speed and urgency, use competition based only on price and promote self-protective behavior (Blayse & Manley, 2004). This is further elaborated by Rose and Manley (2011), who found that economic incentives enhance construction actors' motivation. However, economic incentives do not seem enough to maximize actors' motivation. Rose and Manley (2011) also established the importance for procurement to encourage trust, unity, and fairness into construction projects.

Another important aspect for influence of innovation is the inclusion during development. Slaughter (2000) highlights the importance for innovation in the construction industry to include the on-site personnel; to learn about the innovation. She further advices for tight collaboration between involved actors. This is in line with Gann and Salter's (2000) suggestion that information must be made available. Furthermore, goals should be clearly defined and communicated; the development process should focus on maximizing capabilities, effort, and commitment, while minimizing constraints and challenges (Ling, 2003).

To influence innovation processes through coordination and collaboration one actor in the industry have commonly been pinpointed as important, namely the developer. In the construction industry the developers are not only a client who buys an end product, they often have a central role during the project execution (Nam & Tatum, 1997). Developers can function as innovation supporters for innovation development. Developers, as innovation supporters, should both have knowledge of the construction project process and innovation competence, as highlighted by Manley (2006). According to Ingemansson Havenvid et al. (2016) this support can be formal and intentional, but an informal support can also help the development.

2.2 Receptive context for innovation

The factors discussed above which influence innovation processes can be seen as parts of the change context. The context for change is discussed by Pettigrew et al. (1992) in terms of investigating whether an organization is receptive for change. This receptiveness is described as something fluid, which may change when conditions for the innovation process change. The receptive context is by Pettigrew et al. (1992) evaluated through eight features, which will here be described and evaluated in the construction context (see Table 1). As mentioned in the introduction this model was developed for the health-care industry, but it seems relevant for the construction industry as well. Larsen (2011) stresses the importance to get a richer picture of the contextual setting for actors in innovation processes in the construction industry. The evaluating features should be important for the construction industry due to the similarities to the case presented in Pettigrew et al. (1992). Both the health-care and the construction industry are commonly labeled as traditional and change-resistant. Further, both are segmented, consisting of a wide range of interdependent actors from different professions. However, the construction industry is mainly project based, which should be reflected in the adoptability of the model.

Features for receptive context (adapted to the construction industry)	***Description of feature to achieve receptiveness***
1. *Quality and coherence of policy*	*Policies generated on a local level, with link between goals, feasibility, and implementation.*
2. *Availability of key people leading change*	*A stable leadership (preferably small group), positive attributes including wide range of professions and hierarchy.*
3. *Intensity and scale of long term environmental pressure*	*Create right level of pressure, were too much can drain the energy for the innovation while some pressure will stimulate change.*
4. *Supportive organizational culture*	*Create motivation and rewards for change, from management. Include a focus on flexibility, competence, and risk-taking.*
5. *Effective inter-professional relations*	*Step away from stereotypes. Key-persons should be able to think and communicate across professions and project boarders.*
6. *Co-operative inter-organizational networks*	*Create networks between projects and organizations. Economic incentives, clear communication, and shared ideologies are important for the networks.*
7. *Simplicity and clarity of goals and priorities*	*Change agenda including prioritization, were the foundation of change is clear and short-term pressure can be dealt with.*
8. *Fit between the change agenda and locale*	*Innovation process should include awareness of site specific aspects.*

Table 1: Description of features for a receptive context adopted from Pettigrew et al. (1992)

The features are not regarded as a check list, rather inter-connected aspects that work together to increase the receptive context, or in other words the energy level towards innovation processes. Pettigrew et al. (1992) presented the features as; (1) quality and coherence of policy; (2) availability of key people leading change; (3) intensity and scale of long term environmental pressure; (4) supportive organizational culture; (5) effective managerial-clinical relations; (6) co-operative inter-organizational networks; (7) simplicity and clarity of goals and priorities; (8) fit between the change agenda and locale.

To make the features applicable for the empirical setting of this paper Table 1 presents somewhat altered features, including a description.

3. Case study and method

As mentioned in the introduction, a qualitative research study was executed at the UDP in Stockholm, Sweden, called the Stockholm Royal Seaport (SRS). Upon completion in 2030 SRS will include around 12 000 new homes and 35 000 workplaces (Stockholm Stad, 2014). The City of Stockholm, the initiator of SRS, decided early on to give SRS a distinctive environmental profile. Therefore, high sustainability goals and requirements for the appointed developers were put in place. These requirements result in special characteristics for SRS, such as high complexity and new technology, which have affected the developers' budgets.

SRS is divided into several sequential stages. In every stage multiple construction projects with several property developers and contractors are running simultaneously within a limited area. This calls for a considerable amount of collaboration between all involved parties, including well planned logistics. To support the needed logistics collaboration and the high sustainability goals, the City of Stockholm decided to develop a BLC. They had developed a similar logistics solution in a previous UDP, but never on a mandatory level. The city, with help from consultants, designed the outlines of BLC, and subsequently procured a contractor to realize the design. The influences during the design of BLC came from production logistics in manufacturing industries.

Included in BLC is everything from work environment regulations, coordinated transport within the area, waste management to short-term storage. The procured contractor operates BLC in collaboration with a sub-contractor, with all developers and main-contractors as their customers. The developers have in different ways incorporated it in their contracts with their contractors. Either developers or contractors are reliable for the payment, depending on the agreement in their contracts. BLC will in this paper be understood and analyzed as a systemic innovation developed in a large UDP. As highlighted in the theory section, systemic innovation is dependent on collaboration among key actors and its development will affect a whole system. This description is comparable to BLC, since a large number (almost all) of the actors in SRS will be involved in developing and using BLC, e.g. the city, developers, contractors, subcontractors, and suppliers. Furthermore, BLC will affect both the supply chains and the construction processes. To state some examples; it will affect the transportations to the sites; waste management processes will be standardized; new forum for communication between actors will be enforced.

This paper will focus on three different actors; Project Managers at developers, Site Managers at contractors, and Supervisors at sub-contractors. They are all users and influencers of the systemic innovation. Project Managers are seen as indirect users due to the developers' contractual relationships with BLC. Site Managers, on the other hand, are direct users due to their everyday interaction with BLC and the contractors' contractual relationships with BLC. Supervisors are also direct users due to their everyday interaction with BLC, although the subcontractors do not have a contractual relationship with BLC.

The paper is based on a qualitative study conducted at SRS during the first half of 2016. It included project documents, interviews, as well as workshops and seminars, common for qualitative case studies

(Yin, 2013). For this particular study 29 semi-structured interviews lasting approximately 1-1.5 hours were analyzed, conducted with different actors as listed in Table 2. The interviews had an explorative approach, since they did not follow specific hypotheses. The interviews explored actors' attitudes towards the innovation, change in work method, and their implementation of BLC. Interviews further explored whether the innovation had any effect on the projects and what those effects were. The collected data was analyzed in steps based on the aim of this study. Firstly, the level of motivation was identified among the actors. Secondly, the receptiveness for innovation was identified using Pettigrew et al. (1992) features for change context. Thereafter, the findings were analyzed together to find influence for the motivation based on the receptive context. Relating this to the existing literature in the field the paper presents tentative suggestions on how to enhance the receptive context and thereby the motivation on an externally initiated systemic innovation process.

Actors	***Number of interviews***
Project management at City of Stockholm	*5*
Project Managers, property developers	*8*
Site Managers, main contractors	*8*
Supervisors, sub-contractor	*7*
Employees at BLC	*1 (with 2 employees)*

Table 2: A summary of number of interviews per actor included in the case study

4. Illustrations of systemic innovation from SRS

4.1 Actors' relationship with BLC, a contractual perspective

The development of BLC was based on a top-down innovation process. The idea and design came from the politicians and top executives in the City, the initiators of the UDP. The topdown approach puts pressure on the City to get all actors involved in the innovation. The City did this by initiating activities to teach and guide all actors using BLC. All personnel working on-site in SRS have to attend an introduction workshop of around one hour. Here the general idea and development of BLC is explained, as well as possible rewards for the projects and SRS. However, most contractors and sub-contractors send their personnel to the workshop right before their production start on-site. If the workshop was attended at an earlier stage the possibility might have increased that actors had incorporated BLC during their planning, which was generally not the case. In line with this is the widespread view across the actors that they thought the City overrated the positive and direct effects of BLC. The Project Managers had hoped for the highly valued rewards of cost reductions and time saving for the projects (based on information from the introduction workshop), but claimed to have mainly observed extra costs for BLC. On a positive note for BLC, Project Managers saw the services as activities which can increase the extent of value-adding work.

From a developers' perspective, one Project Manager *"hoped that BLC would become a resource helping contractors challenge their project processes".* However, many Project Managers state the importance of being an 'attractive client', indicating they did not want to include BLC in their procurement strategy as it could be seen as an extra risk for the contractors to incorporate in their price calculations. These procurement strategies reflect the Site Managers' expectation of BLC. Several Site Managers describe that they might have been able to incorporate BLC better if they had included it during the planning. A reflection is that contractors did not thoroughly plan their implementation process of BLC, possibly due to the lack of incentives in the procurement. Due to most developers' choice to take all costs for BLC the contractors and sub-contractors did not have the same economic incentives to highly value the outcome of BLC. One contractor suggests that "*with partnering a carrot stick would have existed to implement BLC".* A reflection is that a focus on other possible benefits, than cost reduction and time saving, might have led to BLC being more highly valued. These possible benefits are for example a platform for collaboration within the UDP, a clean site, and decreased environmental impacts. However, one supervisor did see effects in terms of time saving when testing the service of on-site material carriage, leading to increased extent of value-adding work.

4.2 Actors' relationship with BLC, a communication perspective

A first thing to note, across all actors an expression that integrated logistics is important in complex UDPs can be detected. A more diverse image appears when analyzing actors' view of BLC. Information is lost along the chain of communication from the City down to the Subcontractors. The Project Managers at the developers received information about BLC directly from the City, both through documents and during meetings, which highlighted the opportunity for cost reduction and time saving with BLC. One Project Manager stated that they "*expected to lower project cost thanks to BLC*". Site Managers at the contractors got information of BLC when studying the developers' tender documents, most commonly as an attachment including general information documents the developers had received from the City. A sense is that Site Managers did not receive enough information to include BLC in their planning. A reaction from a Site Manager after going through the document was that he felt *"concerned and hesitant".* Even lower expectation on BLC can be detected from the Supervisors at the sub-contractors due to poor information. One supervisor tells a story of when they read about BLC in the tendering documents and had some questions about how it would work. When calling BLC for more information he received the following response; "*visit the website and read".* A summarizing perspective is that, because information is lost down the supply chain, lower motivation is detected from the developers down to the sub-contractors.

This is in line with the lower usage of BLC along the supply chain. One Site Manager says that their low usage of BLC is not unique for this UDP, saying that; "we do not usually plan to utilize coordinated logistic solutions". Another reason for the low usage can be detected from all Site Managers. They use the reason of BLC being inflexible as an explanation for why they did not implement it in full extent. However, one Site Manager had at least a partial positive view on BLC; "*It is a luxury to have a short-term storage when your timetable suddenly change, but the set-up is tedious". Contrastingly, Supervisors' view is more straightforward and sceptic, one "did not fully understand it to a 100 %",* due to lack of information, while another "did not notice it much", apart from the collective waste management and gate system.

Another important activity to shed light on is the communication between BLC and the projects. One Site Manager discussed this, giving the example that the usage of BLC increased after the initial production started, thanks to better communication when employees at BLC started to go on informal site visits on a daily basis, rather than to wait for contractors to reach out to them. The employees at BLC also indicate that their change in work process could be part of the increased usage of BLC over time.

All in all, two main conclusions can be drawn from the findings above. Firstly, a lack of motivation seems to be present due to low expectancy on the design of BLC and the possible values from it. Secondly, involvement and increased communication can be correlated to the increased usage of BLC over time. Furthermore, a common and explicit understanding of BLC seems to be missing between actors.

5. Influence on innovation from actors' motivation

An analysis of the receptive context of the presented innovation will now be described, building on Pettigrew's et al. (1992) features for change context. Based on the analyzed data features 1 and 3-7 (see Table 1) will be in focus. Features 2 and 8 are excluded from this analysis since they need data describing the initiators and the design process of the innovation, which was not included in the initial case study. The analyzed context is summarized in Table 3, showing an overall inadequate receptive context to foster innovation. The results show that the differences between the involved actors, their fragmentation and interdependencies (Winch, 1998), put great pressure on communication and procurement strategies (Gann & Salter, 2000; Dubois & Gadde, 2002) to enforce coordination and collaboration to enhance the receptiveness.

Furthermore, by analyzing the receptive context a lack of motivation from the actors towards the innovation is revealed. Building on Larsen's (2011) findings of the need to manage actors' awareness and influence on innovation, the motivation should also be important to identify and manage. To exemplify, low motivation stemmed from the direct users conservative view of not fully believing in the innovation, a seemingly common attitude in the construction industry (Styhre, 2010; Holt, 2015). Furthermore, Gann and Salter (2000), Slaughter (2000), and Ling (2003), all state the importance of right communication for innovation success, in this case highlighting the possible benefits of the innovation to increase the actors' motivation. The important thing to note from this is that designing an innovation and promise substantial benefits for the projects does not seem to be enough, if a lack of motivation and in turn low efforts to incorporate the innovation into the project exists.

Table 3: analysis of the innovation receptive context in SRS

Features for receptive context	***Innovation context in SRS***
Quality and coherence of policy	*Policies for BLC were decided on a top level (the City), thereafter mainly incorporated in contracts between developers – contractors and subsequently contractors – sub-contractors without adjustment to local level.*
Intensity and scale of long term environmental pressure	*The forced aspect and the top-down perspective of the innovation development can be seen to drain energy from the actors to adapt the innovation. On the other hand, the top-down pressure could possibly have stimulated the actors. The effect would largely depend on individual actor's resilience to pressure.*
Supportive organizational culture	*A support culture does exist in one perspective, namely the shared ideology of logistics in construction as important. On the other hand, the construction industry is commonly viewed as conservative and sceptic towards innovation.* *Furthermore, a large number of the direct users show low support for the specific logistic solution BLC, because of its systemic innovation nature and inflexible and mandatory set-up.*
Effective inter-professional relations	*The inter-professional relations can be illustrated through the communication between actors. The loss of information along the communication chain indicates inadequate relations to support an innovation.* *Contrastingly, the formal communication base which BLC make up should foster the relations between actors and projects.*
Co-operative inter-organizational networks	*The UDP is an inter-organizational network, the actors and projects co-operation is however debatable. The shared ideology is a starting point, unfortunately the identified inadequate communication lowers co-operation. Furthermore, the presented skewed economic incentives lower the contractor involvement.*
Simplicity and clarity of goals and priorities	*Actors had difficulties identifying and realizing the goals and benefits presented by the City, indicating a lack of coherence in the presented goals, the prioritization used when communicated them and the feasibility to achieve them.* *Note that, data on how the goals were decided and priorities should increase the insight on this feature.*

5.1 Communication, a main activity to increase motivation

The research findings demonstrate the importance to involve key actors early in the innovation process, for the actors to be able to include the innovation in their project planning. As found in the literature review, collaborations are of high importance to achieve good results of the innovation (Slaughter, 2000; Rose & Manley, 2011). This can be confirmed in the findings where increased usage of BLC's services were witnessed once their employees started to include more informal communication with the contractors, the actors felt seen and heard. Additionally, Slaughter (2000) called for a need of inclusion all the way to the on-site workers. This top-to-bottom inclusion was not visible when

analyzing the development of BLC; information was lost along the supply chain. The introduction workshop, for communicating the innovation is in line with Gann and Salter's (2000) recommendation to make information available.

Furthermore, prior research highlights the importance of gainsharing to increase the motivation (Winch, 1998; Slaughter, 2000; Ingamansson Havenvid, et al., 2016). To reach a successful gainsharing in a UDP a certain amount of collaboration need to exist. The first step in collaboration must be to create a common understanding of the systemic innovation. The Supervisors' lack of understanding of the innovation leads to a conclusion that a common understanding did not exist, which in turn hampered the collaboration and the innovation success. So, the first step to reach gainsharing of the benefits, of the innovation, is to early on decide on a common understanding of the innovation.

To conclude, the findings in this paper reflect prior research with the importance to make information available and to achieve collaboration through communication and inclusion, to be able to reach a successful innovation.

5.2 Innovation supporters a key for innovation success

Despite developers' lack of innovation initiatives (Seaden & Manseau, 2001; Holmen, et al., 2005; Winch, 2010), their Project Managers can influence the direct users of the innovation, both through incentives in the contracts and through overall procurement strategies; therefore they should be able to serve as innovation supporters (Manley, 2006). For a formal support (Ingamansson Havenvid, et al., 2016) the Project Managers could use the construction contracts to include more than just basic information of BLC, it could be seen as a tool to build incentives and motivation for innovation.

Partnering should be mentioned as a procurement strategy which can increase both formal and informal collaboration as suggested by Dubois and Gadde (2002), Holmen et al. (2005), and Ingemansson Havenvid et al. (2016). Partnering was also desired by a Site Manager as a way to find incentives for the innovation, and possibly increase the motivation and develop the receptive context. Partnering should therefore be considered by developers discussing procurement strategies to enhance innovation development.

6. Conclusions

Communication, long-term relationships, gainsharing between actors, and most basically a common understanding are all key influencers to successfully develop a systemic innovation, seen both in prior research and from the findings highlighted in this study. This paper suggests that developers' Project Managers, play an important role in developing externally initiated systemic innovation in UDPs in the construction industry. They control important mechanisms and activities that can influence how a systemic innovation is developed in a construction project and an UDP, namely the construction contracts and their chosen procurement strategies.

A conclusion is that the indirect users of a systemic innovation in the construction industry influence the receptive context and thereby the direct users' motivation for innovation. The importance of high motivation for the actors of a systemic innovation is highlighted in this

paper, why this should be important to focus on when designing procurement strategies. The theoretical implication of this study is therefore that for successful innovation the developers' procurement strategies must be designed to serve the innovation development. The procurement strategies should consider and include how to create the right receptive context to foster motivation for innovation. Practical implications are to create awareness and understanding of the different actors' roles in systemic innovation development, and the importance to early on include the direct users of the innovation.

The conclusions of this paper should be viewed as tentative; further research must be conducted to establish a more extensive description of the receptive context which fosters actors' motivation for systemic innovation, as this study is limited to one UDP and does not include the initiators' perspective. Here, a comparative study should be included, between similar UDPs as SRS, with developed systemic innovations such as the BLC.

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New collective knowledge in a practice context – real-life experiment with BIM and collaboration

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Abstract

The implementation of Building Information Modeling (BIM) is slow to emerge into the Architecture, Engineering and Construction (AEC) industry. In spite of the benefits of BIM, it challenges the work procedures in the AEC industry. The challenge of handling new work procedures and practices requires new knowledge and skill, which ought to be learned by the students. The ambition to facilitate this learning have been taken up by several scholars. In Northern Denmark, this led to the organization of "The Digital Days" – a learning event focusing on BIM, digital tools and inter-disciplinary collaboration. The participants are students from AEC educations and local companies, which allows for challenging "current practice" with digital tools and ways of collaboration. Despite of this setting, a resent study showed a lack of new collective knowledge.

Activity theory and expensive learning are used to set-up a theoretical framework, which is used to generate opportunities for new collective knowledge. In April 2017, this will be tested during the "The Digital Days" where data will be gathered through ethnographic observations. It is argued that this approach offers a novel theoretical contribution towards understanding how and when new collective knowledge takes place in an educational setting involving BIM.

Keywords: Activity Theory, BIM, Collaboration and Expansive Learning

7. Introduction

Building Information Modelling (BIM) has emerged into the Architecture, Engineering and Construction (AEC) industry during the past decades (Volk et al. 2014). In Denmark, the governmental initiated requirements of Information and Communication Technology (ICT) have been established with the research and development program of "Digital Construction" (Det Digitale Byggeri) (Moum et al. 2009).

The complexity of the building projects are increasing (Eastman et al. 2011), creating a growing interest in BIM to manage the projects and grasp the benefits of less mistakes, more efficiency and up-to-date information (Kerosuo et al. 2015). However, the implementation of BIM creates a fundamental change in the AEC Industry, due to the procedural and technological shift (Succar 2009). This challenges the practices of the AEC industry and the ways of working together (Kerosuo et al. 2015). One of the challenges to this is the fragmented work procedures, and though BIM creates tighter links between disciplines (Dossick and Neff 2010), the adoption of BIM in the AEC industry requires more than just working together (Volk et al. 2014). BIM redefines the professional and disciplinary arenas of workplace role and responsibility for all the parties involved in AEC activities (Kocaturk and Kiviniemi 2013).

From this backdrop, it is clear that new knowledge and skills in both the AEC industry and by implication education, to enable the incorporation of the new procedures and practices are needed (Hon *et a*l. 2015). The ambition to integrate BIM into the current curriculum is shared by many scholars around the world (Pihlak et al. 2011, Kocaturk and Kiviniemi 2013).

In Northern Denmark, the response to the challenge of implementing BIM in the AEC industry and in the current curriculum was to create a three-day long learning event, called the "The Digital Days". "The Digital Days" is an annual learning event at University College Northern Denmark, UCN in the form of a workshop. It was first held in 2010, where the focus was on creating an event, where new BIM methods, knowledge and technology could be displayed and experimented with while designing a building project. In 2016, the learning concept of Reflective Practice-based Learning (RPL) was applied to the workshop. The main idea of RPL is to create a close-to-real-life education in order to combine theory and practice. This is UCNs learning strategy as a close *"cooperation with practice is decisive"* to generate students with professional knowledge, skills and competences (UCN 2016: p9). The strong encouragement to use and experiment with new technologies remained crucial during the event. A close link to practice is ensured by inviting companies and institutions from the AEC industry to participate together with students in an effort to solve problems during a design process. The participants are working on a real-life refurbishment project, which the organisers have found in the close-by environment. The participating students come from different educational backgrounds. The participating professionals have different educational backgrounds as well as different occupations within the industry. In this way, the organisers of the "The Digital Days" have created a situation close to a real-life working situation, which requires interdisciplinary collaboration of different professions in order to solve a real-life design project.

The practice-based learning approach allows the students to learn in an environment close to their final practice. The participation of students from different education will give the students the opportunity to experiment with communication and problem solving across educational communities. The different

participating educational programmes are normally set in a strong context of its own community. Upon graduation, this may cause difficulties for the students as it can become difficult for them to communicate across communities (Bechky 2011). Another concern caused by educational programmes focus on its own professions is that the *"characteristics of knowledge that drive innovative problem solving within a function actually hinder problem solving and knowledge creation across functions"* (Carlile 2002: p442). "The Digital Days" enables the students to experience communication and knowledge issues across professional disciplines similar to what will happen in their work life after graduation. The tasks given to the students during the workshop mimics those they will face in their work life. The expected learning outcome for the students are expected to be high, due to the close connection to practice (Tynjälä 2013).

However, the vision for the "The Digital Days" is also to contribute to the collective knowledge of how to implement and use BIM in the industry and not only to improve the individual students learning. A recent study of the "The Digital Days" examined, whether the creation of new knowledge by Expansive Learning through object transformation was generated. The findings of this study showed a lack of expansive learning, and thus displayed an absence of generating new knowledge (Klitgaard et al. 2016). New knowledge, which might prove of value to the industry as a whole.

Present focus in workplace learning and expertise has been on the individual level finds Tynjälä (2013: p23) based on her review of workplace learning and recommends for *"future research on expertise to focus on collective and collaboration expertise, rather than solely on individual expertise."* It is the intention of this research to follow part of this recommendation as it intends to document how/if new knowledge of implementation and use of new technology is developed by the students during the "The Digital Days".

By adopting an Activity Theoretical perspective, the researchers aim to develop a framework, which enable them to identify the learning process by use of the Expansive Learning model. Firstly, the focus will be on identifying the beginning of a possible learning process. Secondly, a documentation on how the participating students and professionals reflect towards opportunity. Thirdly, if the learning opportunity develops into a learning process, a registration of how new collective knowledge is created.

This paper will proceed as follows: Section 2 introduce the theoretical framework needed to design an event, which facilitates the possibility for creating new collective knowledge. Then the set-up of the new workshop event is presented in section 3. The proposed research approach is described in section 4. Section 5 discusses the value of the careful planning of the event based on activity theoretical section, while section 6 is the conclusion.

8. Theoretical Framework

The theoretical perspective of this research is Activity Theory and Expansive Learning. Expansive Learning happens when *"learners learn something that is not there yet"* (Engeström and Sannino 2010). In this way, they learn something new, i.e. some knowledge that was not there when they started their collaboration. The expansive learning concept allow the researchers to analyze "*the processes whereby new knowledge and new mediating objects of activity are collaboratively created, whether in schools or at world"* (Paavola et al. 2004: p573), which is the aim of this research.

Expansive Learning is based on Activity Theory, so it is through this Activity Theoretical lens that Expansive Learning must be understood. Using Activity Theory and Expansive Learning allows the research to examine, what the participants learn together (Engeström and Kerosuo 2007). The creation of new knowledge in Expansive Learning is one of many ways to understand how learning occur. However, it is important to understand the historical and cultural grounds on which the theory of learning is based (Engeström 2015). Therefore, the understanding of Expansive Learning needs to be placed in its *'historical and cultural ground'* and understood in the historical complex context, before using it as the theoretical framework (Sannino et al. 2009: p10). This section begins with a description of the development of Activity Theory, followed by a description of Expansive Learning.

What is now known as the first generation of Activity Theory leads back to the theory of Vygotsky, where the understanding of objects (humans) should be seen in a cultural context and cultural artifacts, tools and signs mediate the human relationship to the environment. To understand an individual requires an understanding of his or her cultural means, and to understand a society requires an understanding of the individual who use and produce society is necessary (Engeström 2015). The first generation of Activity Theory is illustrated in Figure 2 with a triangle of subject, artifact and object. In the triangle the learner is the subject, the object is what the subject would like to learn, and finally, the outcome is the actual learning (Engeström 2001/1987).

The second generation of Activity theory added focus on the complex relationship between an individual to his or her community inspired by Leont'ev (Engeström 2001/1987). The surrounding culture was found to affect the learning in complex ways. The second generation of Activity Theory adds the considerations of organization and community to the bottom layer in the triangle (Figure 2), as rules, community and division of labor.

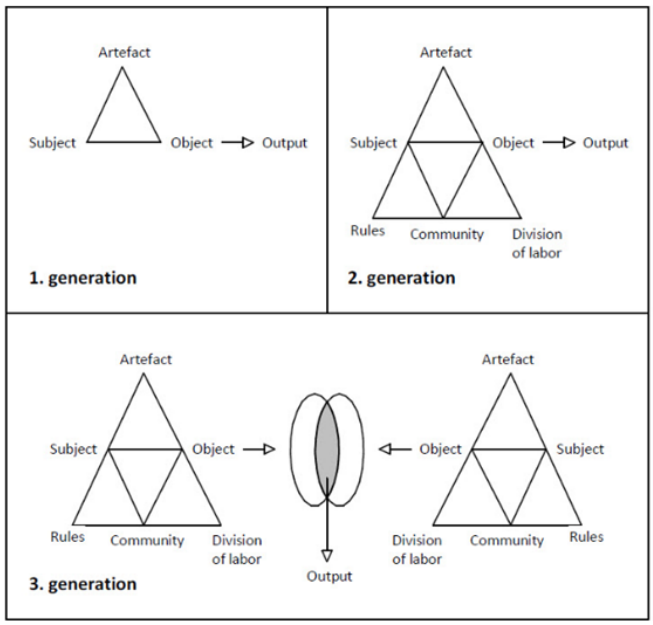

Figure 2: The Collective Activity System based on Engeström 2001/1987

The third generation of Activity Theory includes as a minimum two interacting activity systems (Engeström 2001/1987). The interacting activity systems are working towards the objects. In order to reach the object, they may have to learn to perform new activities; activities which they learn how to

perform during the creation of the activity and thus new collective knowledge by expansive learning is created (Engeström 2001/1987). Expansive Learning can happen in many contexts. In their review on the subject, Engeström and Sannino (2010) find that Expansive Learning can happen as: the transformation of the object, movement in the zone of proximal development, cycles of learning actions, boundary crossing and network building, distributed and discontinuous movement and as a result of Formative Intervention.

Expansive learning by transformation of the object is the focus of this study. An object can be defined as "the 'raw material' or 'problem space' at which activity is directed" (Engeström and Sannino 2010: p6). The subjects of an activity systems will change the object of the collective activity based on the Expansive Learning obtained during their activity; Expansive learning is in this way a "process of concept formation" (Engeström and Sannino 2010: p8). If the collective activity system's subjects change their object then Expansive Learning can have occurred, so the researchers need to focus on object transformations to identify Expansive Learning.

The need to change the object is discovered by the collective activity system's subjects when they enter into the Expansive cycle of learning actions. The Expansive Learning cycle is an ideal representation of the learning process (see figure 2). The first stage in the expansive learning cycle is, where the subjects in the activity system is "questioning, criticizing or rejecting some aspects of the accepted practice and existing wisdom" (Engeström and Sannino 2010: p7). The questioning is happening, because of a tension (or disturbance) in the activity system indicating that a hindrance exists between the Activity System and the activity, the system is performing. If the activity system's subjects reflect upon the tensions by entering into a process of forming a new concept (transforming the object) it enters into the expansive learning circle. In this way tensions in the activity system can become the "actual driving force of expansive learning" (Engeström and Sannino 2010: p7). The researchers also need to focus on the activity system's subjects' reflection upon tensions to discover, if the activity system is willing to enter the Expansive Learning cycle.

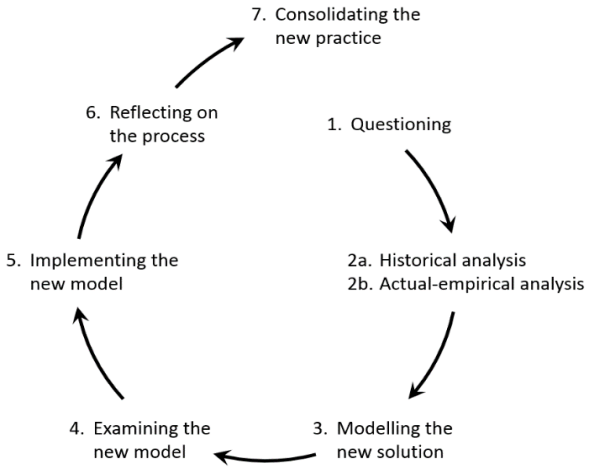

Figure 3: The expansive cycle of learning actions (Engestrom 2000: p970)

9. Towards a set-up for an experimental event about BIM in an educational setting

It has been argued that new knowledge and skills in both the AEC industry and by implication education programmes to enable the incorporation of the new procedures and practices, is needed. By adopting an Activity Theoretical perspective, a learning event will be developed.

From an educational perspective, the students participating in "The Digital Days" are performing an activity, which is "to learn about the implementation and use of BIM". During this process collective new knowledge might be created by Expansive Learning. However, from the students' perspective, the activity is to complete the design process as discovered by Klitgaard et al. (2016). This resulted in a collective activity system consisting of the participating students and professionals, which were unwilling to enter into the expansive learning cycle, and so no new collective knowledge was created.

We wish to develop the setting for "The Digital Days", so a higher willingness of the participating students to enter into the Expansive Learning cycle is stimulated. Our unit of analysis is the collective activity system comprising of the participating students from different educational backgrounds and the professionals from the industry working together as a team to solve the given refurbishment design-process task. We will here view the setting from the educational and learning perspective:

- **The Activity** – the students ought to learn about BIM (technology, collaboration, procedures, etc.)
- **The Subject** – the participating students and professionals from the industry
- **The Object** – to learn and develop new collective knowledge about BIM
- **Rules, Community and Division of Labor** – the organizational conditions, which affects the Activity System

It is the intention to create the opportunity for Expansive Learning. Emerging tensions in the activity system generates an opportunity for Expansive Learning. The students will be given a task to refurbish a building (the object according to the students' perspective). After some time, they will be asked to significantly change the concept for the project. In this way, the collective activity system's subjects must change their concept or object. The provoked change in the concept by the organizers may not provoke the activity system's subjects to enter into the Expansive Learning cycle. This will only happen if it generates a tension in the activity system, which the activity system's subjects chose to reflect upon. The research will show whether this will happen.

10. Proposed research approach

The proposed research approach needs to generate data whereby it becomes possible to identify the beginning of a possible learning process, so it can be documented, how the participating students and professionals reflects upon the opportunity and if the opportunity develops into a learning process how new collective knowledge is created. The unit of analysis is a collective activity system.

In order to identify the beginning of a learning process, the researchers need to identify when tensions are occurring in the activity system. The proposed methodology is a small ethnographic study during the workshop event, where the focus will be on observing the participants. The focus of the study is the collective learning.

The method of the proposed data collection is by Participant Observation. The process of collecting data will take place during the design meetings. Five dimensions must be considered according to Patton, stresses Warming (2009); while she adds a further three dimensions. The dimensions, the choice for the research and the argumentation behind the choice are displayed in Table 3.

The proposed method of analysis focuses on the identification of signs of tensions. The videotapes and recordings from the event will be studied for tensions. When a tension is identified, the participants' reactions to the tension will be recorded, and whether or not this generates new knowledge.

Table 3: Participating Observation Research Design (inspired by Warming 2009)

Dimension	*Choice for the research*	*Argumentation*
The researchers' level of participation (Patton)	*Observing participant.*	*The participating students should be informed that the research is in learning rather than in BIM activities. If their behavior is affected by the presence of the researchers it will be towards the focus of the research.*
The participants' awareness of the research project (Patton)	*The participants are aware of the research project.*	*The researcher need to be able to make visible notes.*
The participants' awareness of the purpose of the research project (Patton)	*Full awareness of the purpose.*	*Openness. Although the students may be affected in their behavior by the awareness of the research, full openness has been chosen to avoid an ethical dilemma.*
Duration of the observation (Patton)	*The researchers will be present at the workshop.*	*The tensions are expected to be develop during the student workshop. The researchers needs to be present when the activity system experience the tensions.*
Focus of the observation (Patton)	*Learning opportunities.* *The researchers are observing the activity system for tensions and object transformation.* *In the participants' language, tensions can be identifying in situations, where two alternatives are separated by the word: "but".*	*Reflections upon tensions needs to be observed and documented.* *A change in the activity system after a "but"-situation will indicate a reaction to a learning opportunity. It should then be recorded, how/if new knowledge is generated.*

Senses and feelings used for observation (Warming)	*The participants will be observed by the researcher.* *The workshop will also be video recorded.*	*The researcher will get a clearer indication of the activity by being present in the room with the activity system.* *The video recording are needed for later recollection of the situation as well as being able to clearly transcribe the situation.*
What is observed (Warming)	*The researcher need to observe the participants' behavior as well as their language*	*Participants' behavior reflect on the attitude towards learning.*
How does the observation become objective? (Warming)	*Clear description of the data collection.*	*A clear description will give the reader the possibility to understand the context of the data collection.*

11. Discussion

We set out to investigate how to set-up a workshop event allowing new collective knowledge about the use of BIM to be generated. We found a recommendation in the present workplace learning research in regards to further research into collective and collaboration expertise (Tynjälä 2013). This research aims to follow part of this recommendation as it intends to documents how/if new knowledge of implementation and use of new technology is developed by the students during the "Digital Days".

The proposed research approach is to use an Activity Theoretical framework. It will allow the researchers to identify tensions and object transformation by participant observation in order to document behaviour towards learning opportunities.

The fragmentation in the current AEC industry have created a need for new collective knowledge and work procedures. This research demonstrates that by carefully planning an educational set-up, not limited by the fragmentation, creates an opportunity to generate new collective knowledge in an experimental context.

Previous studies have shown the importance of a close link between practice and learning. When practice contribute with real-world constraints, the students analysis of these constraints constitute the key content of learning (Miettinen and Peisa 2002). However in an organizational setting Räisänen and Gunnarson (2007: p207) found that to achieve collective learning *"a structured praxis and a legitimate place and time in the organization"* is needed. In the set-up of the workshop event we have introduces real-world constraints. The students perform tasks from their practice in a context close-to what they would experience as employees in an organization. This creates a set-up where both individual and collective learning can take place.

The importance of an experimental approach to develop new practices and learning has in previous studies by Miettinen and Paavola (2014) been linked to the use of novel tools. The set-up encourages the participating students and professionals to use new technologies to problem solving. In this way, we have created a set-up that allows students to develop new collective knowledge while using new technology.

The implementation of BIM is "*an open-ended expansive process"* (Miettinen and Paavola 2014: p89). Experimental workshops events about BIM will allow for new collective knowledge about BIM to be created and in this way contribute to this expansive process.

12. Conclusions

BIM challenges the AEC industry and BIM requires new collective knowledge in both the AEC industry and by implication education to develop the further implementation of BIM. Experimental workshops events in an educational setting may allow generation of new collective knowledge for development of current practice.

During spring 2017, we will be able to test if the experimental workshop concept generated new collective knowledge.

Acknowledges

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Prerequisites for Successful Strategic Partnerships for Sustainable Building Renovation

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Abstract

The purpose of this paper is to identify the prerequisites for establishing successful strategic partnerships in relation to renovating buildings sustainably.

Establishing strategic partnerships is in the paper seen as a potential way to make building renovation more sustainable in Denmark particularly in terms of reducing energy consumption and use of resources and increase productivity. However, until now we have only had a limited number of such partnerships implemented and the few examples that do exist, mostly concern the construction of new buildings.

The paper is based on an investigation and analysis of strategic partnerships models as well as typical processes used in building renovation. Experiences from development of new strategic partnerships have particularly been found in the UK and Sweden. Based on two workshops with practitioners representing the whole value chain in the construction industry and analyses of two exemplary cases the paper suggests prerequisites for establishing successful strategic partnerships for sustainable building renovation.

The results show that strategic partnerships are collaborations set up between two or more organizations that remain independent with the purpose of obtaining a goal of mutual and high priority based on a binding commitment and a long term perspective by a consecutive number of projects. An essential prerequisite for most of the identified challenges in building renovation processes is stable project partners. Framework agreements is a way to legally establish collaboration with more stable project partners, but it is also in itself an important prerequisite to target challenges related to tender, competition and an extreme focus on lowest price.

Keywords: Strategic partnerships, Building renovation, Sustainability, Framework agreements, Renovation process.

1. Introduction

The need for building renovation has in recent years received increased attention in many European countries. One reason for this is an ageing and outdated building stock resulting in a need for more refurbishments and maintenance. Another reason is the need for more environmental sustainable buildings with reductions in energy consumption and CO2-emissions to limit the harmful impact on climate change (Jensen and Maslesa, 2015). There is at the same time a need to upgrade many buildings to improve the quality of life – social sustainability, for instance in relation to indoor climate, and increase productivity in the building process and considerations for life cycle cost to ensure affordable housing – economic sustainability.

Low productivity and frequent conflicts in the construction sector have over the last decades led to an increasing interest in new forms of collaboration between the different stakeholders involved in construction projects. This has resulted in concepts like Partnering, Lean Construction and Integrated Project Delivery (Haugseth et al., 2014). Such concepts focus on the individual projects, but there has also in recent years been an increasing interest in more continuous collaboration across projects, e.g. strategic partnerships. However, at the present we still have a limited number of such partnerships implemented in Denmark and the few examples that do exist, mostly concern the construction of new buildings. There have over the years been several initiatives to increase productivity and innovation in renovation projects in Denmark, both from government, trade organisation and private foundations. However, the main focus has been on developing the technical solutions of the built product rather than the construction process and there has been limited scientific research into this specific domain.

This paper is based on research made as part of a societal partnership in Denmark called REBUS, which is an acronym for Renovating Buildings Sustainably (http://rebus.nu/). The purpose of the partnership is to create innovation and new solutions to improve building renovation of social housing with a focus on three areas: reduce energy consumption of building by 50%, reduce use of resources by 30%, and increase productivity 20%. Several initiatives are taken to meet these requirements, including improvements in processes, methods and products. REBUS is supported by the Danish Innovation Foundation and includes partners from the whole value chain in the construction industry as well as universities and knowledge institutions. This paper is an initial result of a work package concerning 'Strategic partnership and business models'. It has been written by the university researchers involved in this work package and is partly based on workshops with the industry parties in REBUS.

The research question for the paper is: What are the prerequisites for establishing successful strategic partnerships in relation to renovating buildings sustainably? This is done by investigating recent examples of strategic partnerships between partners in the construction industry. Experiences from development of new strategic partnerships have particularly been found in the UK and Sweden. Based on workshops with practitioners and analyses of two exemplary cases, the paper suggests possible prerequisites for establishing successful strategic partnerships for sustainable building renovation.

2. Theory

2.1 Sustainable Building Renovation

Sustainable building renovation is understood as renovation of existing buildings that results in buildings that are more sustainable after the renovation than before.

The meaning of sustainability used in this paper is associated with the consideration of the interdependence of society, environment and economy in complex sustainability thinking based on the definitions from the United Nations with the three sustainability dimensions: social, economic, and environment (UN, 2012). In relation to assessing sustainability of investment projects Haavaldsen et al. (2014) recommends differentiating between the three levels: operational, tactical and strategic, where operational relates to the project output, the tactical relates to target groups and the strategic relates to greater society.

There is no general definition to describe building changes according to Thuvander et al. (2012), who present a large list of commonly used terms. We will like them use the term 'renovation' and we will particular focus on comprehensive renovation projects, which involve a major improvement in energy performance – also called 'deep renovation', for instance in EU's Horizon 2020 programme for research and innovation (EU, 2016).

In the construction industry it is often assumed, that renovation projects merely are a special type of new construction projects. They are often organised in the same way even though mostly with a more traditional division of labour and contract forms, and less standardisation. However, there are a number of differences between the process of new building projects and renovation projects. We have identified the following 7 characteristics, which distinguish building renovation compared to new building projects:

1. In renovation projects there is an existing building and it is possible and necessary to make a pre-evaluation of the building's design, condition and performance in the planning of renovation. However, a full diagnosis is often very costly, why some design solution might not be optimal when production starts (Thuvander et al., 2012).

2. In renovation projects there are also usually existing users and most of them will remain users after the renovation, so it is possible and relevant to collect their experiences and views on the buildings in a pre-evaluation and their needs and preferences in the briefing process during the planning of renovation (Værdibyg, 2013).

3. . In renovation projects it is possible to set performance target for the building after renovation related to the performance before renovation and calculate the expected performance improvement. In new buildings the expected performance has to be related to more general benchmarks like requirements in building codes or benchmarks for other more or less similar buildings (Jensen and Maslesa, 2015).

4. In renovation project there is an existing building design and architectural expression, which has to be taking into consideration and limits the freedom for possible new design solutions. This is of

particular importance if the building is listed or in other ways have been categorized as worthy of preserving by authorities (Værdibyg, 2013).

5. In renovation projects it is usually necessary to open up some of the existing building surfaces, which very often leads to surprises compared to drawings and other documents from the original building design and in relation to condition of building materials and installations (Værdibyg, 2013).

6. In renovation projects it is usually much more important to involve and inform the users during the construction process than in new building projects; both because it is their building before, during and after renovation and because they will experience disturbances and perhaps even relocation during the renovation project (Værdibyg, 2013).

7. In renovation projects it is possible in a post-evaluation after the renovation is finished to measure and make a direct calculation of how the building performance and user satisfaction has been improved compared to the situation before renovation, if a proper pre-evaluation was made (Jensen and Maslesa, 2015).

Renovation processes have in general more or less the same phases as new construction processes: pre-design /preliminary investigation or programming, design, construction, commissioning, and occupancy or use (Thuvander et al., 2012). In literature, there are a number of different models of renovation processes, for instance Thuvander et al. (2012) and Nielsen et al. (2016).

2.2 Strategic Partnerships

The literature on strategic partnerships often takes a starting point in the fundamental business dilemma between "make" or "buy", which also forms the basis for theory of Transaction Cost Economics (Williamson, 2008; Thomassen and Jørgensen, 2013). The alternative of making is equivalent to in-house production and coordination by corporate hierarchy, while buying is equivalent to transactions between independent legal identities with coordination by a market. Williamson (2008) argues that for complex contracts it is beneficial with hybrids between pure market based transactions and pure in-house production. Thomassen and Jørgensen (2013) illustrate the continuum of coordination between market and hierarchy as shown in Figure 1.

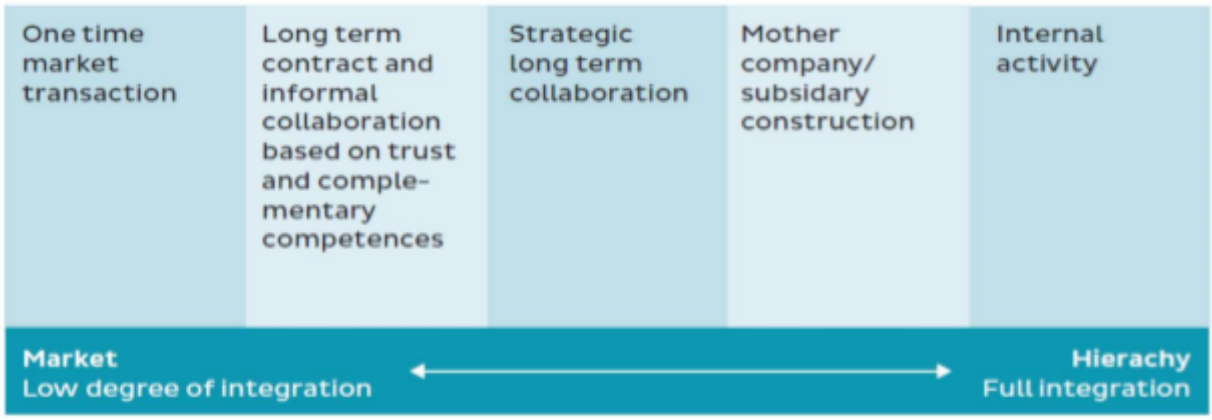

Figure 1: Coordinating inter-organizational activities (Thomassen and Jørgensen, 2013)

The main hybrid forms in Figure 1 are 'long term contract and informal collaboration and complementary competences' and 'strategic long term collaboration'. These are similar to what other authors label on one side operational partnering or partnerships and on the other side strategic partnering or partnerships (Mentzer et al., 2000; Ventovuori, 2006).

Thomassen and Jørgensen (2013) attempts to give a more precise definition of the core elements of strategic long term collaboration and come up with the following primary conditions:

- The collaboration is set up between two or more organizations that remain independent.
- The collaboration is formed with the purpose of **obtaining a goal** of mutual and high priority to the companies involved.
- The cooperation is based on a **binding commitment**.
- The goal of the collaboration has a **long term perspective** either expressed in long term collaboration on a single project or by repetition (or expectation of repletion) of projects.

A characteristic of Transaction Cost Economics (TCE) is that it is based on the common precondition of "economical man" pursuing self-interest and opportunism as in other mainstream economic theory without leaving room for more soft aspects like trust. As Williamson (2008, p. 15) writes in a comparison of TCE with theory of Supply Chain Management: "TCE eschews appeal to user-friendly concepts, such as the illusive concept of trust".

Thomassen and Jørgensen (2013) also identify other theoretical perspectives, which offer explanatory models for the rationality behind forming strategic long term collaborations. They suggest that Network Theory, Cluster Theory and Organizational Learning Theory might be more promising to understand strategic long term collaboration that supports a relational approach with a proactive strategy aiming for development and innovation.

For public building clients in the EU, procurement of building projects over a certain budget limit must follow the regulation in the EU procurement directive (EU, 2014). For procurement of a portfolio of projects, which are not specified in details at the tendering stage as it is typically the case for strategic partnerships, the most suitable contract form is framework agreements. Such agreements can normally only last for a period of 4 years, but projects started within this period can be finished after the period.

3. Methodology

This paper is based on literature studies of scientific publications, reports from authorities and trade organisations, websites and conference presentations of cases from public client organisations. The methodology of the review can be characterized as a scoping study, which aim to rapidly map the key concepts and main evidence in a research area from the perspective of key stakeholders (Arksey and O'Malley, 2005). The empirical research has included workshops with partners in the REBUS project involved in the work package concerning Strategic Partnership and business models and studies of 2 exemplary cases of long term collaboration in the construction industry.

Results from 2 workshops form the basis for this paper and they took place in September and October 2017. In each workshop participated 12-14 people. The participants included the following parties in the REBUS project: A contractor company (leader of the work package), an architect company, a consulting engineering company, a building material producing corporation, 2 social housing associations, and a university. The 2 social housing associations are representing building clients with

a large portfolio of residential buildings and are expected to provide demonstration projects for building renovation in REBUS.

The workshops were facilitated by the university researchers, who made presentations with overview of the current situation in collaboration in construction and building renovation projects according to literature and cases from practice as basis for the workshop discussions. The first workshop focused on common problem areas in the construction and renovation process and the second focused on experiences from exemplary cases of long term collaboration projects in Sweden and the UK.

The 2 cases were selected as some of the most well documented and most relevant for strategic partnerships in relation to building renovation and because they have found interest as good examples by professionals in Denmark. Therefore, the cases have a fairly long history. The case studies are based on information from existing documentation. The cases include one from the UK and one from Sweden. They involved public clients and both concerned local administrations/municipalities.

4. Workshop Methods and Results

4.1 Workshop 1 - Challenges

As part of the introduction to this workshop on challenges in renovation processes the university workshop facilitators presented ten themes or challenges which were identified by literature as important in building renovation, see left column in Table 1 (based on Evbuomwan and Anumba, 1998; Hauser et al., 1998; Kadefors et al., 2013; Reason, 2000). These ten themes were identified by a wide variety of literature and were discussed by the workshop participants. As part of the discussions the participants were invited to suggest themes, which they saw as important to the renovation process. In the following round table discussions four more themes were identified, see right column in Table 1.

Challenges identified from literature	*Additional challenges added during workshop*
1. Mistakes and defects in renovated buildings	*11. Lack of focus on building operation*
2. Stumbling blocks in renovation	*12. Lack of holistic risk management*
3. Phase transitions	*13. Communication*
4. Tender and competitions	*14. Extreme focus on lowest price*
5. The lack of common goals	
6. The lack of reuse of teams	
7. The lack of repetition in renovation projects	
8. The productivity of the building industry	
9. The state of the building prior to renovation	
10. Understanding the project partners	

Table 1: Challenges in the building renovation process

After the discussion each participans was asked to select the three topics, which they found to be the most important for a strategic collaboration to address. Four topics out of the 14 were the most voted for and subsequently the participants were split up into three groups and all groups were asked to discuss the four topics: 4. Tender and competitions, 6. The lack of reuse of teams, 8. The productivity of the building industry, and 13. Communication. In the groups the participants were asked to substantiate the reasons they thought were causing these challenges, and their responses were collected by the workshop facilitators. The responses were then discussed in a final round table session.

4.2 Workshop 2 – Strategic collaboration

The goal of the workshop was to present and discuss cases and experiences from previous building and renovation projects which had employed some form of strategic collaboration. To do this a practitioner who had participated in strategic collaboration through framework tender for a Swedish municipality, and representing the building owner perspective, was invited to make a presentation (see section 4.4).

As part of the presentation by the workshop facilitators, cases from Sweden and the UK were presented to exemplify a top down strategic partnership approach adopted by the UK government and a bottom up strategic partnership approach used in the Swedish building industry instigated by several members of the construction supply chain. After the presentations the workshop participants were invited to share their thoughts on strategic partnership and which aspects they found insightful and useful resulting in the following:

- Alternative selection and allocation of partners in framework tenders.
- The transferability of funds from one project to another.
- Insights into the use of one or several strategic collaboration partners.
- Not only looking at strategic partners as a model when considering design-build projects.
- The use of open books not only to gain discounts.
- Strategic partnerships as a way to promote certification of sustainable construction
- Improved recruitment of talent to the construction industry by improving the building process.
- The many positive experiences with strategic partnerships were encouraging.
- The understanding that it is people in companies who collaborate and not companies themselves.
- The strategic partnership can be a way to focus on the building process and not so much on the design process.

5. Case studies

5.1 Case - Salford City Council

The case study of the Salford City Council on their experiences with strategic partnerships was presented by Paul Mallinder, director of Urban Vision, in September 2006 at an event in Denmark. Outlining a number of challenges in construction projects which the city council sought to elevate through strategic partnerships, Mallinder (2006) listed:

- Tender every scheme irrespective of value.
- Traditional tendering is slow, costly and bureaucratic and waste of valuable resources.
- Select on lowest price - risk created by the use of fixed tendered rates does not encourage quality workmanship or good relationships.
- A slow process for getting projects on site and hence completed.
- Little incentive to perform well as the next project will still be tendered.
- Insufficient resource planning.
- Unable to involve the constructor at the planning and design stage.
- Different designer/ constructor teams on each project.
- Does not encourage flexibility or innovation.

- Little incentive to develop new ways of working which reduce costs/improve systems/processes etc.
- No collaborative working on local employment / environmental issues.

The result of the traditional approach to construction lead to poor customer satisfaction, delays and cost over runs, variable construction quality and a high number of defects in the finished buildings. Mallinder (2006) identified the main driver behind the change in approach as being; the UK government, the UK audit commission and strong leaders and innovators in the construction industry. Mallinder (2006) outlined the key changes in the Salford City Council's approach as being: Removal of project by project tendering and select lists to create more certainty with a guarantee of many years work (without having to tender) providing performance standards and value for money remain high, removal of the risks created by fixed/lowest price tendering, creation of long term partnerships with a more robust selection process, greater use of payment linked to performance, more emphasis on quality, increased use of target cost/open-book payment systems, and appreciation that savings potential was wider than just construction costs.

At the time of the presentation the council had appointed 13 contractors for framework agreements of 5 plus two years or four years. These contracts spanned new buildings and refurbishments, highway civil engineering to demolition. Some of the early results of the new partnership schemes was projects completed on time and budget, no defects on handover, use of local supply chain, projects started and completed many months earlier than when using the traditional method and a construction process which is robust when faced with unforeseen delays or disruptions. Mallinder (2006) also described how the strategic partnerships not only helped the Salford City Council keep to their construction budgets but also the contractors which had a guarantee of future work and the users who experienced higher quality of work and a more integrated construction process.

5.2 Case – Telge Fastigheter and NCC

This case description is based on Kadefors (2013) and a presentation by Taina Sunnarborg (2015), Telge Fastigheter, in January 2015 at an event in Denmark. According to Sunnarborg (2015) there are 20 ongoing strategic partnerships in Sweden. In 2007 a new law concerning guaranteed access to municipal childcare was passed in Sweden. In the municipality of Södertälje this meant that the demand for new childcare facilities increased sharply. Traditional tender models were deemed too costly and time consuming and so a partnership model based on framework tender was initiated.

The first framework tender agreement was made between Telge Fastigheter, the company owned by the Södertälje municipality which owns and manages municipal property, and the contractor NCC after the municipality received six tenders. The framework was signed in 2008 and NCC was to construct six nursery schools and two larger schools with the framework terminating in 2012.

The second framework was made to include all major construction projects in Telge Fastigheter and Telge Bostäder with a construction cost of more than 10 million SEK. Three companies was chosen to be part of the framework; Skanska (1st), NCC (2nd) and Arcona (3rd). The framework covered 2010 to 2014 with the possibility to prolong 1+1 year. Skanska was chosen to carry out a few projects within elder care, residential construction and commercial properties. All construction projects concerning

schools and nursery schools were allocated to NCC, while Arcona did not do any work within the framework.

All projects were awarded as design-build contracts with NCC involved at a very early stage and participated in feasibility studies, project groups and workshops before the go/no go decision was made by the client. The projects followed three predetermined phases: 1. Feasibility study and brief, 2. Design development, and 3. Detailed design and construction

The organization setup to handle the framework consisted of a steering group responsible for all projects, project steering groups responsible for each separate project and collaboration groups responsible for carrying out the work in the individual projects. As part of the framework contract bonuses were allocated based on performance in; quality and economy, collaboration ability and attitude, user satisfaction, project control, and accident rates and work environment. On top of these organizational structures and monetary incentives all project managers from Telge Fastigheter participated in a partnering course and NCC utilized their internal partnering training program for all employees working in the framework. This was done to ensure that the necessary trust and emphasis on collaboration was present in the projects.

In material presented from Telge Fastigheter to politicians in Södertälje municipality the following advantages was found when using framework tendering:

- Quicker project start-up: saves time when contractors do not have to be procured for each project.
- More efficient process saves both time and money.
- Better use of project competences – all parties engage in identifying opportunities to save costs.
- Knowledge of which aspects drive costs provides a better basis for decisions in early phases and reduced budget uncertainty.
- May benefit from contractor's discounts on materials.
- More satisfied employees.

An analysis made by Telge Fastigheter found that the construction cost of the buildings made within the framework was comparable with similar projects carried out by other municipalities using traditional tender models. The main difference found was that the construction quality of the buildings made for Telge Fastigheter was significantly higher and that the operation costs of the buildings was significantly lower.

Entering into the framework enabled NCC to get a substantially larger volume of work from one contract, more predictable profit and lower risk. This makes this kind of agreement very attractive and the NCC building division in Stockholm has 90% of their turnover from partnership projects.

6. Analysis

Both cases include the core elements of strategic long term collaboration identified by Thomassen and Jørgensen (2013) and presented in section 2.2. A comparison of the 2 cases is shown in Table 2. Besides general characteristics, it includes the 3 dimension in the 'iron triangle' or 'value triangle' of project

management: Value, cost and process (Jensen, 2013). The comparison shows that even though that case 1 is top down and policy driven and case 2 is bottom up and needs driven, the cases for most aspects are very similar.

		Case 1 – Salford City Council	*Case 2 – Telge Fastigheter*
General	*Initiation*	*Top down – national initiative*	*Bottom up – local initiative*
	Driver	*Policy*	*Local needs*
	Client	*Local administration/municipality*	*Local administration/municipality*
	Partners	*Several contractors*	*Several contractors*
	Legal basis	*Framework contract*	*Framework contract*
	Benefit for client	*Removal of risk from fixed/lowest price tendering*	*Reduced budget uncertainty*
	Benefit for contractor	*Guaranteed further work*	*High volume, more predictable profit and reduced risk*
Value	*Quality*	*More emphasis*	*Significantly higher*
	User satisfaction	*Drastically increased*	*Drastically increased*
	Defects	*Reduced to almost none*	*(Not available)*
Cost	*Construction*	*Reduced*	*Comparable*
	Operation	*Reduced*	*Significantly reduced*
	Incentives	*Bonus scheme*	*Bonus scheme*
Time	*Project schedule*	*Quicker start up*	*Quicker start up – shorter projects*

Table 2: Comparison of the 2 cases

In Table 3 the researchers have evaluated, how the 14 challenges in Table 1 have been targeted in the cases. It shows that having more stable project partners is an essential prerequisite in relation to most of the challenges. Framework agreements is a way to legally establish collaboration with more stable project partners, but it is also in itself an important prerequisite to target the challenges related to tender and competition (challenge 4) and an extreme focus on lowest price (challenge 14). For the challenges related to lack focus on building operation (challenge 11) and lack of holistic risk management (challenge 12), we do not have sufficient information to make an evaluation, but a strategic partnership should not as such prohibit a stronger focus on both of these areas. That is probably more a question of changing the general mindset and management processes among the project partners on both client and provider side.

Challenges in the building renovation process	*Targeted in the cases*
4. Tender and competitions *14. Extreme focus on lowest price*	*Problem reduced by framework agreements*
1. Mistakes and defects in renovated buildings *2. Stumbling blocks in renovation* *3. Phase transitions* *5. The lack of common goals* *6. The lack of reuse of teams*	*Problem reduced by more stable project partners*
7. The lack of repetition in renovation projects *8. The productivity of the building industry* *9. The state of the building prior to renovation* *10. Understanding the project partners* *13. Communication*	
11. Lack of focus on building operation *12. Lack of holistic risk management*	*Not known*

Table 3: Comparison of the 2 cases

The cases were selected as exemplary because they are well documented and seen as successful but they are both some years old. More recent cases have shown an increased focus on sustainability and use of sustainability certification as documentation of the quality of the building projects are beginning to become more common and starting to be used also for renovation projects.

7. Conclusions

Strategic partnership is a collaboration set up between two or more organizations that remain independent with the purpose of obtaining a goal of mutual and high priority based on a binding commitment and the goal has a long term perspective by a consecutive number of projects. An essential prerequisite for most of the identified challenges in building renovation processes is stable project partners. Framework agreements is a way to legally establish collaboration with more stable project partners, but it is also in itself an important prerequisite to target challenges related to tender, competition and an extreme focus on lowest price.

However, framework agreements are not a sufficient condition for successful strategic partnerships. It is also necessary that the involved parties have the right mindset and a maturity to manage the partnership. This is in focus of our further research.

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Developing a business model for sustainable renovation of public housing

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Abstract

Renovating housing properties in a sustainable manner while at the same time attaining a financially profitable project is a challenge for housing companies today. This problem becomes more apparent in socially deprived residential areas. Although there has been a vast amount of research on the topics of business models and sustainable housing renovation respectively, there seems to be a lack of research connecting these two together. The aim and objective of this paper is to propose a business model regarding sustainable housing renovation for public housing companies. A literature study together with an interview study with a public housing company in Sweden form the basis for a proposed business model. The model was derived through an iterative process of coding, singling out themes relevant to the notion of business models and business-like approach. The model was thereafter applied and tested on a real-life renovation case. The case consists of a public property containing 1200 apartments, afflicted with severe technical complications as well as socio-economic challenges regarding the tenants and the area as a whole. Findings show that merging sustainability dimensions with traditional business prerequisites, such as profit, is perceived as difficult. Achieving a profitable project while at the same time undertaking a social responsibility towards the current tenants is a balance act. There are however financial profits to be found in the social dimension and the notion of CSR projects was positive, both from a social and economic perspective. Identifying and evidencing these financial values is an essential part of the proposed business model. It is suggested that a well-configured business model could serve as a platform for renovation projects, demonstrating how sustainability can be brought together with both customer and technical renovation demands of a property.

Keywords: Business models, sustainable renovation, public housing companies, case study.

1. Introduction

Deteriorating and aging housing properties and the management of these is today an important issue in society. In Sweden, a significant proportion of these estates were built during the Million Homes programme in the 1960-1970s and is today in great need of renovation (Olsson et al., 2015). Housing companies face major challenges in renovating these aging buildings (Stenberg, 2015; Thuvander et al., 2012). Renovating these properties in a sustainable manner would mean incorporating economic, social and ecological needs of different stakeholders. Two questions property owners might raise are: 1) Are there business incentives for renovating these properties in a sustainable way? and 2) Are there any available business models related to the problem? According to Williamsson (2014) the definition of the concept business model is ambiguous. Generally, it concerns a system describing how a company should operate in order to stay profitable. The Cambridge Learner's Dictionary (2016), for example, offers the following definition of the concept business model: "A description of the different parts of a business or organization showing how they will work together successfully to make money."

So far it does seem as there is a knowledge gap in research literature between business models and sustainable housing renovation. However, the connection between renovation and a business model approach has been brought up in Swedish trade press, e.g. Fastighetsnytt (Thor, 2016). Thus, the concept seems to be debated within the industry even if not well-researched. The aim and objective of this paper is to propose a business model regarding sustainable housing renovation for public housing companies.

2. Research methodology and case object

Study object is the Swedish public housing company Familjebostäder. The analytical unit is the property owner, meaning that the research takes the property owner's viewpoint in large housing renovation projects. The study specifically focus on Familjebostäder's upcoming renovation project at Siriusgatan in Western Bergsjön, Gothenburg. The buildings at Siriusgatan were built during the 1960s Million Homes programme and consist of 1200 apartments. These are reaching their technical life span and are fragile not only from a technical perspective but also from a socio-economic perspective. The methodological steps were as follows:

1. An extensive literature review was performed in order to establish a theoretical framework related to business models.

2. An interview study was then conducted with 10 individuals from different organisational positions in Familjebostäder. In order to acquire a deeper understanding of the topic both related to the organisation and related to the Sirius project a variety of relevant individuals from the company was interviewed. Both individuals from the Sirius project and individuals with other central roles for renovation decisions in the company. In the results the interviewees are grouped into senior managers (4), project managers (3) and support staff (3).

3. The interview data was structured and analysed in relation to the theoretical framework.

4. Lastly, derived through an iterative process of coding and singling out themes relevant to the notion of business models and business-like approach, the findings from the analysis were developed into a proposed business model for sustainable renovation.

The theoretical framework provided an understanding of the concept of business models, sustainable renovation and how they could be interconnected. The interview study in turn offered an opportunity to obtain in-depth knowledge of how the concept of business models is perceived in the light of Familjebostäder's business and in particular their renovation project at Siriusgatan in Western Bergsjön.

3. Theoretical framework

A business model is supposed to explain how a company stays profitable, i.e. how financial value is created (De Wit and Meyer, 2014). For housing renovation projects, financial value is generally created through increased rent incomes, decreased operating expenses and increased real estate values and the project is ultimately economically sound if it yields a proper return on the invested capital (Lind et al., 2014). Shafer et al. (2005) argues that business models are usually made up of a system composing four main categories: strategic choices, creating value, capturing value and value network. Based on these categories Shafer et al. (2005) sought to develop a definition regarding business models: "A representation of a firm's underlying core logic and strategic choices for creating and capturing value within a value network" (Shafer et al., 2005). This notion of business models is supported by Williamsson (2014) and Teece (2010), who state that the model should mediate the company's business logic and explain how profits are made, i.e. how value is created. Figure 1 illustrates the various elements in developing a business model as proposed by Teece (2010).

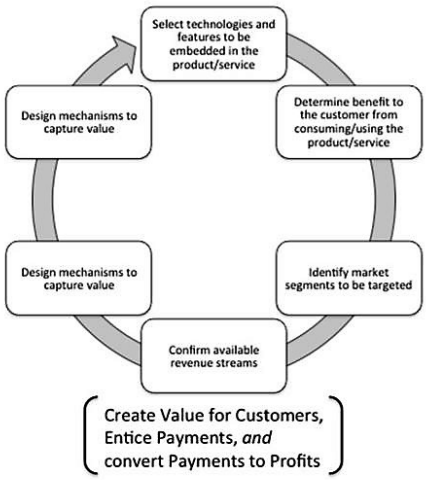

Figure 1: Elements in the development of a business model (Teece, 2010).

From a business perspective, the economic dimension of sustainability revolves around how the company operates in order to stay profitable but at the same time acting sociably just in relation to society and its citizens (Grankvist, 2012). In turn, acting sociably just in a business setting is often named Corporate Social Responsibility (CSR) and typically concerns a widespread collection of issues in which companies are encouraged to act in a socially responsible manner (Dahlsrud, 2008). In terms

of CSR and housing management, Blomé (2012) found that strict economic value such as lower operating expenses and new commercial prospects can be derived from CSR projects.

As properties age, they are subjected to the ravages of time and deteriorate. Renovation is the procedure of returning a building to its original state, or even improving it past its original conception (Ástmarsson et al., 2013). At heart, the purpose of renovation projects is to lengthen the beneficial use of a standing building and as such constitutes a cost-effective alternative to new construction (Mansfield, 2009). As early as 2008 the real estate industry called for major renovation needs of Swedish properties. For the Million Homes programme properties, as high as 40% of the entire programme stock were classified as in need of extensive renovation (see e.g. Stenberg, 2015). The need and magnitude of renovation is contextual since it depends on the original state of the building, what level of maintenance has been done earlier, and what demands the occupants have (Ástmarsson et al., 2013). The property owner is generally compensated for the renovation investment in form of increased real estate value and potential increase of rental income (Ástmarsson et al., 2013). Figure 2 details how the lifetime and value of a property is affected by a renovation.

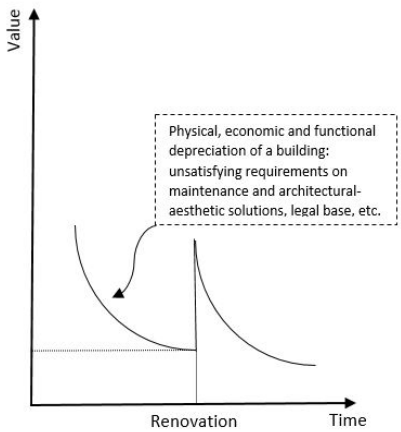

Figure 2 - The relation between value, time and renovation (Kaklauskas, et al., 2007)

However, the increase in rental income can be socially problematic, leading to something which Lind et al. (2014) labels as "renoviction", meaning that the tenants are forced to move due to being incapable of paying their post-renovation rent. Stenberg (2015) continues and argues that today's problem of dramatically increased rents as a result of renovations, causes both social as well as political implications. Boverket (2014) confirms the argument by Lind et al. (2014) regarding "renoviction" and concludes in their study that major renovation projects often result in that less financially endowed households are forced to move out of their renovated apartment. Adding to the topic, Thuvander et al. (2012) states that as sustainable renovation processes are multifaceted in nature, a synthesized and systemic approach is needed in order to make the right decisions regarding renovation investments. Moreover, the authors' call for a wider spectrum of values, such as cultural, social and architectural, to be adhered to when developing policies and business plans for renovation projects. The business and economic aspects of renovation projects are in the end deemed as major obstacles in achieving sustainable renovation (Stenberg, 2015; Ástmarsson et al., 2013).

4. Value creating measures in renovation

Each renovation project is expected to be profitable and as such able to carry its own costs and not become a financial burden to the company as a whole. However, set in relation to being a public housing company, with owner directives to serve the municipality's citizens with affordable housing, several interviewees vented concerns regarding adopting a business-like approach. There is, as one senior manages expresses, a balance act between being business-like and taking social responsibility:

"...and this is where the difficulty is, to achieve a profit while at the same time undertake a social responsibility. This is our owner directive, we are supposed to be profitable, business-like and we are to undertake a social responsibility, so it is a balance act."

This notion of connecting social responsibility with traditional business values is a shared view by several interviewees in together with having a long-term philosophy regarding corporate investments. The view is visible in their way of engaging in financially challenging renovation projects. In terms of value creation in renovation projects, five main components have been identified in the study; increase of rent, long-term approach, sustainability focus and CSR projects, customer dialogue, and area attractiveness.

4.1 Increase rent after renovation

Due to Familjebostäder's role as public housing provider and their management philosophy of acting "business-like" there are contradictions related to an increase of rent. On one hand an increase of rent is vital in terms of profitability and a strong economic driver for Familjebostäder in renovation projects. On the other, and according to some interviewees, rental increase due to renovation is difficult to manage, especially in low income areas such as Western Bergsjön. A Project Manager touches upon the subject, saying:

"It is the social aspect, plain and simple. If we are to be fully business-like, i.e. completely profitable then the rents could run too high and that does not really play well into our commitment as a public housing company."

An increase of rent is thus often viewed as problematic, and as a consequence the level of technical and environmental measures that can be taken are down-sized. Sometimes gradual increases of rent, split over several years, are applied in socially deprived estates. A Senior Manager describes this as a way of lessening the increased economic burden for post-renovation tenants.

Unlike some private real estate companies, Familjebostäder's main objective in renovation projects is not to maximize the rental yield, even though this might increase the financial outcome of Familjebostäder as a property owner, since this could negatively affect the tenants' situation. This view echoes among the employees and one Project Manager emphasize the importance of properly considering the needs of both the customer and the property itself and to do this in an early stage before rushing into a renovation project. The same Project Manager further state that it often becomes an act of scaling the project size in order to find the right balance between the increase of rent and what is reasonable from a residential perspective. A Senior Manager says the following concerning Familjebostäder's objective:

"The property generates a value. It is our investment, we must assure that that value is sustained. In a best-case scenario it increases, but we must [at least] assure that it is sustained. That is the number one priority I would say."

Implementing a separate funding system in regards to renovation projects is brought forward as a possible solution by a Support Staff officer, who also states that if there is no capital fund reserved for the renovation of the property, the project must be financed by an increased rent.

4.2 Adopting a long-term perspective in renovation to visualize value creation over time

Several interviewees agree that there are profits to be found in adopting the environmental dimension in renovation projects. A Senior Manager elaborates by saying that even if the initial investment cost might be lower if overlooking environmental concerns beyond legislation, it often become profitable when viewed from a long-term perspective. Similar views were expressed by other interviewees stating that renovation projects may struggle with profitability the years following project closure, but when considering the properties extended lifetime due to the renovation, the project is profitable. In contrast to the common practice of foremost concentrating on the initial investment cost a Senior Manager mentions the importance of having a life cycle cost perspective. This notion of seeing profitability and investments from a long-term perspective was expressed by many interviewees but also problems related to having an extended time frame was raised in that that current decision models lack support for such arguments. A Senior Manager argues for the difficulty of making the right investment decision when considering an extended time-frame and states:

"With the required rate of return and the financial control we have. Sometimes this can cause the decisions we make to seem as not so smart when viewed in a 100-year perspective."

This idea of a long-term perspective is evident in Familjebostäder's idea of developing the attractiveness of Western Bergsjön, says a Senior Manager, and an increased attractiveness of the area will lead to financial value generation in terms of increased real estate values. Thus, extended time-perspective in projects are viewed positively and several interviewees argue that when considered in a long-term perspective, projects with additional emphasis on social and environmental sustainability are financially sound.

4.3 Sustainability and CSR driven values

All interviewees brought up sustainability as value creator. One Senior Manager points to that all three dimensions are necessary in renovation projects in order to attain a long lasting and technically sound property. However, the dimensions are by most interviewees perceived as somewhat conflicting and one Support Staff officer stated that it comes down to finding the right balance between them. For example, extensive energy efficiency measures contribute to reduced operation costs but also involves high initial investment costs. Even if all three dimensions of sustainability is considered most interviewees believe that the economic dimension is particularly fundamental for Familjebostäder. A Project Manager raised a concern that if additional value is foremost derived from social or environmental measures, the economic side might be overlooked and a Senior manager expressed it as:

"...the economic [dimension] is somewhat the entire basis of it, without it will not be possible [to renovate]. Only because it is socio-economically good, because if Familjebostäder makes a lot of bad investment decisions we would go bankrupt. ...we have to make sound investments, which is an initial condition."

Following this argumentation, another Senior Manager states that social projects and social measures as isolated objectives are not Familjebostäder's main focus, and also says that in the end they are a real estate company and need to operate their business accordingly. A Support Staff officer state however that having a solid financial position gives room for other sustainability perspectives to be explored and invested in. Similarly, one Project Manager argues that if the financial calculation for a project does not add up, other sustainability dimensions are less likely to be accounted for. More, a Senior Manager states that in the long run investments in the environmental sustainability can generate profits, but these investments are often representing an expense during the actual project phase. Several interviewees discussed the difficulty of merging economic and social perspectives in a renovation project. Achieving, the owner's required profitability of a project while at the same time incorporating social dimensions is perceived as difficult. This, they say, often results in that one dimension dominate on expense of the others, and often on the environmental dimension of sustainability.

CSR efforts were mentioned by several interviewees and then in a positive way. One senior Manager argued that CSR related projects are economically profitable for Familjebostäder, combining social and economic sustainability. An example of a CSR measure brought up during interviews were related to youths, in which troublesome youths and young adults are engaged in meaningful projects as a way of reducing vandalism on both real and personal property. A Senior Manager also states that an active social presence and management by property owners could result in reduced repair and maintenance costs due to reduced vandalism. Several interviewees agreed on that CSR efforts, both in renovation projects and property management practice are profitable from an economic as well as a social viewpoint.

4.4 Dialogues with tenants as a mean to generate value

The relationship between the company and the tenants is an important issue brought up by numerous interviewees. One Senior Manager for example says:

"I do not think you should build a relationship [with tenants] because you have to or want to have good scores [customer polls]. You should build a relationship and bring in their viewpoints because it actually improves the project."

The opinion of having a dialogue with the tenants and listen to them in order to understand what they wish for in their living was present in all interviewees. Several Senior Managers emphasize the importance of having a dialogue with the tenants, to "truly ask what they want". To exemplify one Support Staff officer expresses it as: *"Maybe it is only half of the tenants who are aware of that the basement is newly-painted"*. The same Support Staff officer elaborates further and states that it is important to see the perspective from the tenants view for each measure in order to see what their gains from the renovation are. A mutual dialogue would, according to a Senior Manager also provide Familjebostäder with a deeper understanding concerning what measures a renovation should include. Thus, according to a Senior Manager a dialogue with the tenants, not only lead to higher customer

satisfaction, it also contributes to improved delivery. More, a Project Manager stated that it *is "very important with information and communication [with tenants], to from the very beginning signal to the tenants what they can influence"*. This would, according to a Support Staff officer, lead to a higher rate of satisfaction among the tenants, since they would feel more involved in the renovation project. A Support Staff officer elaborates further on the topic and states that: "...[rents need to] be on a level where the cost is reasonable for the tenants in relation to what he or she receives." Thus, proper dialogue increase the tenants understanding of why renovations has to be done and also how the increase of rent relates to the measures taken. Another benefit from tenant involvement, as argued by a Project Manager, is decreased vandalism since the tenants become more caring of the buildings.

4.5 Increase the attractiveness of a deprived residential area

Renovation and renewal projects have previously been found to contribute to an improved socio-economic development along with increased real estate values of residential areas. A Senior Manager explains that if a socially deprived area, like Western Bergsjön could be more closely linked, for example through shared infrastructure, with neighbouring areas with higher real estate values then the values at Western Bergsjön would gradually rise as well. Two Senior Managers state that renovation and renewal projects could be seen as growth drivers with the possibility to increase the socio-economic development of deprived areas. A Senior Manager state that the renovation of Western Bergsjön will be beneficial for Familjebostäder and argues: *"We must do this and there are also values down the road. That if we change the image of Bergsjön the real estate values will be increased."* Another Senior Manager discusses the same topic and mean that increasing the general opinion and attractiveness of an area, the market value of the properties will follow. An example given on how this can be done is to densify the area with new constructions and as such diversify Western Bergsjön's demographic landscape.

A Support Staff officer argued that increased attractiveness can be achieved by having a responsible and proactive property management. However, raised property value in a housing area cannot be done isolated from other property owners in the area, as explained by a Support Staff officer: *"If you want to make an effort in an area, it would have been good if the others also did it, if you want to enhance the area."* Also other interviewees stress cooperation between property owners in an area as essential in order to increase the attractiveness. Here, a mixture of tenure forms, e.g. rental apartments mixed with co-operative condominiums, is favourable, as argued by a Senior Manager:

"In larger areas we can actually sell [properties to private companies] ..., ... in order to get a mix [of tenure forms] but then it need to be a deliberate strategy and not about making money."

5. A proposed business model

Based on the findings from our study the stepwise business model suggested by Teece (2010) has been modified so it is applicable for renovation of public housing properties. The modified business model (Figure 3) illustrates how a renovation project creates value for a public property owner, and in the long-run also for the tenant.

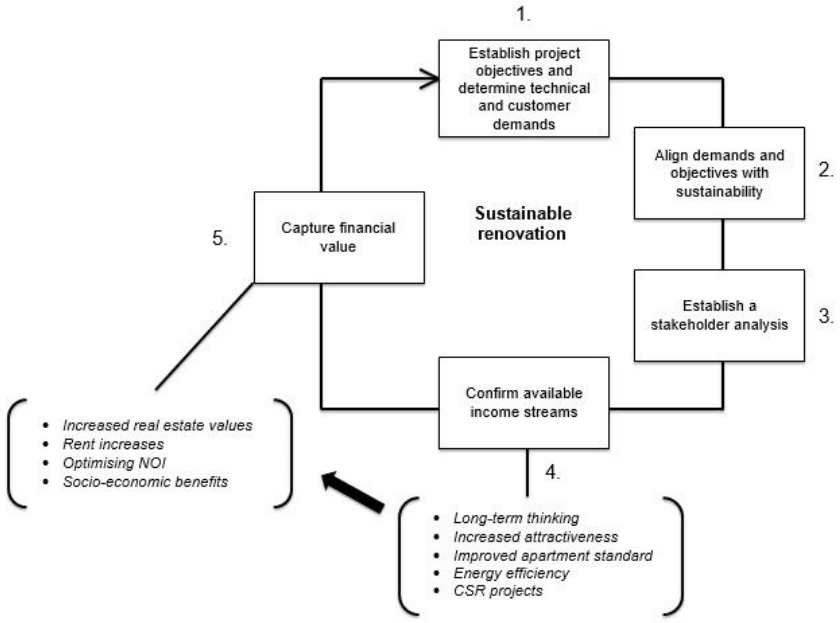

Figure 3 – A proposed business model.

The property owner is rewarded with a sustainable sound and technically improved property, which generates an optimized cash flow and value development over a prolonged timespan. The value for the tenant is an improved living that consider his or her needs and demands. The business model includes five systematic steps of actions:

1. What is the aim of the renovation project? A first step is to establish customer demands through dialogues with tenants. This step is crucial in being able to deliver value for the tenant. Aligning tenant demands with the technical needs of the property and the overall project objectives constitutes a foundation upon which the renovation projects rests.

2. Align the demands and objectives with the dimensions of sustainability. The sustainability dimensions should be entwined with the tenants' demands and objectives in order to deliver the most valuable property. This means identifying which sustainability actions that are most appropriate set in combination with technical measures and the tenants' viewpoints.

3. Perform stakeholder analysis. In short the stage revolves around locating key stakeholders and the management of these. Early stakeholder management would lead to a more efficient project and a stakeholder analysis could help map and identify key stakeholders, for example neighbouring property owners and tenant organisations. It would improve the renovation project's accomplishment, both organizationally and financially, if actors and interest conflicts could be detected and dealt with at an early stage.

4. Confirm income streams. In step four available income streams are established. The income stream is created through the physical renovation of the properties and is brought into the renovation project as a way of increasing the positive cash-flow after project closure. Both actions that generate value in short-term and actions with longterm benefits should be considered, for example by adopting a life cycle cost perspective.

5. Capturing final values. The last step is critical as it revolve around capturing the financial value and relates to the previous steps in order to achieve an economically sustainable renovation project. The step is largely dependent on step four as it deals with capturing the financial value created by the physical renovation measures taken. More specific, financial value can be captured by an optimized operation of the properties and a value improvement in the form of increased real estate values.

However, in socially deprived areas socio-economic benefits are also important to consider. These can be captured by complementing the renovation project with aligned CSR-projects. These types of projects could have great impact on the long-term value development of a residential area.

6. Discussion and conclusions

This paper has examined the possibility to develop a business model applicable for sustainable renovation of public housing. The proposed model seeks to bring a long-term focus on economic, environmental and social sustainability together.

Public housing companies typically have an extended social responsibility and a history of being a society benefactor. Following that tradition, renovation projects seeks to deliver sustainable, good and affordable living while at the same time acting within a business logic. Do these viewpoints come together? The study reveal that realising a profitable renovation project while undertaking sustainability measures, such as extensive energy efficiency and social measures, is an act of balance. Nevertheless, financial value can be found through a social obligation approach, for example in CSR projects. Our findings show that there are tensions between the three dimensions of sustainability in renovation of public housing but also positive attitudes towards gluing them together. Generating (economic) value for the company out of customer demand is stressed in research literature (Williamsson 2014, De Wit & Meyer 2014). The interviewees in our study expressed the importance of having a good dialogue and relationship with the tenants but they also voiced that this relationship should not be built just for the sake of it, it need to create value for the public housing company and for the tenants. Similar to Blomé (2012), our interviewees believed that strict economic value can be gained from a sound tenant-owner relationship, for example through CSR projects. Focusing on renovation measures that both provide increased tenant value and financial profit for the property owner was shared among our interviewees. A management philosophy of "businesslike behaviour" in combination with social projects, echoes to a wide degree the ideas of Grankvist (2012) and Blomé (2012). The environmental sustainability seems more challenging and not always in line with an increase of financial value in terms of raised rent, an issue also brought forward by Lind, et al. (2014). However, the *"renoviction"* problem (Boverket 2014, Lind et al. 2014) could be accounted for by identifying different tenant demands in an early stage and thereafter aligning them with possible revenue streams. Due to the possible tensions between creating economic value for the company and tenant involvement (Ástmarsson et al. 2013, Stenberg, 2015), the proposed model especially focus on demonstrating how value can be generated and captured in a renovation project through a dialogue with tenants. Thus, by acknowledging the tenants and providing them with technical solutions relevant for them, the business model could help display how value could be provided for both the tenants as well as for the property owner.

In terms of value creation in renovation projects, a number of components have been identified. These have been incorporated into the business model and could be applied in projects like Siriusgatan in order to capture financial value from the income streams, enabling an economically successful project. These are increased real estate values through *an increase of rent respectively raised area attractiveness*, by adopting a *long-term perspective* on investments, by generating economic benefits due to *CSR projects*, through *an optimised net* operating income due to a sustainability focus, for example energy efficiency measures. Balancing these components with aspects concerning *tenant demands* is a key for the business model to capture sustainable dimensions.

In conclusion, the benefits that sustainability dimensions bring to renovation projects should be intertwined with the technical state of the property along with the tenants' demands. It is suggested that a well-configured business model could serve as a platform for renovation projects, demonstrating how sustainability can be brought together with both customer and technical renovation demands of the property. The proposed business model could be used as a tool early on in the renovation project process and be a helpful framework when navigating in the intersection between profitability and sustainability and as such avoid negative effects such as "renoviction".

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A program perspective on partnering as supply chain integration

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Abstract

Major complex urban development projects are challenging and put pressure on coordination, cooperation and integration between a multitude of various interdependent construction projects and supply chains. While prior studies on supply chain integration mostly concern continuous exchanges in manufacturing industries, there is less research on discontinuous exchanges in project-based supply chains. This knowledge gap has resulted in an increased interest for partnering as supply chain integration in project-based supply chains and there is a conceptual and practical framework developed for understanding partnering as a multidimensional construct including four dimensions of supply chain integration: strength, scope, duration and depth of integration. This framework is useful for investigating separate projects but fails to acknowledge the program perspective including inter-project coordination and the interdependence between different projects and supply chains in the same program.

The purpose of this study is to investigate how SCI may be achieved across projects within the same program. Findings are drawn from a case study of Stockholm Royal Seaport. Each stage of Stockholm Royal Seaport can be studied as a program including a multitude of interdependent and parallel projects performed within a limited timeframe and a limited area. The findings suggest that supply chain integration between projects is as important as within projects and the theoretical implications suggest an additional dimension to the multidimensional partnering framework when taking a program perspective. Partnering as supply chain integration has a width dimension on program management level that is more challenging to manage since formal procurement and contracting mechanisms are put in place mainly at the project level, not the program level.

Keywords: Partnering, supply chain integration, urban development projects, program, projects

1. Introduction

An increasing amount of the world´s population is living in cities (United Nations, 2014). The continuous urbanisation trend puts pressure on managing the challenges of major complex urban development projects, such as coordination, cooperation and integration between a multitude of various interdependent construction projects and supply chains (Flyvbjerg, 2009). The construction industry is mainly project-based, which means that the industry's performance and development largely depends on the efficiency and innovation in individual projects. However, in the process of planning and building cities, construction projects take place in the context of other projects. This means, in line with the work titled "No Project is an Island" by Engwall (2003), that there are interdependencies between individual construction projects in the same phase of an urban development project and that no construction project is an isolated island. Hence, there is a need for a contingency perspective by applying a program perspective on urban development projects. By a program is meant "a long-term undertaking that includes two or more projects that require a close cooperation" (Archibald, 2003, p. 25). A program can thereby be understood as including several interdependent projects (Thiry, 2002) and program management as a way of managing the interdependence between projects and the possibilities to learn and respond to a changing context (Pellegrinelli, 1997).

While prior studies on supply chain integration (SCI) mostly concern continuous exchanges in manufacturing industries (Cao and Zhang, 2011), there is less research on discontinuous exchanges in project-based supply chains (Martinsuo and Ahola, 2010). This is a problem since SCI is especially challenging in project-based supply chains (Lii and Kuo, 2016; Weingarten et al., 2016). The identified challenges in project-based supply chains are a result of project characteristics such as discontinuities and uniqueness as well as high numbers of specialized but interdependent suppliers and activities (Eriksson and Pesämaa, 2013). This knowledge gap has resulted in an increased interest for partnering as SCI in project-based supply chains. Eriksson (2015) has developed a conceptual and practical framework for understanding partnering as a multidimensional construct including four dimensions of SCI: strength, scope, duration and depth of integration. This framework is useful for investigating separate projects but fails to acknowledge the program perspective including inter-project coordination and the interdependence between different projects and supply chains in the same program. In fact there is a lack of research on SCI with a program perspective, dealing with collaboration both within and across projects in the same program. Prior research has also shown that findings obtained in the project context are not automatically valid in the program context (Lycett et al., 2004).

The purpose of this study is to investigate how SCI may be achieved across projects within the same program. Findings are inductively drawn from a case study of Stockholm Royal Seaport (SRS), an urban development project in the City of Stockholm that is performed in several sequential stages and that are including a multitude of interdependent projects and supply chains. Each stage of SRS can be studied as a program including a multitude of interdependent and parallel projects performed within a limited timeframe and a limited area. The theoretical implications suggest an additional dimension to the multidimensional partnering framework developed by Eriksson (2015) when taking a program perspective. Thereby this study contributes to a holistic understanding of partnering as SCI within and across projects. The practical implications can serve as support and guide for managers developing the procurement strategies and practice in upcoming stages of SRS and other major complex urban development projects.

2. Partnering as SCI

The interest for partnering has increased during the last decades (Bygballe et al 2010; Eriksson, 2010). Partnering is seen as a radically different approach to procurement that stands in contrast to the traditional adversarial conditions typical for the project-based construction industry (Bresnen and Marshall, 2000). Despite great interest and efforts of implementing partnering in the construction industry positive effects are not easily obtained. This is explained by the narrow focus on the dyadic relationship between clients and main contractors while neglecting to involve other actors that might be of importance (Dainty et al., 2001). The transformation from adversarial to cooperative relationships in construction requires holistic and systematic change in structures, processes and attitudes (Eriksson and Pesämaa, 2007) and there is a need for increased understanding of how partnering can be implemented (Eriksson, 2010).

While partnering is seen as a cooperative approach to procurement, SCI can be understood as a coordination mechanism that simplifies internal and external business processes (Cagliano et al, 2006). Flynn et al (2010, p. 59) define SCI as "the degree to which a focal company strategically collaborates with its supply chain partners and collaboratively manages intra- and inter-organizational processes". SCI is thus seen as a multidimensional concept that includes internal, supplier and customer integration (Flynn et al, 2010) and the concept of integration is closely related to collaboration and collective actions to meet mutual goals. Compared to continuous manufacturing contexts, SCI is especially challenging in project-based supply chains due to discontinuous demand for projects, uniqueness of each project, uncertain demand requirements and production conditions, and complexity in terms of a high number of specialized but interdependent suppliers and their activities (Eriksson and Pesämaa, 2013). In order to enable a more detailed and systematic understanding of collaboration in project-based organizations Eriksson (2015) has developed a multidimensional conceptual framework on SCI in project-based supply chains. The framework includes four interdependent dimensions: strength, scope, duration and depth of integration and provides a better understanding of partnering as a multidimensional phenomenon.

The strength dimension is dependent on the extent to which integrative activities and technologies are utilized, for example collaborative procurement, contracting related procedures and a joint project office. While the scope dimension is dependent on which organizations that will jointly perform the integrative activities and technologies, for example clients, suppliers, contractors and consultants, the duration dimension is dependent on how long the partners will collaborate and jointly utilize integrative activities and technologies, for example integration across sub-sequent projects and/or project stages. Finally, the depth dimension is dependent on the integration of different types of professionals at different hierarchal levels within each partner organization. Due to their interdependence, 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).

3. Method

As mentioned in the introduction, the case studied is Stockholm Royal Seaport (SRS), a major and complex urban development project initiated by the City of Stockholm that will include around 12 000

new homes and 35 000 workplaces when finished in year 2030. The specific program in focus in this study is called Brofästet, which is the fifth succeeding stage of SRS. Brofästet encompasses nine properties assigned to eight different property developers (one developer have been assigned two properties) with a total of 560 dwellings and some joint facilities. The specific project phase in focus is the project initiation and early design and planning phase, i.e. before systems and detailed design. It is in this early phase of construction projects that project and procurement strategies are developed and decided upon.

The City of Stockholm decided early on to give SRS a distinctive environmental profile. Hence, there are high requirements on environmental sustainability in combination with high price for land and tight spatial conditions. These characteristics make SRS a complex project, which calls for good collaboration between all involved actors, including well-planned logistics and integrated supply chains. In order to handle the operational, environmental and spatial complexity in SRS, a building logistic centre (BLC) has been initiated by the City of Stockholm. BLC is mandatory to assign to by all developers and contractors and includes, for example, coordinated transports and short-term storage.

The empirical approach was qualitative and included the study of literature and project specific documents, interviews, seminars, workshops and informal discussions. The main actors in Brofästet during project initiation and planning were the city representatives, the developer representatives and the BLC representatives. The research followed a case study approach exploring how the work was managed and perceived during initiation, planning and coordination. The empirical data development process was inductive (Eisenhardt and Graebner, 2007), which is suitable when exploring a new research direction and aiming at theory development (Merriam, 1988). Six master students and two senior researches were involved in the case study.

The main empirical data for this particular study is based on semi-structured interviews with three of the developer representatives in Brofästet (Developer H that is planning for 62 apartments, Developer T that is planning for 80 apartments and Developer B that is planning for 91 apartments). Also, informal discussions with city and BLC representatives, two formal twohour meetings with all eight developers from Brofästet, city representatives and BLC representatives, and three consecutive half-day workshops with all actors in Brofästet are included. All together, the data covers more than 20 hours of participant observation. In addition, 30 interviews with representatives from previous stages in SRS and three master thesis reports serve as contextual information. The interpretation process began with applying the four dimensional framework by Eriksson (2015) and continued with focusing on perceived project interdependencies. Hence, findings presented below begin with four dimensions of SCI before going in to project interdependencies and implications for program coordination and collaboration.

4. Findings

4.1 Four dimensions of SCI

When initiating and making early design and planning for the construction projects in Brofästet each developer put great efforts into estimating and calculating their projects and they spent time negotiating with the city representatives for special project terms and conditions. Developers also took part in joint meetings initiated by a program manager to get and give program specific information such as the status for previous and partly parallel stages in SRS, legal approvals and the main time plan including dates

of start and stop for different activities. It is during this initial phase of the projects that the developer's strategies for procurement and SCI are developed and decided upon. The strategies define the strength of integration, i.e. the extent of collaboration between project actors; the scope of integration, i.e. what actors will be included in the collaboration; the duration of integration, i.e. for how long the project actors will collaborate; and the depth of integration, i.e. what roles that will be included in the collaborative activities.

The project strategies defining the four dimensions of SCI had not definitely been set by the developers at the time of the interviews. The new requirements made the project and procurement strategy extra challenging. "*New requirements create uncertainty"* explained Developer H the current situation and continued *"many developers have a hard time getting the projects to work in a good way because of the high prices for land in combination with high requirements on sustainability and quality"*. Developer H concluded the reasoning with "*there is a lack of experience of working with all these new materials and solutions"*. Developers B and H also expressed concern about the challenges to work in new and unfamiliar ways and still get the budget in order to get the projects approved in time in the internal sales processes. Finding the right contractors with experienced staff was also an expressed concern among the developers. Another factor that Developers T and B mentioned was the need to find good ways of collaborating with the next-door developers in the same program and there were also a general concern among the developers about the tight pre set time schedule developed by the city, which *"is a consequence of all of us being in the same block"* (Developer H).

To summarize, the uncertainty included both contextual and operational factors such as high price for land, tight construction area, pre set time plan, and high targets for efficiency and sustainability in terms of high energy demands and high demands on health and safety. These requirements made each project in Brofästet more complex and uncertain compared to regular construction projects. Hence, there is a need for special attention and adjustments since developers and contractors cannot plan for and apply their standardised solutions and traditional working procedures. Projects in Brofästet are extra challenging because they "include extra everything" (Developer B) and because the product is "a premium product – not a regular product" (Developer H).

4.2 Project interdependencies

A program factor that is special for all developers and contractors in Brofästet is the mandatory requirement to use BLC. This new requirement creates project interdependencies and uncertainty concerning costs, benefits and working procedures. Developer B says that "*BLC increases the complexity because we can´t really calculate it and the contractors need to adjust to new ways of planning. They can't plan as usual"*. Construction logistics is however not a new thing and most of the developers and contractors have developed their own construction logistics solutions. Experiences from previous stages of SRS are claiming that BLC will add extra work and extra cost to the projects "*BLC contributes to the complexity in this project. When I listen to previous experiences, I hear that BLC comes with extra work and extra costs"* (Developer H).

Other program factors that create uncertainty for developers and contractors in Brofästet are the construction site location (if the specific property/construction site is near the stage entry or exit or at the rare end of the stage area), previous experiences of working in SRS (some actors have been partaking also in previous stages of SRS), interconnections with other projects in the same stage (some

properties are so called community facilities, i.e. shared responsibilities that require a close cooperation) and existing contractor specific logistic solutions (some contractors have company specific logistic solutions that are used in other projects but are not allowed to be used in SRS). These factors create interdependencies between the projects in the same stage, which add extra complexity and uncertainty to the projects, or, as Developer T describes it, "*these are issues that you don't have to worry about when you have a block of your own".*

4.3 Program coordination and collaboration

From a program perspective, the main complexities in Brofästet are the project interdependencies that make it impossible to work with standardised solutions such as standardised platforms and familiar working procedures. Because *"there are many actors to consider, you don't only have to take care of yourself"* says Developer B. This has led to a situation where developers are facing high project complexity and uncertainty that requires a high degree of non-standardized solutions, coordination and cooperative relationships. The need for coordination includes both coordination between developers in the same stage and between developers and the municipality and it creates a feeling of lack of control. Developer T expresses concern about inter-project coordination and the lack of control by saying that *"we also have the coordination between all the developers and the municipality. We don't really have control over our own project because we are dependent on each other".*

This coordination put pressure on planning for efficient production, for example concerning logistics and *"when planning we need to collaborate regarding the cranes."* (Developer B). Developer B explain that *"we can´t just focus on our own production but we need to take consideration to our neighbours"*. While some of the challenges, such as coordinated logistics, backfilling and occupation, are perceived positive and necessary by the developers, other requirements are seen as unrealistic and the input provided by the municipality is seen as insufficient. Developer T explains that *"there are many things left to be planned, but there are not much time for that, neither spatial or content wise. For example the general work place disposition plan where the municipality has planned for streets where concrete trucks can't get through".*

Collaborative planning and operation is needed to handle interdependencies between projects, actors and supply chains and it is "*of outmost importance here because it is not just a flat field where you set up your own stuff and take care of yourself"* (Developer T). Collaboration between developers and contractors is however not easily established. One of the developers stresses the importance of working with experienced collaborators during planning, design and production. "*Our closest neighbours are two very experienced clients, which makes it easier. It could have been more difficult. There are many technical issues to solve"* says Developer T. Developer T also stresses the importance of both project and site management having necessary communication skills in combination with an unbiased and open mind-set when collaborating with others: *"There is a need for a site organization that is neutral and that can communicate with all".*

5. Discussion

When initiating and planning construction projects, focus is often on the project specific factors that fulfil project objectives (i.e. time, cost and function). These factors neglect that most projects are interdependent and that project outcome is depend on other projects and supply chains, i.e. that no

project is an island (Engwall, 2003). To ensure successful SCI in a project, four dimensions of partnering have to be considered, i.e. strength, scope, duration and depth (Eriksson, 2015). Consequently, issues such as what integrative activities and technologies should be used (i.e. strength), what organizations should be included i.e. scope), for how long the collaboration should continue (i.e. duration), and what professionals are needed (i.e. depth), are important to discuss and plan for from a project management perspective. However, when planning and managing a project that is interdependent with other projects in a program, there is a need to address both the dimensions that fulfil each project and its objectives, and dimensions that fulfil the aim of the program.

The construction projects that are planned and performed in the program Brofästet in Stockholm Royal Seaport can be regarded as nine separate projects, each one facing their own complexities and challenges. However, when taking a contingency perspective and applying a program perspective there are project interdependencies that need to be considered. These project interdependencies are: BLC, site location, previous experiences of working in SRS, interconnections with other projects and contractor specific logistic solutions. Spatial effects of being project next-door neighbours and sharing the program specific characteristics put pressure on supply chain integration during planning and production.

The case study indicates that previous collaborative experiences, an open mind-set towards other actors and good communication skills are important qualifications for handling project interdependence. When applying a program perspective on the conceptual framework on SCI as four dimensions of partnering, developed by Eriksson (2015) it becomes apparent that there is also a need for including a dimension that address project interdependencies. This dimension includes necessary skills and experiences to handle the project context, i.e. project interdependencies that will affect planning and production. Consequently, from a program perspective, qualifications on how to collaborate and coordinate actors, activities and supply chains across spatial, organizational, contractual and professional boundaries are of importance to enable successful SCI.

6. Conclusions

Increasing urbanisation and increasing focus on the development of sustainable cities, put pressure on urban development projects. To ensure successful SCI in construction projects that are part of the same program, the four dimensions of SCI as suggested by Eriksson (2015) are important but not sufficient to consider when developing project and procurement strategies. A fifth dimension that address project interdependence and that includes skills and experiences of managing the project context has to be added. Consequently, developers and contractors need to develop and demand procurement strategies and practices that include experiences and skills in project coordination and collaboration, including the skills to communicate across project boundaries. The theoretical implication of this study is a development of the multidimensional framework presented by Eriksson (2015), by adding a ***width*** dimension of integration. Practical implications are support and guidance to municipalities and developers to include qualifications on coordination and collaboration as well as communication across project boundaries when developing strategies for procurement in upcoming stages of SRS, and for lessons learned in other urban development projects.

To conclude, the findings suggest that SCI is important not only within projects but also across projects in a program. Accordingly, SCI needs to address also project interdependencies such as spatiality and

construction logistics. Consequently, partnering as SCI from a program perspective includes also a width dimension that is more challenging to manage since formal procurement and contracting mechanisms are put in place mainly at the project level, not the program level.

This study is limited to one urban development project and one particular program, Brofästet. In addition, the empirical footprint is during the initiation and early planning phase and should be expanded to also include the production phase. The findings and suggestions are thus to be regarded as tentative. Additional research is needed on other stages in SRS as well as on other urban development projects.

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Sustainability of Building Projects in Urban Planning – A New Evaluation Model

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Abstract

Evaluating the value of a building is a complex matter in itself. With an ambition to evaluate the value of a building embedded in its surroundings, and with a wider societal perspective, the task becomes even more complex. A new conceptual evaluation model was introduced at the 8th Nordic conference in Tampere, 2015. The model is further developed and tested since then, and this paper gives an update on the results.

The original model was based on principles from well-established evaluation methods and inspired by the OECD integrated evaluation model. It was made as simple as the authors found reasonable, considering the reduction in precision that comes with simplification. The authors tested the original model on three real-life case-projects in the development phase. Initial results proved promising, but also indicated issues for further development.

After this initial development, the authors tested the model on two real-life building projects in parallel with testing a different evaluation model developed by Sweco Norway. The purpose of the two models are similar, but the methods have different takes on the process and what information is used as basis for evaluation. The direct comparison gave interesting findings and signals for further development of both models. Both models are developed in Norway and may be characterized as adapted to the Nordic context.

The model evaluates the whole urban planning situation, including the neighborhood and transport infrastructure. The model has the potential to help practitioners achieve better results in terms of real sustainability in urban planning. Successful implementation and use of the model may lead to more conscious choices in urban planning and a more sustainable community.

The authors also wanted to test the application of the tool as a self-assessment-tool, and one case study was conducted as self-study. And although the results clearly indicated that the tool need some improvements, the results shows that the method has a potential as a self-assessment-tool, for early phase decision making.

Keywords: Method development; Project Evaluation; Sustainability; Key indicators, Urban Planning

1. Introduction

Our starting point is that we believe that is there is a limited action space for the support of human activities (Meadows et al 1972). Of the many limitations humankind is about to face, we agree with IPCC (2014) and others that global warming is the most immediate threat to a sustainable future (WCED 1987). Global warming is caused by a lack of carbon sinks, and thus a limit to our consumption of energy from fossil fuel. In other words, we have a waste handling or "self-pollution" problem.We need to act upon this challenge rapidly.

Furthermore, buildings – and especially residential buildings – are identified as key consumers of energy and materials (Bohne et al. 2016). According to UN, most people is living within or near cities, and the number is growing (UN 2014). This suggests that Urban planning, and near-Zero-Emission-Buildings (nZEB) and near-Zero-Emission-Neighborhoods (nZEN) in or close to cities is one route to a low carbon society (Høyer and Næss 2008, Bohne and Solli 2011).

Since the early 1990's, many building assessments schemes has been developed all over the world, where BREEAM and LEED by far is the most used ones. Mostly these tools is focuses on reducing the environmental impact from single buildings or groups of buildings, by focusing on efficiency gains and appliance to rules and regulations. Thus they refer to, but does not assess non-technical dimensions of organizational, social and behavior and do not consider the diversification of stakeholders involved (du Plessis and Cole 2011, Kallaos and Bohne 2013, Schweber 2013, Schweber and Leiringer 2012). Others have considered a wide perspective in a holistic or integrated assessment (IA) approach. Examples are Ravetz (2000), Lee and Quazi (2001) and Wiek and Binder (2005).

In Bohne et al 2015, we presented the NTNU Sustainable Building Project (SBP) Model, a model that assesses building in a systematic way, based on the project's performance and success criteria to evaluate against. The modelgives an evaluation framework that enables a dynamic capabilities approach and addresses some of the gaps left by existing tools. The OECD model for evaluation of development programs and projects called the OECD Integrated Evaluation Model (OECD, 2006) was the starting point of this development. It is based on the five success criteria as follows:

- **Efficiency:** A measure of how economically resources/inputs (funds, expertise, time, etc.) are converted to results.
- **Effectiveness:** The extent to which the development intervention's objectives were achieved, or are expected to be achieved, taking into account their relative importance.
- **Impact:** Positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended.
- **Relevance:** The extent to which the objectives of a development intervention are consistent with beneficiaries' requirements, needs, priorities and the policies of partners and donors.
- **Sustainability:** The continuation of benefits from a development intervention after major development assistance has been completed.

The OECD model also includes six cross cutting issues which should be considered for each of the five criteria. These areEconomic and financial aspects, Institutional aspects, Societal aspects, Technological aspects, Environmental aspects and Policy support measures (Samset, 2010). The purpose of this work was to see if we could adapt the OECD model to a "quick & dirty" but still useful tool for project

assessment. The purpose of the tool is to identify areas for project improvement in an early phase. An important feature of the OECD model, and our assessment tool, is to include the projects interaction society at a local or national level.

2. Method

As first shown at 8th Nordic in Tampere (Bohne et al. 2015), we started our work with a literature study. Not surprisingly, the literature study revealed an extensive literature on different aspects of evaluation of sustainability. As commented by Hacking and Guthrie (2008:74), *'[a] difficulty when considering assessment and SD [sustainable development] is not the scarcity of literature, but rather the vast quantity*'. There is a plethora of indicators and evaluation frameworks to choose from. Our approach was to simplify the process of evaluating sustainability by adapting a well proven framework with as few as possible indicators, while at the same time assessing the overall sustainability of complex projects. The model was desk tested against known case-projects and then finally introduced into real life situations.

The NTNU SBP model has five main columns, representing the OECD criteria efficiency, effectiveness, impacts, relevance and sustainability. For each of the five columns, there are seven sub-criteria on which we give the project performance a score 0, 1 or 2. When a case perform according to minimum national requirements, we give it the score 0. When it perform better than the minimum requirements, but potentially could have achieved better, we give it the score 1. In order to get this score, some additional investments or measures need to be made. In order to get the score 2, the project must have ambitions that are high enough to really make a difference. The maximum total score for each of the five OECD criteria is fourteen and the minimum is 0. Having found a functional form, we took the model to the first real test: evaluating three real life projects.

Accompanying the model itself is a guideline to how the model should be used in evaluating situations and how a group process is best planned and facilitated to handle the complexity and subjectivity. This is based on guidelines for uncertainty analyses (Klakegg 1993) and accumulated experience by NTNU Department of Civil and Transport Engineering over more than 20 years.

The authors deliberately chose to start with a wide array of different projects to make sure we address all major practical issues in the use of the model right from the start. All case studies were completed with document studies, one interview for each of the six cases and finalized through an evaluation report. The document studies were based on documents we got from our interviewees, and were executed in order to find facts about the cases. After the interviews were finished, we made an evaluation report for each case. This report was sent back to the interviewees for comments and confirmation to make sure the characteristics of the project was accepted as adequate

2. Method development: Self-assessment

The initial testing was performed with the authors as external interviewers (Bohne et al. 2015). We have experienced six real life tests with little problems related to the understanding of the concepts, the format and the process. We have had some challenges with values for the assessmentscale, but in a situation where the user evaluates his or her own project, we expect this to be a small problem as long as they are consistent. For the seventh case study, we tested the NTNU SBP as a tool for "do-it-

yourself" assessment. The idea was that this tool should be so simple that the user should not need any special training, as long as the individual has knowledge of the actual project and the sustainability issues we ask for. Experience from the process indicated that it might be realistic to let users fill in the survey form by themselves and get useful results.

Self-assessment is not without challenges, as observed by Mascharenhas, Nunes and Ramos (2014). Different stakeholders interpret value and view indicators differently, due to different values, interests, and cultural and academic context. This may lead to gaps between the intended communication role of the indicators and the actual result. Self-assessment and participation in evaluations are still an important and natural element in improvement work. Mascharenhas et al. (2014) show that different stakeholders actually assess indicators differently. However, two reasons why self-assessment is still valid:

1) It is economic whereas third party assessment is costly (the two should be combined for more objective results - calibration).
2) the purposes of self-assessment are to identify areas of strength and weakness in one's work in order to make improvements and promote learning (Andrade and Valtcheva 2009).

In an internal improvement process, self-assessment will not give major problems in terms of skewed judgement (the self-assessor makes the same error consequently and compares to own results over time, unless deliberately lying for tactical reasons). Self-assessment can be used, at least indirectly, for evaluating strengths and weaknesses and draw conclusions about utility and societal value (Mascharenhas et al. 2014).

The purpose of NTNU SBP as a self-assessment tool is to provoke the right questions to be asked in real life situations, and early enough to influence key decisions. In this case without any intervention from the authors or anyone else from the development team. We performed the test as follows:

The authors contacted an established BREEAM-NOR certified expert working with sustainability issues on several real life projects. The expert accepted taking on the test. This expert has education in environmental analysis and approximately 10 years' experience as a consultant for sustainable construction projects. This respondent is an experienced sustainability expert and works as special consultant for owners in building projects implementing BREEAM-NOR[2] (the Norwegian application of the BREEAM[3] sustainability assessment method for master planning projects, infrastructure and buildings). This means the respondent is highly qualified to do assessments in this field.

The respondent had previous experience with NTNU BPS as informant to one of our first real life test cases. This was three years earlier, and we have changed some attributes of NTNU SBP since then, so we were confident this would be a realistic test on how a qualified external user with subject matter knowledge will respond.

[2] http://ngbc.no/breeam-nor/#
[3] http://www.breeam.com/

4.Case studies

We deliberately chose a wide array of different projects. Case 1, 2 and 3, has been presented at the 8th Nordic Conference on Construction Economics and Organisation (Bohne et al. 2015). The fourth case is a traditional office building in Trondheim, with no environmental ambitions, but built near public transport and commercial development area. The fifth casewas a project with high ambitions on sustainability. The project was demolition of an old school, and construction of a new school with a multifunction sport center in Trondheim. The school was built as a Passive house school built from massive wood. The project has been part of a large national initiative, "Future cities", focusing on developing sustainable built environment in Norway.The sixth case is a social housing project, on top of a commercial center in East Stavanger. The ambition was high on the local and social development (mixed users), but no specific focus on energy consumption or sustainability.

The seventh case is a 15 000 m^2 "BREAM Very good" office building in Bergen. This was developed with both high ambitions of the projects, plus the developer has a strategy of developing new office buildings close to public transport hubs. The location of this project is at the railway station, close to the city line, the bus station, the motorway system, and a large parking house. The seventh case was also used for testing the NTNU SBP tool as a "do-it-yourselves" assessment. In addition to the self-assed evaluation, we also provide "corrected" result, where we as "experts" has filled in the open spaces from the self-evaluation in order to evaluate the case in the same line as the other case studies.

Table 1 Overview of case studies.

Project	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Case 7***
Location	Oslo	Trondheim	Bergen	Trondheim	Trondheim	Stavanger	Bergen
UFA m^2	16 422	3 500	~5 500	~5 000	10 073	~7 000	15 000
Site m^2	7 279	3 500	~1 000	~2 000	~5 000	~3 000	2 580
Year	2012-2014	2002	2014-2015	2014-2015	2013-2015	2014-2016	2013-2016
New build/ renovation/ extension?	Renovation	Extension, new top floor	New build	New build	New build	Renovation/ Extension	New build
TEK/PH/BREAM	BREEAM Excellent	TEK 97	PH	TEK 10	PH	TEK 10	BREEAM Very Good
Energy Demand	66	High	PH	TEK 10	PH	TEK 10	84
Net energy demand	81	High	PH	?	PH	?	104,6
Fossil Energy	?	0	0	0	0	0	0
Renewable energy?	10,6	0	0	0	0	0	15,2
Energy source	El	El, district heating	El, district heating	El	El, heat pump, District heating	El, smart house energy control	El, Heat pump
Office/ School/ residential	Office	Office	Residential	Office	School	Residential	Office

5. Results and discussion

The result from the case studies are shown in figure 1.

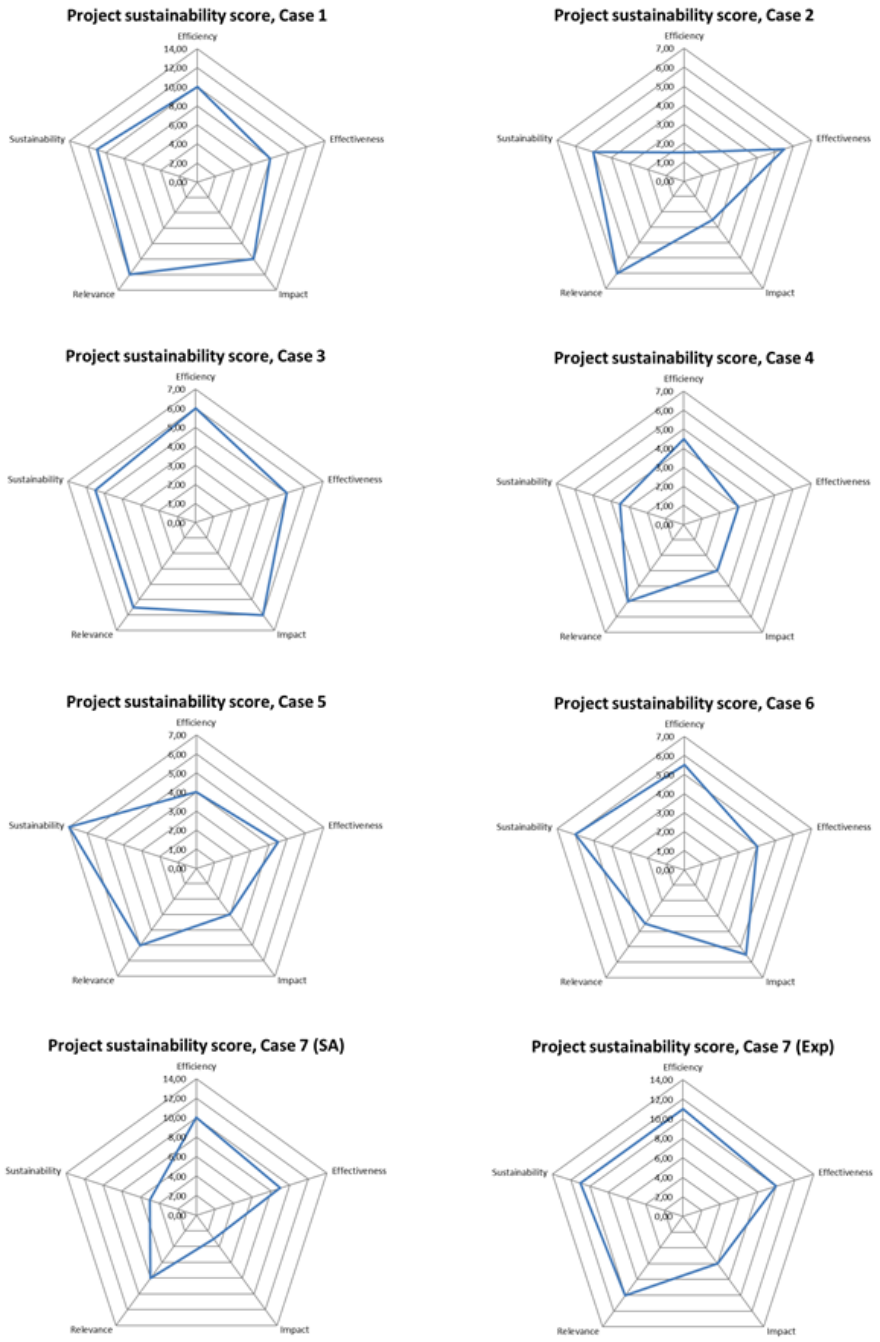

Figure 4 Project sustainability score for the case st

The result shows some interesting features:

- BREEAM projects scores overall very good in *Efficiency, Relevance and Sustainability*.
- Only projects (renovation) that actively seeks to interact with the surrounding developments scores good in the *Impact* category (and both where residential developments).
- There is little relationship between the scores in the *impact* category and the score in sustainability.

For the self-assessment, Figure 1 - Case 7 (SA), we sent the NTNU BSP tool to the expert by e-mail without any further instructions on what project to select or how to use the tool. The tool itself has a simple instruction explaining the purpose, definitions, criteria and grading scale. A week later (without any contact in the intermediate period) we received the completed assessment along with comments on his experience. The assessment result, accompanying comments and the follow-up telephone interview gave us the following result:

- NTNU BSP includes 35 questions for the respondent. 24 questions were answered without any problems. 11 questions were not answered.
- In 6 questions the reason for not answering was that the actual information was unavailable for the informant. The information could have been available, but from other respondents.
- In the remaining 5 questions, the informant did not feel confident to interpret the questions as they are formulated without any examples, additional information or instructions.
- For additional 5 questions that the respondent actually answered, he added a comment on how additional information would help the user understand the question better.
- We note from the returned assessment tool that it is the *Impact* theme that gave the respondent the biggest problems in answering due to lack of information.
- The *Relevance* theme is the hardest to answer due to unclear questions.

The respondent added, after the assessment the following observations:

"All questions on economy and stakeholder management require knowledge on the project's economy and strategy for stakeholder involvement. In my role, I rarely have this information. For such question, the project manager is in a better position to answer." This of course was no surprise, we have included the project manager as informant in several ordinary test cases and this experience is confirmed there. We should always include one representative from the project management together with an individual with solid knowledge of the actual sustainability performance in the project.

"There are some questions that generally is difficult to answer, either due to their wording, lack of precision of that they actually have to be answered subjectively. Where there is subjectivity, the answers will be colored by the informant's position and role in the project, as well as his or her political or local interest. You do not want that in this assessment. I would recommend making them as fact based and measurable as possible." This is also confirmed by other test cases. Some of the questions have room for improvement, both in wording and orientation. What will help moderate the subjectivity is discussing the questions in a team. We have done this in approximately half of the test cases, and it helps balancing out the subjective tendency – unless all respondents have the same view. In the Norwegian context there is no problem with lack of will to challenge or argue alternative views. We consider this a minor problem for the self-assessment, but it highlights that it is always an advantage to discussin a group, not alone – even for a highly qualified expert.

Then there is the matter of making the questions more fact based and measurable. The model is still under development and this will be considered as more test cases are available. However, as indicated by the test where we used two different evaluation methods on two test cases, making it more fact based does not necessarily make it easier to answer (then you need accurate information) and not always more thought provoking. Remember, the purpose is to rise questions that influence users into thinking it over. It is not a tool for pointing out hard facts.

The respondent noted that questions in the *Effectiveness* category is focused on energy, water and recycling of materials. As experienced BREEAM expert, the respondent suggests including other aspects of sustainability too. Examples are ecology, indoor climate, environmental toxins etc.He suggests «*These are all focused in evaluation tools like BREEAM, LEED and GREEN STAR. How about asking about such sustainability certification systems and let the effort count in this part? A potential challenge is that these classifications cover parts of the efficiency theme as well*". The authors note these excellent suggestions for further development.

For the sake of comparison with the other case studies, we have also included a second graph for case seven, where we have filled in the blank field from the self-assessment, Figure 1 – Case 7 (Exp). As can be seen, the difference is significant in all categories, but mostly in the *impact* and *relevance* categories. Overall, it seems that the self-assessment was performed with a more critical perspective than the expert assessment, but there was also the issue of questions not answered due to lack of clarity.

6. Conclusion

From contact with the industry, we have learned that there is a need for a "quick & dirty", early phase tool for sustainability assessment of building projects. The NTNU BSP is our response to this challenge. We find this version of the tool to work reasonably well during interviews, but not ready as a self-evaluating tool in its present form.

The strengths of the NTNU SBP Model are that it evaluates the sustainability of buildings from several perspectives, and it considers how the project interacts with its surroundings. The projects are not isolated, but parts of a larger society. A project result can be very successful seen from the executing party perspective, without being successful from a society perspective. Vice versa, it can be successful from the society perspective without being good in the executing party perspective. Evaluating projects from only a pure economical perspective or pure environmental perspective is not sufficient. The NTNU SBP Model aims at considering all relevant perspectives and help achieving a balance between them.

The weakness of the model is that the evaluations are vulnerable for the subjective assessments of the evaluators, and it is difficult to keep all aspects completely apart. This may lead to a double count of score for some measures, and following from that the allocated scores will not be perfect. This may lead to biased evaluation results, but this can happen anyway as long as the evaluation is only concentrating on the easy-to-measure criteria. We have experienced that asking questions from a variety of distinct positions and with specific angles give the best results.

The respondent of the self-assessment concluded the experience by indicating positively: "*The idea is good and many of the questions are good. Those questions that are unclear should be reformulated to*

be easier to answer, and maybe also some of the focus adjusted to give a more complete and holistic picture. When finalized and available I believe this will be a good tool. The scope is acceptable. I used a little bit more than an hour to answer all questions and gather information on the case project".

As this was the first test as self-assessment tool, and the respondent was more than well qualified, we need to be careful in what we take away from this experiment. However, this test proves that it is possible to develop a relevant tool for this purpose. Some points for improvement is noted – they confirm experiences we have made also when using it as an expert tool (with external facilitator). Put together with the other tests we have made with this tool; it seems likely that project teams using this tool will actually be pushed in direction of increased awareness to sustainable development.

7. Further work

We still consider the model as ready for use as a beta-version, but we expect further improvements and adjustments to be necessary as we gain more experience. In order to make the NTNU SBP model accessible for other users and to gather more experience with its use value, our plan is to adapt the spreadsheet to a web-based model. In the future, building project owners will have the opportunity to evaluate their projects and get an immediate comparison with other projects. From this, they can see how their project performs in an overall perspective. Even more important they can identify measures necessary to improve their sustainability performance in a wider perspective and more balanced than with previous models.

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Appendix A. The NTNU SBP Model

The evaluation table with the five OECD Criteria Efficiency, Effectiveness, Impacts, Relevance and Sustainability, and their respective sub-criteria (evaluation questions).

NTNU SBP MODEL

Low/Minimum national requirements 0
Medium/Qualities added 1
High/Ambitious energy and environmental effort 2

Efficiency				Effectiveness				Impacts				Relevance				Sustainability			
A measure of how economically resources/inputs (funds, expertise, time, etc.) are converted into results (OECD, 2002).	0	1	2	The extent to which the development intervention's objectives are achieved or are expected to be achieved, taking into account their relative importance (OECD, 2002).	0	1	2	Positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended (OECD, 2002).	0	1	2	The extent to which the objectives of a development intervention are consistent with beneficiaries' requirements, country's needs, global priorities, and partners' and donors' policies (OECD, 2002).	0	1	2	The continuation of benefits from a development intervention after major development assistance has been completed. The probability of continued long-term benefits. The resilience to risk of the net benefit flows over time (OECD, 2002).	0	1	2
Was the project finished within budget?		x		Did the new building create enthusiasm among users?		x		Has the project avoided negative impacts for other stakeholders?		x		Is the project solution according to decisions and current priorities (policies, rules&regulations, area plans)?			x	Are future financial flows sufficient to maintain operations?			x
Was the project finished within scheduled deadline?		x		Did the new building create expectations of increased performance?		x		Has the project attracted media attention?			x	Did the project solve a factual problem?			x	Is the project institutionally sustainable (will it survive changes in politics and		x	
Was the project finished with at least the expected quality?			x	Does the building promote efficient use of the location?			x	Has the project developed technical solutions that can be transferred to other projects?		x		Was the project executed at the right time?			x	Has the project result got political patronage (continuing support from key stakeholders) in the future?			x
Was the project finished without unacceptable health and safety issues?			x	Do the building perform (equally or) better than the minimum requirements regarding energy use?		x		Has the project developed working processes/production methods that can be transferred to other projects?			x	Was the building the proper solution to the experienced (real) needs?			x	Are there no competing solutions coming up? (link til factual problem - better wording?)			x
Did the project avoid producing unneccessary waste (output)?			x	Does the building perform better than the minimum requirements regarding water management systems?		x		Will the building lead to change in stakeholder (consumer) behavior?			x	Was the building built with adequate capacity?		x		Will the project contribute to a future, positive **economic** impact on national or local level?		x	
Did the project avoid using unneccessary energy (input)? (embodied energy)			x	Is the building designed for material recycling?		x		Did the project avoid unneccesary (minimize) irrepearable damage to the site?			x	Is the building/space flexible enough to support future needs?		x		Will the project contribute to a future, positive **social** impact on national or local level?		x	
Did the project avoid unneccessary (minimize) inconveniences for users during construction (reduced air quality, daylight, temperature, reduced access)?			x	Does the building facilitate sustainable interactions with the surroundings in a positive way?		x		Does this building require investments from other stakeholders to facilitate sustainable interactions?		x		Is the project properly located (in the right place) in terms of transport, functions etc.? Do the building facilitate reduced transport needs for the users?			x	Will the project contribute to a future, positive **environmental** impact on the national or local level?			x
Score			10	Score			8	Score			10	Score			12	Score			11

Focus: In the construction phase
Is the planning and production process well dc
Perspective: Executing party

Focus: The building in itself
Is the possibility for sustainable effect establishe
Perspective: Users

Focus: The impact on surroundings and society
Intended and unintended impacts.
Perspective: (Other) Stakeholders

Focus: The solution
The right solution at the right time - did we nee
Perspective: Society

Focus: The future
Sufficient and lasting positive effects in the future
Perspective: Society

Learning across disciplines - Use of the Constant Comparative Method

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Abstract

The AEC industry (Architectural, Engineering and Construction) is an industry in change adapting to new requirements concerning e.g. environment, climate and sustainability. The industry is characterized as a fragmented industry and producing unique products. The most challenging stage of the AEC industry is the design phase. In the design phase the crucial decisions are made. Several researchers point out that the management of this phase of the AEC industry is under researched compared to management of the construction phase. This represents both a lack of maturity, research tradition and proven methods within this field.

In this paper we first present some of the key traits of building design management. Through a review of articles we present what research methods are the most common in the field of building design management. The review shows that 47 % of the studied papers are based on a qualitative research approach, 40 % on a quantitative research approach and 13 % on a mixed method approach. The overview also shows that only 9 % presents their research strategy clearly and only 36 % describes how the data was analysed. Secondly the paper presents an example showing how a qualitative research approach and the use of constant comparative method of analysis can increase the knowledge of building design management.

The research questions we address in this paper are: 1. What is the most common used research approach in building design management, in the last 20 years? 2. What challenges exists in building design management research? and 3. Can the constant comparative method of analysis contribute to better rigour in building design management research? This paper could help other researchers in the field of building design management in their choice of research design.

Keywords: Building design management, Constant comparative method, Qualitative analysis

1. Introduction

The AEC industry (Architectural, Engineering and Construction) is an industry in change adapting to new requirements concerning e.g. environment, climate and sustainability. The industry is characterized as a fragmented industry with temporal organizations and producing unique products(Bølviken, 2012). One of the most challenging phases of the AEC industry is the design. In the design phase, including concept design, crucial decisions are made to ensure that the environmental, climatic or other demands of the client are met. There is a consent that the early stages of the design phase is especially important to improve the quality and the value of the project (El. Reifi and Emmitt, 2013, Hamzeh et al., 2009). Several researchers recognize these challenges, and in particular, the challenges of managing the design phase (Ballard and Koskela, 1998, Hansen and Olsson, 2011, El. Reifi and Emmitt, 2013). Building design management embrace multiple disciplines (Josephson and Saukkoriipi, 2009), and that contributes to the challenges. However, the research regarding building design management is limited (Emmitt, 2016).

Building design management has existed as an own research field for some years, and as it matures the need for more rigour in research appears. Therefore, we address the following research questions in this paper:

1. What is the most common used research method in building design management, in the last 20 years?

2. What challenges exists in building design management research?

3. Can the constant comparative method of analysis contribute to better rigour in building design management research?

In the next section, we describe the methodological approach of this paper. Later, we present some of the key traits of building design management (BDM), typical research approaches in the field and how a qualitative research approach from the social sciences field – together with the constant comparative method of analysis – can contribute to the research of building design management.

2. The methodical approach of this paper

In order to answer the research questions of the paper the methodical approach of the paper is twofold. The first part is a search through publications concerning building design management over the last 20 years. The search maps the research methods used in the different publications. The second part is presenting the use of the constant comparative method of analysis and illustrating the use in a case study. The collected material is from semi-structured open-ended interviews with four design managers and one architect. The structure of the interviews was twofold. First to get a better knowledge of how building design management is perceived by the informants, and secondly to specifically understand how organizational power as defined by Morgan (2006), are perceived in the context of building design. The methodology used for the literature search in this paper follows the five steps described by Bloomberg et al. (2011).

The following three search engines where used: Scopus, Google Scholar and Oria.no. The search strings used on those engines where: 1) Title: Building Design Management. 2) Title: Lean Construction +

Design Management. 3) Title: Communication in Construction Design. This resulted in over 1800 journal articles, of those only 45 articles was found to be relevant for the topic of building design management.

3. Theory

3.1 Building design management

Lawson (1997) defines designing problems and designing solutions as interdependent. Design problems cannot be comprehensively stated and there are no optimal solutions to design problems, and design solutions are unlimited in number. Not only points this out the need for controlling of the design process, but in some way it also describes the major challenge. The design process can therefore be viewed as an endless reciprocal process while the building production process as a strictly sequential process. These are processes which many solutions, thoughts and ideas are shared between the stakeholders in the design phase. The process has an iterative form (Kalsaas and Sacks, 2011). It needs to be open to enable the best solution to arrive so each iteration can contribute to the end value of the project (Hansen and Olsson, 2011).

Bølviken et al. (2010) through the work of Thompson (1967) describes the different processes of design and their interdependences. The interdependencies are pooled, sequential and reciprocal. Bell and Kozolowski (2002) added a fourth interdependency called intensive. The interdependencies will emerge at different times and at the same time in the design phase, creating a need for coordination. Coordination of these dependencies is described as: coordination by standardization, by plan and by mutual adjustment, and needs different building design management approaches. “Design decision making is often negotiated amongst groups and teams, it is an iterative process.” (Kestle and London, 2002)

AEC projects can be viewed as complex, yet the complexity can be defined in many different ways. A complex system has many typical characteristics such as it involves a large number of non-linear interacting elements, in which a small change can produce large major consequences (Snowden and Boone, 2007). Snowden and Boone (2007) use the Cynefyn framework to describe the context of the situation. The framework describes five different domains, in order for a manager to make the appropriate choices. The domains are simple, complicated, complex, chaotic, and disordered. The Cynefyn framework of management is also used for understanding complex AEC projects (Klakegg et al., 2010, Walker, 2015). This is relevant regarding design and design management, where the processes themselves are complexly interdependent (Knotten et al., 2015a, Knotten et al., 2014)

“Design management is the discipline of planning, organising and managing the design process to bring about the successful completion of specific project goals and objectives” Sinclair (2011). Emmitt and Ruikar (2013) states that design managers manage people and information. The people, i.e. design team members, have a specific knowledge, explicit or tacit, that they can transform into information needed by the project. So a definition of building design management could be; Building design management is planning, organizing and managing people (their knowledge) and the flow of information in order to obtain specific project goals and objectives.

So not only does the building design manager need to manage complex, multidisciplinary intensive processes but also to manage the people so they relay their knowledge to the best of the project. The dependency of the people and their behaviour is especially challenging due to the fragmentation of the AEC industry, meaning that they all have at least two considerations in mind at all times, serving their own company and serving the project. This leads to conflicts of interest such as power struggles (Knotten et al., 2015b) and the possibility of unethical behaviour (Svalestuen et al., 2015b, Lohne et al., 2017). Trying to make these people work as teams is essential for success, and one of the most important factors of successful design teams are trust (Svalestuen et al., 2015a).

Power issues affect on a personal level as well on an organisational level, and are well documented in permanent organizations. Killian and Pammer (2003) describes power as "one party´s attempt to impose an outcome on the other party". Power can be exercised at an individual level or as a group. In all organizations the power balance of the stakeholders will influence the work and processes. The design process, as an open, creative and multidisciplinary process is challenging to control for a building design manager, how will the power imposed by stakeholders influence the process? To follow up this a framework based on Morgan (2006) 14 sources of power was used. Several researchers address the issues of power yet they seldom define the sources or interactions in exactly the same way (e.g.(Ivancevich et al., 2013, Daft, 1997, Engelstad, 2005, Morgan, 2006)). The choice of using Morgan (2006) was because he divides power in the 14 sources, making it easier to identify power in the building design management context.

3.2 Building design management research

In this chapter, we present the most common research methods within the field of building design management and the existing challenges with the research. During the literature study the process of mapping the research methods used in the field of building design management was carried out. 45 journals were studied. Qualitative methods are most used, but the difference between qualitative and quantitative is rather small, 47% vs. 40%, overwhelming compared to 13% of mixed methods. The use of quantitative methods were linked to research of management tools. From the studied journals, the most commonly used research approach in building design management is a qualitative case study with interviews.

Only 4 out of 45 articles have explicitly described what kind of research strategy they used. Most articles stated what type of research method they use for collecting data but only 16 out of 45 described how they actually analysed the data afterwards. This was again divided in eleven quantitative research analyses and five qualitative analyses Gioia et al. (2012) address the critic of qualitative research methods and their lack of rigour compared to quantitative research. They emphasize the importance of a thorough methodology section; " as we are careful to explain the systematic approach we employ with the data gathering and their analyse".

The focus and dependence of the team members in building design management as informants and actors makes it therefore interesting to research the people as well as the process and management tools. Learning more of the behaviour of the people participating in a design phase tends to focus the research on sociological understanding and results rather than a metric bound understanding. In research connected to sociological studies it is important to know of the theoretical perspective and theory of knowledge before the research is planned and executed (Creswell, 2003, Alvesson and Sköldberg,

2009). These perspectives or philosophies of science will influence the researcher and the research should be addressed in advanced.

Qualitative research is focused to get an in-depth understanding of human behaviour and of the circumstance around. Different research methods used in qualitative research are; ethnographies, grounded theory, case studies, phenomenological research, and narrative research (Creswell, 2003). In a case study the researcher explores in-depth a person, task, event etc. A case is limited by time and activity, and the researcher collects different types of data through a period. Trying to define what this case study is about is a major part of the research design (Ragin and Becker, 1992). In order to design the case study it is important to define the extent of the case and the bounding of the case (Yin, 2014). By using case studies with a low amount of cases, small "N"s, the possibility of an in-depth understanding to reveal important issues is larger (Ragin and Becker, 1992).

Yin (2014) argues for the need of a strategy to analyse the findings of the case study. In order to obtain a high quality analysis Yin (2014) has four important points. – Attend all the evidence, address all plausible rival interpretation, address the most significant aspect of the case study, and use your own prior expert knowledge.

3.3 The constant comparative method

Yin (2014) argues for research strategies and methods that are transparent and replicable. An answer to this could be the Constant Comparative Method (CCM). It has some disadvantages, as it is work demanding, is based on the researchers interpretation, can be overwhelming with big data sets etc. However, in many cases the advantages overweigh the disadvantages. The constant comparative method was first mentioned by Glaser and Strauss (1968), but has since been adapted and evolved by other researchers e.g Corbin and Strauss (2008). The constant comparative method is a versatile method used in social science research and can be used not only for grounded theory(Glaser and Strauss, 1968) but also for case studies and phenomenology (Postholm, 2005, SavinBaden and Major, 2013). The basic of the constant comparison method is to compare incidents in order to classify data. Each incident is compared with other incidents for similarities and differences. The similarities are then grouped together at higher level descriptive concept (Corbin and Strauss, 2008). The three primary ways to handle the data is as following: 1) Open coding is looking at the text and either line by line or paragraph grasps the essential of what is said. 2) Axial coding is comparing the open codes and relating them together in categories or concepts. 3) Selective coding – is trying to find the main theme of the research.

This is to be a core category that fits with the theme of the research, and can explain what the research is all about. The process is illustrated in figure 1.

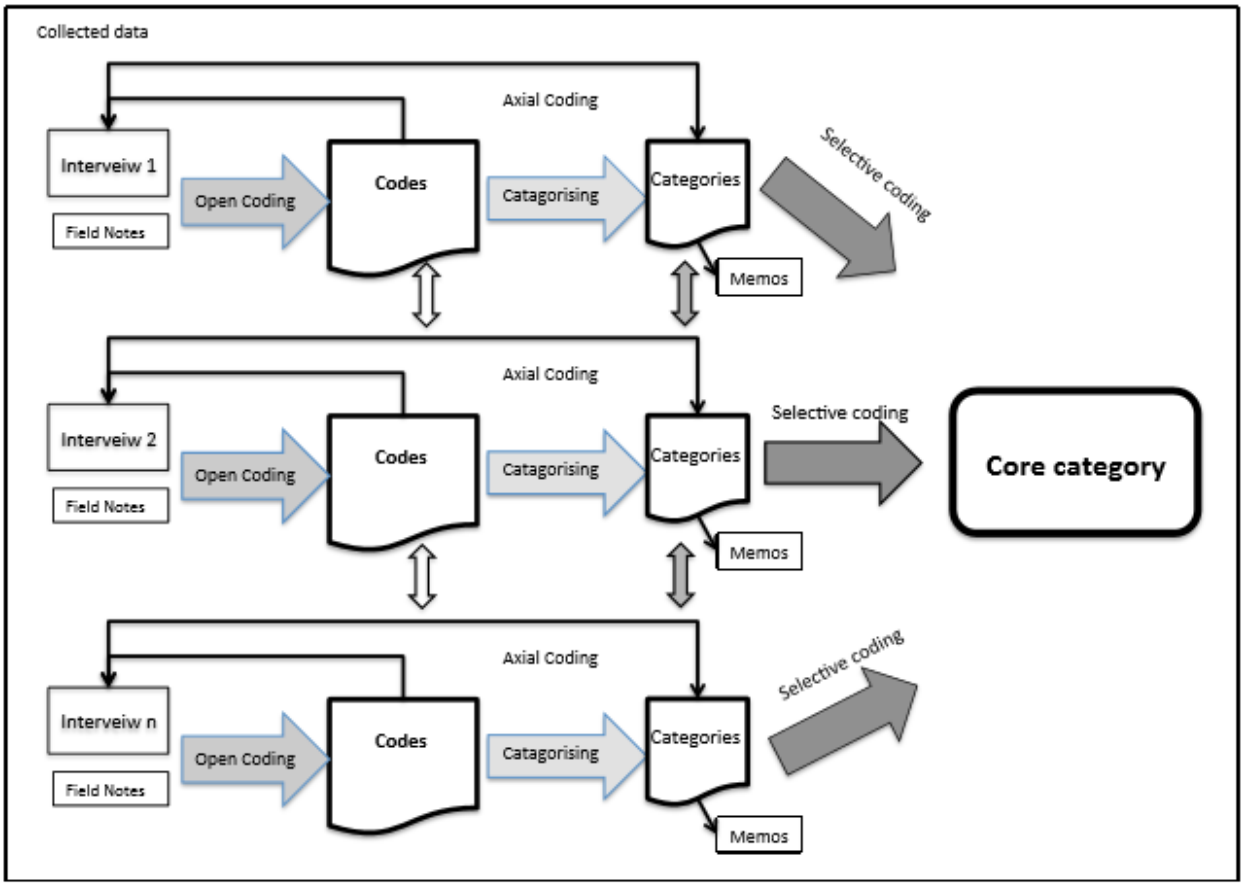


Figure 1: Constant Comparative method of Analysis based on Corbin and Strauss (2008), Glaser and Strauss (1968), Creswell (2003), Creswell (2012), Savin-Baden and Major (2013)

The process is an iterative process meaning that you go back to question your choices and recoding several times. In a case study with several data sources you constantly compare them with each other to see if the categories fit, or need to be adjusted. You always go back to see if the collected data supports the codes and categories. After a time when you are satisfied with what you have discovered from the data material, the material is saturated. You can now explain and describe how thing fit together.

4. Presenting an example of using the constant comparative method in building design management research.

The collected data material is from semi-structured open-ended interviews with four design managers and one architect. The structure of the interviews was twofold. First to get a better knowledge of how building design management is perceived by the informants, and secondly to specifically understand how organizational power as defined by Morgan (2006), are perceived in the context of building design. The example is selected because it shows that building design management is multidisciplinary, and that many challenges appear in the building design phase.

As previously mentioned building design management is very much about managing team members in a fragmented industry. The acceptance that the team members might have a different agenda and could act in opposite of the projects goals, intrigued the researchers to look at power in the building design management.

The interviews was recorded and then transcribed before the analysis started. To ensure the validity of the case study there was made a case study protocol, field note memos to summarize the first reflections of the interview, and the informants got to read the transcription (Yin, 2014).

4.1 The analysis

The first author did the data collection and analysis, and as in qualitative analysis the researcher experience and bias will influence the research and therefore should be commented in the results. The first author has more than 20 years of professional AEC experience, and this gives him an opportunity to pursue the relevant themes and place the findings in a relevant context. The researcher will therefore narrate the example of analyzing.

When analyzing the text I felt that my own experience, knowledge and bias were much more in the way than the philosophical knowledge claim. These reflections of the primary interpretations are important (Alvesson and Sköldberg, 2008). By trying to distance myself from the person and text, I was able to study the text with another lens, more as an informative text. The text was then coded through a process of open coding. I used a technique of listing up all the codes in a separate sheet and using that to look for the common themes or categories (Axial coding). This again let me work with the material as a text and the using the codes to look for themes, instead of the words of the informant. I then placed the themes back in the text to see if they fit. When placing the themes back to the text I felt they fit nicely. The next step is to summarize the themes by making memos as suggested by Glaser and Strauss (1968). The full presentation of the case study is previously published (Knotten et al., 2015b) but in this paper we highlight the process of using constant comparative method

The first themes I ended up with were:

-Power: This was a key interest for the interview, and several of the answers relates to this. This was therefore a natural theme, yet many of the findings are related to the other themes. An interesting finding was the difficulties to get an early participation of the production team, yet they seem to realize how important their participation is to the result they need.

-The qualities of the design manager: This is also a theme that relates to power and especially the power of the design manager. This is also a subject with little previous research, which in fact makes it more interesting. Design is much more focused on process, organization and product, than actually on the design manager's qualities. The design manager should be humble to the knowledge of others, take charge and lead the process, communicate clearly with everyone and have a complete knowledge of the project.

-The design meeting: This theme was a surprise for me when it emerged. As I interviewed I did not sense the importance the informant made of the design meeting, but as I studied the text and coded it, it emerged. This is also a theme that was not so eminent at the other interviews.

-Team: Since design management is very much about coordinating people, ideas, thoughts and solutions the team is important, and that this ended up as a theme was not surprising. Team is connected to the quality of the design manager, since he/she is an important team member. I chose to have team as a theme because of its importance. For me there was one interesting and partly surprising discovery,

and that was the emphasis of the design meeting. It felt like everything in the design phase has to be done in the design meeting, all coordination and every decision. The design meeting was described as a place where issues are raised and solved. Since the design meeting was considered so important it was imperative for the design manager to be in control of the design meeting. This was surprising because in my own experience, I do not feel that the design meetings really are that "all- important". One informant said. "If I only let the process run and follow the agenda, I have no power, but I´m only a secretary taking notes." There was also an interesting duality in one of informants by stating the importance of key decision makers in the design meeting, but also the wish of keeping the client out of the design meeting because they disrupted the meeting by asking what the informant referred to as "posing questions about things they do not know about". The control of decision-making is a source of power, and by keeping the client out of the design meeting actually deprived the design manager of control in the setting the informant viewed as the most important place to have control. This piece of information was not clear during the interviewed but first emerged after the coding.

Working further with the four categories I decided to pursue the power again. I did not feel that the material was saturated. In my material I had sorted out the answers concerning power and organized them in a matrix by the 14 sources predefined by (Morgan, 2006). These served as codes, as well as other codes. By viewing the informants' explanation of power in the building design phase, I re-categorized (axial coding) the 14 sources of power into 3 categories. See table 1.

Source of Power (Morgan)	**Category**	**Influence**
Formal Authority	Strength	Increase the control for the Design manager
Symbolism and the management of meaning		
Structural factors that define the stage of action		
The power one already has		
Use of organizational structure rules, regulations and procedures		
Control of scarce resources	Challenges	Reduce Impact on the design process
Control of the decision process		
Control of knowledge and information		
Control of boundaries		
Ability to cope with uncertainty		
Control of technology		
Control of counter organizations	Threats	Reduces the control of the design manager
Gender and the management of gender relations		
Interpersonal alliances, networks and control of informal organizations		

Table 1: Sources of Power in building design management (Knotten et al., 2015b)

The categories of power are:
• **Strength** – views the sources that empower the manager. These are important to be able to maintain the control.
• **Challenges** – several of the sources descry`bes directly what the key challenges of building design is. These sources must be monitored closely so the contribute to the process and don´t work against it.
• **Threats** – these are basically the sources that work against the common goals of a project, and need to be reduced or eliminated.

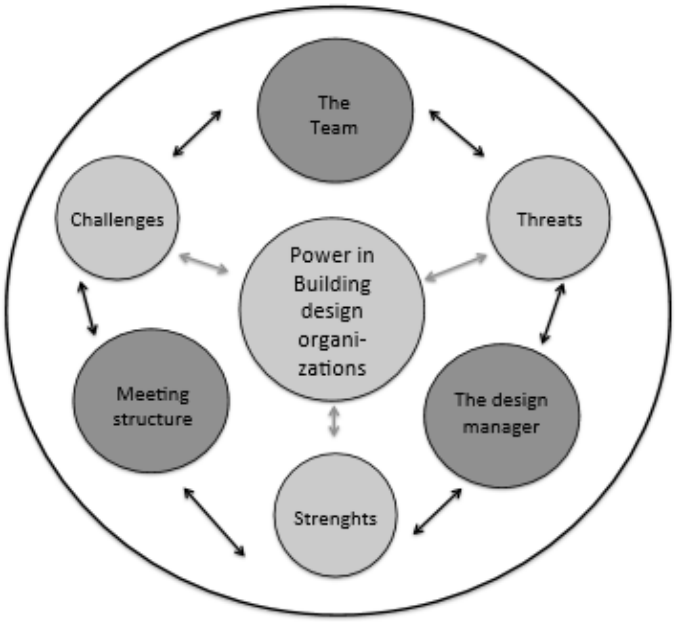
With these new categories of power together with the previous categories of design management the pieces started to fall in place. By looking at the correlation of the now 6 categories I discovered a link, and a need of adjustment in the previous categories. The first three categories are explained above, but looking at the quality of the design manager I saw that he/ she needs to strengthen his/her position in order to lead the design process. This means that there is a link to strength, and to the sources of power.

In viewing the team, they are the one dealing with the challenges. A well functional team deals with the challenges far better, than a poor one. But the team also needs someone to guide them, manage them or lead them, i.e. the design manager.

Last there was the design meeting. Findings in exploring the sources of power the informants focused on transparency and collaborative planning. Which would be arranged in a meeting or work sessions. The original category design meeting linked up with this. The category of design meeting is changed to meeting structure.

The question posed in the interviews were only half about the sources of power, and half about how they perceived building design management. Yet the core category ended up as "power in building design organizations". This can be explained with the close link of the design process and the sources of e.g. uncertainties, decisions, information etc. Secondly to get the process done, you need to secure and strengthen the design manager's position in order to achieve an efficient process. Thirdly most of the problems described in the design process, are due to subcultures, hidden perspectives etc. Figure 2 illustrates the correlations of the findings, and the themes of the selective coding.

Figure 2: The building design management process - and its dependence on power



5. Discussion and Conclusion

The design phase of AEC projects – and the management of it – is challenging. Building design management can be defined as: planning, organizing and managing people (their knowledge) and the flow of information in order to obtain specific project goals and objectives. Therefore, it is interesting to study the members of the building design teams, in order to learn how they function together and what challenges building design managers can face.

A review of building design management literature shows that the most common way to study building design management was through qualitative case studies. Qualitative research was slightly more common than quantitative research. A challenge we saw in building design management research is the shortfall of descriptions of research analyses. Less than half of the studied journal articles presented how they had analysed the collected data. This was most apparent in the qualitative research, where only eleven percent of these studies describe how they had analysed the data. This presents a potential challenge for other researchers in the field because it makes it difficult to assess the results and to discuss the validity and reliability of the research. This lack of rigour in qualitative research is a debated issue in organizational studies (Gioia et al., 2012).

The authors of this paper believe that building design management has existed as an own research field for some years, and as it matures the need for more rigour in research appears. Said with other words, researchers within the field must pay more attention to what research methods to apply. To exemplify the availability of different methodological approaches that exist, we present the constant comparative method that is widely used in social science research. The method is presented in theory and exemplified by a case study pertaining organizational power in building design management.

The constant comparative method presents a transparent and replicable structure for analyzing qualitative research material. Even though the results of a qualitative analysis depends on the collected data and the researchers interpretation, this method makes the process easier to follow. As presented in the example the researcher discovered new pieces of information during the coding, that was not directly emergent through the interview process. Without the thorough analytic process, the researchers might not have discovered these issues and probably would not have further pursued the topics leading to the model in figure 2. The example also shows the importance for a narrative when conducting a qualitative research analysis.

The qualitative case study with the constant comparative method of analysis is only one approach toward filling the gap of research in building design management. There are several other approaches all depending on what part of building design management you want to research. However, the authors believe that any research could favour from a more thorough description of the research and of the analysis in particular.

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A Scandinavian collaboration icon falls? – the development of a dual building labour market in Sweden

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Abstract

The Scandinavian welfare society model and its results has in the post second world war period been an icon beyond its geographical borders. Yet the model has also been exposed to continual challenges. In a construction sector context, the characteristics of peaceful collaboration, a productivity pact, well skilled and organized labour force, high level of work environment quality and enforcement, are all elements seen on Swedish building sites, and almost as prevalent as in other Swedish industrial sectors. In the recent years the construction sector has however seen an unprecedented influx of companies and work force, and they are contributing to what appears to be another labour market in Swedish construction.

The aim of this paper is therefore to study these tendencies of erosion of the Swedish model labour market on a high level, and the emergence of another low level labour market. Theoretically the paper draw on industrial relations labour market studies, and concepts of dual labour markets.

Empirically, a macro oriented approach is used, yet involving as much micro knowledge as possible. The study uses a host of sources. To address the low level labour market material such as reports on fatal accidents and police cases is used.

The result of the analysis is that the high level labour market in Swedish is still strong. Existing and new institutions serve to maintain and adjust this market. However the low level market is emerging, not only on the private house market, but also at large infrastructure projects, impacted by companies working with lower pay, and worse conditions. Even the main public client are actively encouraging foreign companies to engage, to maintain a market competition on infrastructure. This leads to systematic poorer conditions managed through recruitment companies and other sub suppliers that places the phenomenon at a distance from the main contractor. Another type of intermediaries, union employees with foreign language skills, are a counter tendency. It is discussed whether the Scandinavian model can recast itself, to, not only counter the present developments, but also into a new integrative multicultural model, supporting the foreseen growth in the Scandinavian building sector.

Keywords: Dual labour market, Sweden, building sector

1. Introduction

The Swedish construction industry and its adjacent labour market and professional communities are under cross pressure by a set of somewhat positive dynamics. The building sector is growing and so is employment, placing the construction sector as a primary job creator in the Swedish economy (SCB 2016). The investment amount to 10% of the gross national product annually (SB 2015) and 300.000 are employed at contractors alone. Sweden have 10 mil. inhabitants. At a time a combination of raising building costs and too few players for doing construction, there is a continual pressure on the industry to perform better and at a lower cost. A continual influx of foreign and international construction companies, but also East European building workers, migrants and refugees has followed from the sector's growth.

Sweden is renowned for its well organised relatively healthy and equal labour market, also in construction, where for example more than 95% employed are on permanent contract (SCB 2016). This high level labour market is part of what is often called the Swedish or Scandinavian model, referring to a particular collaborative set up of industrial relations, equity, democracy and a welfare state (Sandberg 2014). However this high level labour market appear to be under pressure despite present growth in employment. Another labour market with poorer conditions, such as temporary contracts, unsafe and more unhealthy work environment, and less codetermination, appear to be emerging. This low level labour market is fuelled by a constellation of interests including that of large Swedish and foreign construction firms (Frank 2013), aiming a controlling costs by employing new groups at the Swedish building sites.

This paper will scrutinize the recent developments of the Swedish construction industry and labour market. It asks; are Sweden moving into a dual labour market, with a coexistence of high and low level labour markets? And why is this happening?

Theoretically the paper draws on industrial relations and labour market studies, especially concepts of dual labour markets (Boje, 1986,Edwards et al 1982, Hodson and Kaufman, 1982,Kalleberg and Sørensen, 1979, Palier and Thelen 2010, Svalund 2013).

Empirically it is the aim to establish an overview of the construction sector and its labour market(s). The paper adopts a macro oriented approach, supported by exemplary micro knowledge where possible. The study uses a host of sources, including research, labour market organization material and newspaper articles. To address the low level labour market, which is difficult to access and poorly studied, the paper comes to use material such as reports on fatal accidents and police cases.

The paper is structured in a traditional manner. Opening with the method, the backbone of the argument, the research design to answer to the aims. Then proceeding to provide the theoretical framing. The empirical material is organized in two sections, one on the high level labour market and one on the low level. The paper integrates these in the discussion arriving at answers to the aim. The conclusion sums up the argument.

2. Method

The paper adopts a position of interpretive sociology. As the main aim is to understand labour market dynamics in construction, and its features of "Scandinavian model", a framework of labour market theory, work sociology and industrial relations is drawn together.

In prolongation of this, the empirical work aims at establishing an overview of the Swedish sector and labour market. This asks for a macro oriented approach, yet following Gustavsen(2007)'s understanding of local industrial relations and practices demands involving as much micro knowledge as possible. The study uses a host of sources, including research, labour market organization material, newspaper articles. To address the informal labour market the study comes to use material such as reports on fatal accidents and police cases, that "opens the door" to parts of the second labour market.

Material on large infrastructure- and building project are used to study the high-level labor market, but also the intersection with the low level labor market. Several studies on migrant workers employment at infrastructure projects are drawn upon (Frank 2009, 2013, Jonsson et al 2011, Thörnquist 2013, Thörnqvistoch Berhardsson 2015).

The low level labor market in the building sector is studied far less i.e. this involves a fragmented and partially local market for building and renovation of single family house, villas, villa-gardens and row houses. Frank (2013) studies this segment through the unions "Byggnads" filing of cases at the police in Skåne. Studying police cases (reports) gives an access to elements of the low level labour market. Here also Byggnads list of recent mortal accidents is used as another access route (Byggnads 2016). Finally the author has carried out observations in a local villa area in a suburb of Gothenburg, where at least half of the many ongoing renovation job were carried out by foreign labour.

As the macro-oriented aims of this paper ask for coverage of an entire labour market, it also introduce the limitation of drawing on other researchers and institutions work. Moreover this paper does not present primary material, but only draw on the rich material provided by previous studies. Drawing on Frank (2013) for example implies that only what the union Byggnads have been able to find and engage the police arrives as data on the researcher desk. Yet at a time this diverse source provide the overview that the paper aims for.

3. Framework of understanding

In industrial relations contributions (Ferner& Hyman 1998, Gustavsen 2007, Hyman 2001, Sandberg 2014) it is not uncommon to describe Scandinavian countries as pursuing a social compromise/consensual agenda. Some of the recurrent features pointed to are Welfare states, well-functioning economies and well-developed mechanisms for the inclusion of socially peripheral groups (Mcloughlin & Clark 1994), and even a specifically socially responsible form of management (Byrkjeflot 2003). As pointed out byGustavsen (2007) macro features does not automatically map to local work organisation, but many of the efforts addressing the development of the inclusive collaborative model draw on and invest in developing trust between employers and employees. And this linking between local collaboration and national collaboration is also indeed central for the operation (Sandberg 2014). Moreover the role of organised labour stands out as a very important explanatory element of the Scandinavian model (Woolfson et al 2010). The Scandinavian unions

maintain a high level of organisation in contrast to other European countries (Ferner& Hyman 1998, Hyman 2001, Sandberg 2014).

It is however common for the industrial relations contributions that they tend to portray the national labour markets as homogenous and unified. This is in contrast to theories of dual labour markets.

Dual labor market theory predict clear differences between two parts of a national labor market (Edwards et al 1982, Kalleberg and Sørensen 1979, Rueda 2007), often portrayed as core and periphery segments. Such labor markets, with one segment with safe, well-off permanent employees with employment protection and another segment with unsecure labor condition, poorer work environment and temporary employees, can be seen as a way to provide numerical flexibility for firms (Svalund 2013), but also a manner of realizing an effective overall production system, with dedicated role for core firms as well as subsuppliers. A classical example is Toyotas production system, where core assembly factories are characterized by a stable safe workforce under longterm employment conditions, whereas sub-suppliers feature low pay, unsafe working conditions and precarious employment (Elger& Smith 2013). Such set of dual labor markets are usually protected by institutions (Gash 2008, Palier and Thelen 2010), including legislation, such as employment protection legislation for example which makes it easier to hire employees temporarily (Skedinger 2010,Svalund 2013). And educational system, where there are remarkable national differences in how vocational training support high level or low level labour markets (Brockmann et al 2009) Palier and Thelen (2010) posits a development of early dual labour market approaches (such as Edwards et al 1982) to later that put more emphasis to the institutional and political set up of national labour markets. Such "legalized" dual set ups can be found in France and Germany (Palier and Thelen 2010). With or without legal underpinning, in an operative dual labour market one might witness the dismissal of productive temporary workers in order to prevent them from becoming insiders (Svalund 2013). Moreover intermediaries bridge the two segments often with contradictory and contested functions. They might appear as relaxing the segmentation, but can also at a time strengthen it. The transition from temporary employment to permanent is one example (Svalund 2013). Recruitment agencies, unions and large companies purchasing practices are other examples of intermediaries. According to Svalund (2013) segmentation and dualism theories predict clear differences between the segments (Boje, 1986; Hodson and Kaufman, 1982; Kalleberg and Sørensen, 1979). Some segmentation theories focus especially on the role of employment contracts (Gash, 2008). These theories predict reduced transitions from temporary to permanent contracts in such labor markets, and higher transitions from temporary contracts to unemployment.

Summarising we find two competing interpretations of how the Swedish building sector might develop. One, the industrial relation approach, notes that the Swedish model of collaboration has been robust towards globalization, liberalisation and other dynamics. Whereas the other, dual labor market theory, predicts a split in two mutually dependent labour markets, a high level and a low level condition situation.

4. High level labour market

Within the contractors' part of the labourmarket, 93 percent of the employed have a contract defined work time of 35 hours or more (SCB 2016). Since 1988, building workers have been largely employed on permanent contracts with 2 months' notice or more (Landin and Andersson 1989). In 2012, employment grew with 8, 7 % out of which almost all (8, 2%) was permanent employment. In 2015

the growth was 13%. The industry is characterised with a strong concentration at a few large firms. The five largest companies cover 40% of the market. International comparisons on work environment show that the high level labour market have standards beyond comparable countries (Spangenberg 2010).Also the building sector and its labour market exhibits strong institutionalization around labour contracts and their negotiations, education of craftsmen and other employees. In Sweden the education system for skilled workers clearly constitute a support to the highlevel set up. Wages and labour conditions are negotiated both at a central collective level every three years and locally more frequently. The two sub sectors building and infrastructure are somewhat split in terms of employers associations, unions and contracts. In building, one main employers association The Swedish Construction Federation (SverigesByggindustrier) and six unions are active. ”Byggnads”, the largest union, have some 75.000 members, and they organize 65% of the workforce in construction of those they in principle could organise (Kjellberg 2017). The other unions are the electricians, janitors, painters and SEKOs members (for SEKO see below). “ Byggnads” represent about 80 professional groups and have some 6-7000 shopstewards, safety representatives and employee representing posts. Within building five main collective contracts exists. The building (“Byggavtal”), technical installation (”Teknikinstallationsavtal VVS ochKyl”), Roofers and ventilation (Plåt- ochventilationsavtalet), Contractors machines and glassmiths. In infrastructure the main employers organizations is The Swedish Construction Federation (SverigesByggindustrier), followed by the Machine contractors and the public employers. SEKO (Union for SErvice and KOmmunikation), the Road and Rail section, is the main union, organize 19 professional groups and have 20400 members (2014) mainly within infrastructure build and operation, Within the infrastructure area a rigorous privatization has been carried out, and SEKO today have most of its members in private companies, counter to previous where it was public employees. However unionization, collective contracts and high level conditions have largely survived this transition, even if today some members are indeed the only member in their particular company.

Within the ten last years a series of large international contractors have established themselves in Sweden. This encompasses civil engineering contractors like Zublin/Strabag, Hochtief, Bilfinger Berger/Implenia, Strukton Rail (previously Balfour Beatty Rail) and Installation contractors like Bravida, Imtech, and Caverion, Also architechts and engineering consultants (like WSP) are establishing in Sweden. International companies have been active in a series of projects including infrastructure projects as “NorraLänken” (Hochtief, Zublin), and “Förbifarten” (Bilfinger Berger) (Jonsson et al 2011). Largely these newcomers integrate in the high level labour market, at least officially.For examplesome enterprises join the employers association; Hochtief, Implenia, and Strabag/Züblin are members of The Swedish Construction Federation (SverigesByggindustrier).

However their praxis at large infrastructure projects like “Citybanan” och “Norralänken” show how these companies actually are challenging the Swedish model. Through corporate human resource management, the companies exercise a recurrent international type of labour relation, focusing more on the individual than on collective rights. In this manner the collective aspects is twisted even if not directly in contradiction with collective agreements and collaboration (Boglind et al 2013, Kjellberg 2017, Jonsson et al 2011).Another aspect is a characteristic use of subcontractors. Even if this is normal practice in the Swedish construction industry the global companies more systematically used recruitment service companies as middlemen in hiring subcontractors and building workers (Jonsson et al 2011). In this way a chain of subsuppliers become an intermediary between the highlevel and low level labour market (Thörnquist 2013) The foreign labour at the end of the sub-contracting chain are

offered poorer working conditions. Very few of them are offered a permanent employment, the pay is lower, the work environment more unsafe and with occupational accidents (Jonsson et al 2011). These building workers interprete their situation as lawless and unjust (ThörnqvistochBernhardsson 2015). Some contractors even take a step further through hiring the workers as selfemployed, making the responsible for parts of their labour conditions (Thörnquist 2013). Another mean are phony collective agreements. Foreign contractors operating temporarily in Sweden sign a Swedish collective agreements, but does not follow it. It is even that the new building site control system "personalliggera" (human resource accounting) are circumvented by cheating the access system, being registered as guests and the like.

When it comes to migrants and refuges, Sweden has a well-established receival system, which however for the time being operated rather slowly. This means that despite good will from labour market parties only a few recent refugees have been successfully channelled into the labour market. Most are "parked" on site track presently.

5. Low level labour market

For quite some time Sweden have experienced a strong increase in single person companies (Landin & Andersson 1989). 55,739 out of 96,721 building and construction firms (including demolition) and 14,200 out of Swedish 24,500 contractors, or 58%, are one man companies (SB2015). The share of own account self-employed workers are more than three times higher than the average level on the Swedish labour market (Thörnquist 2013).

The influx of foreign labour is a strong dynamic of erosion of the Swedish model in the building sector (Frank 2013). Especially since the enlargement of EU in 1992 where labour from Eastern Europe started a substantial migration to Western Europe (Likic-Brboric 2011). A small part of this wave found its way to Sweden. Early movers were staffing agencies (Frank 2013), but recruitment through social networks became prevalent. This channelled companies, craftsmen and building workers into the market of renovation and new build of villas and other local markets (Frank 2013).

The legality of these entries have been constantly disputed (Woolfson et al 2014). It almost lies as a thoroughgoing condition that the volume is difficult to estimate. Taking the legally registered part as departure, in 2010 some 1,050 persons were legally present in Sweden as out stationed employees in the building sector (Woolfson et al 2014). By 2016 this figure was grown to around 18,000 whereof the largest group, 6,000, was from Poland. Half of them work in the Stockholm area (Arbetsmiljöverket 2016), where also 37% of the new built investment are done (SB 2015). This however also indicate that the legally out stationed workers is a different trend, from those who seep in at local markets in Southern Sweden (Frank 2013), where around half of the building investments are made (SB 2015). It is indicative that following building works in a suburb villa district of Göteborg, saw at least half of the works carried out by foreign labour. Here clients are family house owners with relatively small assignments such a building new porches, kitchens, renowing underground cellar wall etc. At a time however such clients appear quite resourceful and the activity level high. Some companies appear to move from one client to the next through word of mouth.

A "mediumsize" example from the Mälardalen region in Mid Sweden, involved a larger local contractor hired by a real estate client (Thörnquist 2013: 15). The contractor in turn contacted a staffing

agency for a project manager.The project manager then hired a number of polish craftsmen and led them during the project. He also was responsible for materials, tools and other equipment. All polish craftsmen were registered as self-employed in Poland, even if they worked with reference to the project manager (Thörnquist 2013). When the union, Byggnads, interfered, the craftsmen lacked the proper social security and taxation documents. Moreover there was no contracts to document that the workers were single man companies contracted to particular tasks (Thörnquist 2013).

This low level labour market are not well studied. The few investigation made find low salaries, occupational accidents, short term contracts, poor documentation of contracts, prolonged working hours and poor living standards outside work (Byggnads 2015, Frank 2013, Petterson 2012). Contracts are made short to accommodate tax regulation (Thörnqvist,ochBernhardsson 2015). Fatal accidents occur in this labour market and they tend to surface in contrast to many non- claimed accidents that would never be registered. 12 fatal accident in construction from 2006-2014, registered by Byggnads gives a picture of small companies with roofing and demolition activities hiring foreign workers to this dangerous work. However fatal accidents as such also occur on large building sites and "native" Swedish workers. Investigations of staffing agency employment in construction (in other countries) have repeatedly shown that building workers are more exposed to hazards and accidents and often not trained as required (Hintikka, N. 2011, Håkansson et al 2013). It is important also to include the work force of permanent un-employed outside the labour market arrangements supported by public social care as well as refugees, in the understanding of the possible development of the low level labour market. With a large group of the population under permanent un-employment, some 400.000, the pressure of the highlevel labour market is considerable as well as the grey part of the low level labourmarket.

At present the formal, public part of Sweden is trying hard to integrate the many new refugees including the Syrians. An active, yet prolonged effort to integrate under well organized conditions into the high level labour market is by late 2016 emerging. But a share of the refugees is likely to seep into the low level labour market and become part of Swedens informal economy. At present the refugees are pacified in camps waiting for their skills to be acknowledged by the Swedish authorities (Jörum 2015). It has been estimated that some 25-35,000 refugees live illegally in Sweden (SOU 2011, SVT 2016). Also there are indications that thousands of refugees have been able to pass the border controls without being registered, and that these also live illegally in Sweden (Kudo 2016). It is known from previous waves of migration to Sweden that even after a long period, the official unemployment rate are significantly higher amongst these groups than in comparable groups in the labour market (Engdahl 2016).

6. Discussion

In the presentation of the two labour markets, we have tried to demonstrate how Sweden is moving towards a dual labour market where the low level market are quickly expanding and getting accepted. One can ask how the dual arrangement have spread in Sweden. First it can be viewed as a result of a gradual weakening of the high level labour market. Unionisation in the building sector have moved from 81% in 2006 to 65% in 2015. So even if there is continual reference to, and also practice behind, the labour market parties collaborating, latest seen for example in creating fast tracks for refugees into the labour market, the unions are weakened and the employers increasingly advocate a lower element of collective bargaining and a larger element of individual pay.

Second it has to be noted that the dual labour market has been around for a long time. But where the low level market was previously populated by craftsmen doing moonshining and operating on small local markets, it has now spread even to parts of large infrastructure projects. It is likely that many building sector players plainly have copied what happened on large infrastructure projects (Frank 2013) and what happened in local villa areas they entered ”by coincidence”. In this way an acceptance of the use of low pay work force have spread (Frank 2013). It has become legitimised.

Third Sweden are member of the European Union and the union has had a labour market mobility political agenda and reform program running for a long time. This implies the creation of a single common inner labour market with the union member countries. This creates tensions and pressure on national labour markets. Adding to this the enlargement of the European Union with eastern Europe joining, meant introducing larger differences inside the unions between high level and low level labour markets. The dual labour market is in other words not a national market phenomena. This dynamic of the dispersion and strengthening of the European dual labour markets erodes the present conditions for the Swedish model. It is epitomic that a European court verdict for long have created serious barriers for trade union activities against building sites where selfemployed, lowpaidetc workers are operating, in the so-called Lavalcase (Woolfson, Thörnqvist, & Sommers 2010).In the spring of 2017 the government announced a reform of this issue, which if implemented would strengthen the high level labour market and the large Swedish contractors.

Even if the Swedish construction marked can be understood as dual, we still haven’t seen that dualism being explicitly institutionalised by state policy and regulation, as in Germany and France (Palier and Thelen 2010). We have already seen public institutions acting in manners that support dualism (the Swedish transport administration), so the question is how far we are from such an institutionalization. It should also be mentioned that another type of intermediaries than the long subsupplier chains, such as union employees with foreign language skills, are representing a counter tendency as this reach out to workers employed under low level conditions. The institutions of the high level labour market do have resources to build bridges towards the lower level market and undermine parts of it, and channel people into the high level labour market (Svalund 2013). Actually the Scandinavian model has been under continual challenge since the Second World War (Sandberg 2013). Under these circumstances it has been reforming itself numerous times.

7. Conclusions

This paper set out to scrutinize the recent developments of the Swedish construction industry and labour market. It asked whether Sweden is moving into a dual labour market, with a coexistence of high and low level labour markets? And why is this happening? Theoretically, the paper has drawn on industrial relations and labour market studies, and especially pointed to concepts of dual labour markets as frame of understanding.The result of the analysis is that the high level labour market in Swedish is still strong. Existing and new institutions and mechanisms serve to maintain and adjust this market. However the low level market is emerging, not only on the private house market, but also at large infrastructure projects. They are impacted by companies working with lower pay, and worse conditions. Even the main public client are actively encouraging foreign companies to engage, in an attempt to create a market competition on infrastructure. This leads to systematic poorer conditions managed through recruitment companies and other sub suppliers that places the phenomenon at a distance from the main contractor. Other type of intermediaries represents counter tendencies, enabling a channelling of new

work force into the high level labour market.Actually the Scandinavian model have developed and emerged under continual external pressures since the Second World War. Its stabilization have been permanently precarious, yet it has developed significantly forward. It has been recasting itself and even advancing several times, for example when a frameagreement for all building workers transferred them to permanent contracts in the late 198ties, or when the industry transformed into services and when privatization of the public sector broke through. Thus the Scandinavian model is robust and able to recast itself yet again, to not only counter the present developments, but channel them into a new integrative multicultural model, supporting the foreseen growth in the Scandinavian building sector in the future.

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Radical Sustainable Innovation of office buildings

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Abstract

The recent development of technologies, processes and methods of sustainable building has enabled an unprecedented quantum leap in the available solutions. These possibilities could be interpreted as radical, yet they appear at a time as results of a long emergent development. The aim of this paper is to critically scrutinize, theoretically and empirically, whether radical innovation is occurring in sustainable building and what the implication are.The theoretical framework is based on concepts of radical innovation, inventions and sustainability. Radical sustainable innovation (RSI) should be characterized by high degrees of newness in the entire life cycle. RSI should offer significant enhancements of known benefits, entirely new benefits, or substantial cost reductions, leading to the transformation of existing markets, the creation of sustainable growth, and global sustainability. Thus, if buildings were RSI, it would be a shift in paradigm of how buildings are designed, build and used.Serious limitations on these notions are addressed. Buildings are large complex products realised through complex processes and with a long lifecycle. It appears impossible that an entire building should/could be radically new. How to evaluate radicality is a major challenge. It is tentatively proposed, to use standards for sustainable office buildings. Standards are developed to accelerate the sustainable development but has to some extent come to constrain possibilities of radical innovation. As the criteria of newness is incorporated in standards, going beyond them, could be viewed as radical. Empirically a selection of international cases of office buildings with very high scores of BREEAM, LEED and DGNB are examined. Six selected cases were analysed more in detail, one of them,GeelensCounterflow's Headquarters, being the most outstanding.This handful of office buildings have reached remarkable higher level of sustainability than contemporary building regulations. There isindeed a gap between these few buildings and the majority, making them more radical, yet due to weak social sustainability, they are not evaluated as radical innovation.

Keywords: Radical innovation, sustainability, office building, standards

1 Introduction

The development of sustainability opportunities within buildings is quickly accelerating, and it is multifaceted. It has become difficult – if not impossible – for building professionals to stay updated on new methods and approaches for processes of innovation as well as the technological development of new products, i.e. building components and systems. Yet sustainable initiatives in offices have limited voluntary uptake and at time have low tenant satisfaction in compulsory initiatives. This is due to that sustainability is perceived resource heavy and demanding by tenants. Because of this double challenge of lack of knowledge about technical options, and a negative perception of sustainability measures, the take up of new sustainability opportunities is moderate. At the same time, one witness some clients, real estate developers and owners, prepared to pay the continuously diminishing premium for higher levels of sustainability (World Green Building Council, WGBC 2013). Moreover, the regulatory frame is moving, posing ever stricter demands (even if the legislation is behind the technological development). These supporting trends make the Scandinavian countries some of the best prepared to do become trailblazers for ambitious sustainability efforts in buildings. Still, at present most office building projects stay close to the building regulation (Birgisdottir et al 2013, Hojem et al 2014). And many projects outside Scandinavia attracts attention. Internationally standards such as Leadership in Environmental Energy Design (LEED 20016), Cradle to Cradle (Braungart and McDonough 2002), Deutsche Gesellschaft fürNachhaltigesBauen (DGNB 2013) were created to accelerate sustainable building, going beyond present day and foreseen building regulation, and one witness how these standards are continually upgraded. However, the standards have also come to play a role as commodity price setters and often represent quite main stream levels of building. BREEAM for example, is a sustainability assessment method for masterplanning projects, infrastructure and buildings. It addresses many lifecycle stages such as “new construction”, “refurbishment” and “in-use” (BREEAM 2016). Globally there are more than 550,000 BREEAM certified buildings, and more than 2,250,000 buildings registered for assessment since 1990 (BREEAM 2016). This entire portfolio is hardly radical in character. Neverthelessbeyond the standards the unrealized potential creates a possibility to take a quantum leap in of sustainability by exactly transcending existing norms. And do this on a business basis. Moreover, recently, radical innovation scholars have developed quite extensive and explicit models for managing such innovations within large companies (Hartmann 2005, O’Connor et al. 2008).So, on this background this paper asks

How can radical sustainable innovation (RSI) be conceptualized?How can RSI be evaluated or even measured? And are there examples of RSI in international office buildings?

One can ask: Why office buildings? Many radical ideas in buildings have been realised over the years under slight problematic conditions if one insist in the notion of innovation. First as private housing with loads of entrepreneurial effort by the designer, owner and constructor in one. But the initiatives never got beyond providing a singular impressive realisation. Second as demonstration projects made for example as public buildings on university campuses. Such projects often aim at demonstrating and verifying that it is technically possible to build a certain type of sustainable building. That it is technically possible does not make it radical innovation however, as it does not automatically enter the building market. Third certain types of companies such as Utility Companies want to show off. So, by choosing office buildings, a type of building are picked that are tested by the market, paid by private companies and therefore comply with classical definitions of innovation, linking it to market and economic development (OECD 2005).The contribution of the paper is to commence conceptualising

radical sustainable innovation by combining approaches to radical innovation with sustainability. Radical innovation concepts are well established (Christensen 1997, O'Connor et al 2008) and useful when attempting to underpin radicality is sustainable innovation, which is often too readily dismissed as "buzz word" or "hype". The paper is structured in a classical manner. Following the aim, it commences by conceptualizing a theoretical framework, which discuss radical innovation, sustainability and inventions. On this basis, the method for evaluating radicality is discussed and presented, followed by the six case studies that emerged out of the selection process, five short cases and one, the most outstanding, a bit longer. The paper then discusses these findings reaching a conclusion responding to the aim.

2. Theoretical Framework

The framework commences by the concepts of innovation and inventions, moving on to radical innovation. Sustainability is then introduced and inserted into our tentative definition of radical sustainable innovation. The Oslo Manual (OECD 2005) defines innovation as follows:

"An innovation is the implementation of a new or significantly improved product (good or service),or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations"

This definition distinguishes, in a linear manner, between invention and innovation, believing that inventions are globally new and not necessarily implemented in a practice, whereas innovation is only counted as such if the change is implemented. This implies that radical innovation at a time needs to be almost as new as inventions, yet is required to have experienced implementation. Also, innovation is normally measured up against its context, i.e. innovation is new in relation to a specific contextual and not necessarily globally new. We suggest to depart from this contextual criterion for innovation below.Radical Innovations break away from the customary and are characterized by high degrees of newness. Radical innovations offer significant enhancements of known benefits, entirely new benefits, or substantial cost reductions, leading to the transformation of existing markets or the creation of entirely new possibilities for growth. These innovations are also referred to as "breakthrough", "discontinuous", or "paradigm-shifting" (Christensen 1997 Hartmann 2015, Leifer et al 2000).It is important to note that disruptive innovation is different from radical. Disruptiveness may occur from well-known elements of innovation reshuffled. Disruptive innovation can be defined as "a process where a smaller company with fewer resources is able to successfully challenge established incumbent businesses" (Christensen et al 2015). Disruptive innovation originates in the low-end of new-market footholds and only compete with mainstream when quality catch up to their standard (Christensen et al 2015). We adopt the position that innovations within sustainability should comply with certain special rules. Where innovation concepts are embedded in market economy concepts, sustainable innovation needs to depart from this unambiguous embeddedness and rather refer to a sustainable economy.

2.1 Sustainabilityand Sustainable Buildings

Sustainability was originally defined as "development that meet the needs of the present without compromising the ability of the future generations to meet their own needs" (Brundtland 1987).The notion of sustainability has undergone signification development even if still ambiguous. As many other societal goals, it is a moving target, and should be. This goes for the content and weight of the

original Brundtland dimensions of environmental, social and economic sustainability (Chethana et al 2015).Sustainable innovation in buildings has seen considerable progress since the first niche experiments of the 1970s (Lovell 2004). This has led to a situation in which the reduction of a new building's ecological footprint to the bare minimum can be achieved with the help of available components and concepts (Müller and Berker 2013). In terms of technology there is little radical about energy efficient installations, energy conservation through increased insulation, balanced ventilation with heat recovery, and/or a certain extent of renewable energy production in/at the building. The next incremental step in this line of development is the inclusion of embodied energy and CO2 emissions into equations that seek to make buildings environmentally "neutral", i.e. that reduce their ecological footprint to zero. The most comprehensive of these definitions include all CO2 emissions caused by the production and transport of the building's materials and caused by construction, operation and demolition (Marszal et al 2011). The more and the more heterogeneous elements included into the equation, the more demanding changes to the building and its surrounding systems become. Reaching a point where combinations and incremental improvements of existing solutions do not suffice any longer to reach "zero".Today's radical perspectives on sustainable construction rethink a building's position in larger infrastructural systems. Where the conservation- and reduction-logic seeks to minimize and eventually eliminate impact without touching the basic structures in which buildings are embedded, newer initiatives treat buildings as agents of a larger transition to more sustainable societies, including social sustainability in particular. When buildings, for instance, become producers of significant amounts of surplus energy, existing energy systems are affected and must adapt. Another example is how buildings are now seen as building blocks in smart neighbourhoods and cities, where synergies are sought between different temporal rhythms of stationary energy demand, possibilities of local energy production and storage, transport infrastructures and other resource flows. The common element in these visions is that the building is assigned a constructive and active role in a sustainable future.

Summarising, a tentative definition of radical sustainable innovation is: RSI Break away from the customary and are characterized by high degrees of newness. In the entire life cycle and in all elements, financial, process, product, client relations, organisation management. RSI offer significant enhancements of known benefits, entirely new benefits, or substantial cost reductions, leading to the transformation of existing markets or domains or the creation of entirely new possibilities for growth and sustainable balances encompassing at least an environmental, social and economic aspect. RSI contributes to a sustainable globe. We suggest that within radical sustainable innovation in office buildings a global convergence has meant that it makes sense to move from a contextual definition to a world-wide covering definition, which resembles the demands of patented inventions, whose novelty is tested in a broader region like Europe or US. In fact we suggest that radical sustainable innovation should be measured by a global novelty criteria. For a further discussion of the convergence – context tension in sustainable building standards see Inkoom& Leiringer 2016.

3. Method

The paper is exploring ideas and concepts that might be useful in approaching radical sustainable innovations of buildings. It involves several iterative cycles between theory and empirical work.We draw on innovation and radical innovation literature to conceptualise these parts and combine these with sustainability. This approach is chosen because of a paucity of contributions conceptualizing radical sustainable innovation (important exceptions include Tonkinwise 2013).In an initial phase,

radical examples were sought for in two directions. First through searching on databases on patented building components, systems and concepts. Second searching on the net for building realized "outside" or beyond the certified portfolio. This approach however quickly was abandoned, because we only found building components, and systems with limited scope, which were patented and even if patenting guarantees that the product is new to an area of the globe,its not automatically sustainable, nor does it extend to an entire building. As for the second search we did not have resources to follow up on promising, yet poorly documented cases. Compared to these potential radical cases, the certified were far better documented. On this basis we then use sustainable building certification schemes.The literature comparing certification schemes within sustainable building, show large similarities between tools (Chethana et al 2016). The emphasis is on environmental sustainability (roughly 70% of the criteria points), and less on social sustainability (roughly 25 % of the criteria points), and very little emphasis is assigned to economic sustainability (Chethana et al 2016). DGNB constitute a minor deviation in its larger emphasis on social and economics sustainability (Madsen &Beim 2015). Several consecutive searches have been made in BREEAM, LEED, DGNB and Cradle to Cradle certification databases from 2012-2016. Case studies of remarkably sustainable building has been collected over this period. Cradle to Cradle certification encompasses by 2016 137 building supply and components (Cradle to Cradle database 2016). As cradle to cradle only covers building components it is used as a supplement to the other certifications present.According to LEED there are 852 certified platinum buildings, the highest LEED level (LEED 2016). They were examined on an exemplary basis using the LEED database entries, selecting those with highest scores. Two high performance project attracted attention and were selected for further scrutiny: The Hilmar Cheese headquarters in the US awarded Platinum in 2014 with 53 out of 69 possible (a simple score of 77%) and the Rosenborg Group headquarters in Stockholm awarded Platinum 84/110 (76%) from April 2016.We found 61 office buildings awarded the DGNB Certificate in platinum (the highest DGNB level), here the project must achieve a total performance index of at least 80 % (search carried out in October 2016). We used the DGNB database encompassing DGNB certified building from 2009 to and including 2016, covering all countries with DGNB (including Denmark, but not Sweden or Norway), 1256 in total. DGNB was updated in 2015 and of the 61 platinum office buildings selected, 39 was from 2015 and 22 from 2016 (DGNB database, see also Madsen &Beim 2015). These 61 buildings was screened on the basis of their DGNB database entry. Three office projects were particular interesting and selected for further study: first Hugenottenallee 173 Neu Isenburg with a building rating of 83,9 % and a space rating of 92,8 % (simple sum indication for comparison,176,7). This one scored low in sociocultural quality however (69,3%). Second the JFK office building in Berlin with the score 84,4 and 90,6 (simple sum 175). The score of social quality was 87,85 And third the Kö- quartier Dusseldorf score 81 and 90 (simple sum 171) and 74,4% on socio cultural value. Based on first the comparisons between standards, second the screening exemplary evaluation and third the features of the five high performing cases of LEED and DGNB, the DGNB and LEED cases appeared less performative than the BREEAM "outstanding" certification, which was therefore selected for a more detailed discussion here.There are several limitations to our approach. Our analysis here relies on first other authors' comparison of certification, second our own preliminary and tentative comparisons and exploratory searches. This is accepted because the interest is to identify cases that go beyond the certifications. As for patented sustainable products and processes, although preliminary searches were made into patented sustainable building components, it has not been established whether the patented products constitute a more radical innovation than cradle to cradle certified products. Our preliminary position is that patentingdoes not evaluate the products as systematically as a cradle to cradle certification would. It is newness that are the central criteria.

4. BREEAM as example of a sustainability standard

BREEAM is an entire suite of certifications targeted different phases of a building's life and different sectors of buildings (domestic, offices, public institutions etc. BREEAM 2016). There are certifications for four different phase/stages: Master planning, new construction (incl. design), refurbishment, in-use. They include up to ten aspects related to energy and water use, the internal environment (health and well-being), pollution, transport (access to public transport and bicycle facilities), materials, waste, ecology (including biodiversity), management processes and innovation. In total there are typically 80 evaluation points. The criteria dimensions are typically the following: Management, Health and Wellbeing, Energy, Transport, Water, Material and Waste, Landuse and Ecology, Pollution, Innovation.The scores at these evaluation points are summed up in a score card, with a score from 1 to 100%. The scores are translated into stepwise categories: "Passed", "Good", "Very Good", "Excellent", "Outstanding". Outstanding means scoring more than 85 points out of 100 and around 1% of all ratings do that (BREEAM 2016). For example in the BREEAM 2014, the energy dimension Excellent is 37-52,5% reduction of energy consumption compared to national building regulation and Outstanding is 60-82,5% reduction (BREEAM 2014b). Although BREEAM is increasingly international, it is 96.4% of its certifications of non domestic buildings (including offices) that are placed in the United Kingdom. The figure for 2012 was 92.5% showing the gradual grow in internationalization (BREEAM 2014). Using our latest searches in the greenbook data base we were, first, in april 2016 able to identify 256 cases of BREEAM certified buildings in class "outstanding". Second this figure had grown to 281 in october 2016. Out of these, 76 were categorized as office building, but our search also covered mix-use buildings. The certification were according to BREAAM 2009 or BREAAM 2011. None referred to BREEAM 2014 which is presently a draft (BREEAM 2014). In the further selection the more recent and highest scores (meaning more than 90%) were selected, and thus deselecting even relative high scores such as the building Rue de Port in Nanterre, France which scored BREEAM outstanding 90% in 2010. Also, some examples of "protected economy" cases, such as experimental buildings on university campuses, electricity utility headquarters and the like were sorted away in line with the developed criteria for radical innovation.

5. Cases of RSI?

This section presents first five shorter cases and then one a bit longer, the most outstanding. The short are Air Street, London, UK, Bentley Works, Doncaster, UK, Le Hive, Ile de France, FR, PwC One Embankment Place, London and Angel Square, Manchester UK. The longer is the headquarters is Geelen Counter Flow, NL.

The *Air Street*building is placed in central London, Regent Street and part of a larger project carried out by Crown Estate. The building was certified after BREEAM 2011 New Construction, Office and scored 94,16 after finalizing in autumn 2015. An earlier interim certification was rated slightly lower. The project is a combination of preservation of an existing listed building, and demolishing and new built of the two upper floors aiming at delivering office facilities. The stronger part of the evaluation were energy, waste, materials and management. The weaker health, transport, water and innovation. On energy for example the building scored 25 credits out of 27 due to the low carbon energy strategy adopted, provision of monitoring facilities, use of district heating, LED lightning and solar panels. Also the wall insulation used reduces heat loss by 65%.The *Bentley works*building was rated outstanding with a score of 92,5 % in BREEAM interim in 2015. The owner, SKANSKA UK, a contractor, also

used the company's internal "Color Palette" certification tool. The Colour Pallette tools is organized in economic, green and social dimensions. Skanska describe the economic scores like this; a total green payback period of 11 years and creation of 70 new full-time positions. The green scores are the following:

Table 1: Green Score of Air Street

•Net zero primary energy site •Office building uses 67% less energy than UK building regulations •11% reduction in embodied carbon •Zero construction waste materials to landfill •Zero hazardous materials •Net zero potable water & 70% less water than BREEAM benchmark

In the social dimension SKANSKA highlights a healthy indoor and outdoor environments for building occupants and workers. In other words it derives that the building substantially surpass BREEAM outstanding criteria in one dimension, water use, yet operate a very limited social sustainability perspective (as other BREEAM certified buildings also usually does, see the discussion below).*Le Hive* is Schneider Electric headquarters in France. Schneider is a large paneuropean electricity installations supplier. The building scored 93,8% in the BREEAM In-Use certification in 2013. The building complex is at 35.000 m2 and energy consumption level at 78 kwh/m2 per year was achieved from the double level of 150 kwh/m2 per year. The BREEAM In-Use rating included asset performance 'Excellent', 75%; Building management performance 'Outstanding', 88%; Occupier management performance 'Outstanding,' 92%. The energy use for Heating Ventilation and Air Conditioning (HVAC) and lighting have been halved over three years through active energy efficiency, without changing the structure of the building and without energy production, per Schneider. Other dimensions of sustainability are entered in table 2:

Table 2: Features of Le Hive

•Recycling and sorting of 12 kinds of waste (0% to landfill). • Efficient management of water – rain sensors, real time leak detection. • Health and well-being services on site such as like fitness facilities, consultation with occupiers, acoustic comfort improvement, innovative comfort measurement. • Greenhouse gas emissions study, use of 100% eco-labelled products for cleaning. •Closely managed energy consumption with a dedicated manager for energy and the environment, and centralised control and monitoring using innovative tools. • Conservation of green outdoor areas, improvement of bio-diversity, beehives on site.

Thus despite many impressive results the Hive stays within the BREEAM outstanding category.The *Angel Square* building in Manchester, is the headquarters of the Co-operative Group. The building provides office facilities for 3,000 employees. The Co-operative Group is owned by 8 million members. The building scored 95,16%, outstanding, in the BREEAM (2008) offices certification in 2013. Some of the dimension highlighted were: The building is powered by a pure plant oil fed Combined Heat and Power (CHP) system and utilizes rapeseed oil which is grown on The Co-operative's own farm land. Excess energy is sent back to the grid. Other features include LED lighting and a system to recycle waste and rain water.Apart from its unusual architectural qualities, the building's sustainable solution *does* appear to go beyond the BREEAM certification in some dimensions such the CHP system and the recycling of water.*One Embankment Place* is a commercial 39936 m2 office building constructed in the 1990s. The BREEAM rating is Outstanding with a score at 96.31% in Post-Construction BREEAM

2008 Offices certification. Approximately 40,000m2 total floor area comprising a ground floor below the station and floor 1 to 9 above with structure, services and lifts passing through Charing Cross station. The current occupier PwC desired a high BREEAM rating as part of their corporate policy along with a good EPC score and considered this high on the priorities at the concept stage, with the BREEAM requirements featuring high on the list next to space planning and cost analysis. The resulting building also feature biofuel trigeneration CCHP with and absorption chillers, biofuel is sourced from locally collected and refined waste vegetable oil, green walls and landscaped garden planting, waterless urinals and low flush toilets, comprehensive metering strategy and BMS, >95% of materials used within the construction were responsibly sourced with an ISO 14001 certificate as a minimum, staircase installed within the atria to promote vertical movement, not using lifts.The scores in dimensions are: Management 100.00%, transport 100.00%, materials 100.00%, energy 95.65%, waste 85.71%, water 83.33%.

7.1 GeelenCounterflow, Haelen, NL

The headquarters of the Dutch company GeelenCounterflow, that manufacture industrial coolers and driers, is an office building for 50 staff. It obtained two BREEAM certifications at the level Outstanding in autumn 2015. “Design” at 94.19% and “Post construction” at 99.94% (Greenbook 2016), which is the highest score found. Moreover, several features go beyond. The building exhibit prefabricated walls and floors of 100% unglued and non-chemically treated wood, grown in sustainably managed forests in the Black Forest region of Germany. By building in compliance with the "Passive House" guidelines and powered with 330 solar panels on the roof, the office produces 50% more renewable energy than the total energy consumption for heating/cooling, ventilation, lighting, copiers/printers, servers and PCs. The extra energy will power machinery used to laser-cut stainless steel and recharge electric forklift trucks in the company's factory. Adjustable daylight infiltration, air quality, and indoor lighting, imply that the office provides a healthy work environment that not only meets the needs of employees, but also boosts their productivity according toGeelenCounterflow. Where possible "Cradle to Cradle" certified building materials was applied. The materials used include those shown in table 3:

Table 3: Materials used in GeelsCounterflow

•The basement, “ecocrete” concrete
•The basement, (partly) prefabricated,a hollow-wall system, made of 100% recycled granules.
•Building Structure (beams, pillars) NurHolz
•Facade Accoya wooden battens (cradle to cradle certified)
•Window frames Accoya
•Indoor window frames and doors Vouten
•Glass AGC (cradle to cradle goal and transport minimizing)
•Paint Drywoodwoodstain semi-transparant water based lack
•Roof Derbipure vegetal (cradle to cradle certified)
•Insulation cellar DOW XPS (cradle to cradle certified)

These are examples of sustainable materials employed. More than mentioned here is in use. To use this many is unusual and beyond the BREEAM certification. Around the office the garden includes a variety of local plants and flowers. The landscaping also includes nesting sites for birds, bugs, bats and amphibians (GeelCounterflow, interview).Through producing more 50% energy that it consumed, and adopting the policy of “as many as possible” cradle to cradle certified building material, the building

clearly transcends the BREEAM outstanding certification, apart from scoring almost 100%. Nevertheless, some elements in the building appear to be of more traditional kind. This includes the electricity cabling and the cloak. Moreover, there is no mention of any social sustainability dimensions beyond what is incorporated in the BREEAM certification.

8. Discussion

The cases on BREEAM outstanding performance are intended used to approach and scrutinize the concepts of RSI. It is therefore important to discuss where the cases surpass the scale of BREEAM or not. As we have suggested that RSI should surpass the certification standards of sustainable buildings. In general, the cases scored high, yet they did not surpass the scale. There are few exceptions: Bentley works surpassed the BREEAM outstanding certification in one dimension, water use. The Angel square building features a CHP system feed by rapeseed oil and recycling of water. Finally, the Geelen Counter flow case has manycradle to cradle certified building components inbuilt, yet still missed a number of others. The cases mention little about social sustainability. The actual measures in the outstanding cases rarely relate to "outside" building stakeholders. Rather social sustainability is viewed as being about one's own employees. In this dimension, we thus find no elements beyond broader understanding of what social sustainability is defined as (Colantinio and Dixon 2010). It does appear that the certified companies go "hunting points" inside the certification, to lever the commodity value of their estates rather than pursuing comprehensive sustainability concepts (Chathera et al 2016). As mentioned in the method section,in 2016,we found 852 LEED certified platinum buildings, 61 DGNB platinum and 281 BREEAM outstanding. These numbers do raise an issue whether buildings that perform just above these many certified building can be understood as RSIs? As our concepts requires, a substantially improved product or process the distance to this portfolio of very well performing sustainable building does appear marginal and thereby in contradiction of being radically different. Yet still the distance to building regulation compliant building are quite substantial and these, the building regulation compliant, are far larger in volumes. For example the rating "Outstanding" is 60-82,5% reduction of energy consumption compared to law (BREEAM 2014b). And was obtained by 76 buildings in BREEAMS coverage area. The outstanding certified building is thereby an exception and an elite. However, buildings are complex products and even out best cases are not able to demonstrate radicality in all dimensions. Even if we have been careful, sorting away protected economy case, we have not been able to here to establish the business case for radical sustainable innovations. The case companies do not provide cost benefit analysis. We know from general studies of LEED and BREEAM that they do involve a value increase and a cost reduction, but such comprehensive calculation has not been available here (WGBC 2013). Moreover, LEED and BREEAM only consider economic sustainability on a very low level (Chethana et al 2016). The very asymmetric emphasis given to environmental sustainability, and prioritizing social sustainability relatively low does indicate that striving at high score in the rating, will lead to too little attention to the social sustainability. RSI therefore need to go beyond the scales, not only in a linear manner, but also by emphasizing other dimensions. The certification schemes are useful as measurement of this complexity, and the certifications given, also demonstrate that the buildings studies do arrive at some radical elements, yet still possess many more traditional elements. We argued that the concept of RSI should go beyond the usual relative understanding of innovations and radical innovations by comparing realized RSI globally. We explored this idea here, only to find many examples of regional confinements of the certification schemes. While the content of the certifications schemes BREEAM, LEED and several others support this idea by being largely comparable (Chethana et al 2016), the actual use of most of the certifications are regional.

9. Conclusions

This paper set out to critically examine, whether some parts of sustainable building technology can be understood as radical or whether we rather witness a continued slow and emergent development. We conceptualise radical sustainable innovation, RSI, as innovation that break away from the customary and characterize RSI by high degrees of newness. In the entire life cycle and in all elements, financial, process, product, client relations, organisation and management. We posited that RSI offer significant enhancements of known benefits, entirely new benefits, or substantial cost reductions, leading to the transformation of existing markets or domains or the creation of entirely new possibilities for growth and sustainable balances encompassing at least an environmental, social and economic aspect and that RSI contributes to a sustainable globe. Methodologically a selection of international cases of office buildings with very high scores of BREEAM, LEED and DGNB were examined. Among the certified "outstanding", "platinum", most buildings with slightly lower performance (including some s older), and also "Protected economy" cases were sorted away in line with the developed criteria for radical innovation. The result shows that a portfolio of office buildings have reached substantially higher level of sustainability than contemporary building regulations (such as those in EU). There is indeed a gap between a few, substantially more sustainable buildings and the majority of buildings, indicating some radicality. However we do not evaluate this as radical innovation, mainly because of the weak social sustainability dimension. Buildings are complex products and the certification schemes are useful as measurement of this complexity and the certifications given also demonstrate that the buildings studied do arrive at some radical elements, yet still possess many more traditional elements. Future research will be a further search for examples of radical sustainable innovation in office buildings. To support this also a more systematic comparison of certification systems, highest rated building from LEED, DGNB, CASBEE, and others.

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The challenges of building inner sea offshore wind farms - the cases of Lillgrund and Anholt

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Abstract

Offshore wind power installation is a growing business within the construction sectorasoffshore wind represents large available renewable energy resources and availability of space. Offshore wind energy is however expensive due to the large capital expenses. The construction of an offshore wind farm encounters many challenges throughout its construction processes. Therefore“inner sea” offshore wind farms receive increasing interest, due to their assumed attractive features of reduced costs of erection and operation. The aim of this paper is to identify the challenges encountered during the installation phase of offshore wind turbines at “inner sea” conditions, understood as the Baltic Sea region and neighbouring areas. Offshore wind farm installation is conceptualised as a building operation. Consequently, theories on construction management, operations management and strategy, supply chain, building logistics and concepts on offshore wind farm development were used. A qualitative approach using interviews and literature. Out of seven farms in operation in the southern Baltic, Øresund and Kattegat, two were selected. Interviews were conducted with professionals that were involved in installation of Anholt and Lillgrund. The analysis showed that installation challenges can either be due to local natural conditions or technical issues related to equipment, planning, technology and work practices. At Lillgrund challenges were bad weather conditions and breakdown of a vessel, causing a delay of export cable installation and the tight tolerances for the bolts at the tower-foundation interface. At Anholt, a soft seabed necessitated the abandonment of some turbine positions. Irregular supply by the turbine supplier forced the vessel operator to change planning, andit was needed to handle gas leaks from the sea bed.Installation challenges grows as wind turbines are becoming bigger and heavier and locations go further from shore. Developers and contractors must continuously innovate processes and equipment to overcome these challenges.

Keywords: Offshore construction, offshore wind farms, inner sea, Baltic Sea,

1. Introduction

The global energy consumption is projected to grow by 56 % between 2010 and 2040 (U.S. Energy Information Administration, 2016). A larger percentage of the global energy used is mainly from non-renewable sources such as fossil fuel. Non-renewable energy is associated with different negative environmental impacts such as greenhouse gas emission (Rodrigues et al., 2015). As countries in the European Union therefore seek to meet this challenge through renewable energy use, wind energy is increasingly being adopted for electricity generation. The interest for offshore wind is also increasing and is the focus here.However, offshore wind farm development is still constrained by large capital investments resulting from among others costly marine foundations, expensive installation procedures and limited access for operation and maintenance (Bilgili et al., 2011). The development process is further complicated by the involvement of different stakeholders, a complex set of contracts (Koch 2014) as well as increasing interest in locating larger offshore wind farms farther offshore and in deeper water (EWEA, 2011). As result, offshore wind energy remains more expensive and less competitive than other energy sources.Against the background of increasing interest in offshore wind farm development coupled with complexities in the offshore development processes, there is need to continuously reduce the costs and constraints by improving the operating methodology involved in offshore wind farm planning, design and installation processes. This can be achieved by among others learning from challenges encountered and processes employed on completed projects.One particular strategy is to place offshore wind turbine parks under less harsh conditions than known from the North Sea and attempt to exploit “inner sea” conditions of more shallow waters, closeness to land and an environment with lower salinity (Swedish Energy Agency, SEA, 2015).

The aim of the research was to identify the challenges faced in the installation of offshore wind farms (i.e., from installation of foundations to commissioning) with specific focus on offshore activities within the Baltic Sea region and neighbouring waters such as the Gulf of Bothnia, Øresund and Kattegat.To achieve the aim, the objective was to find answers to the following questions:What are the major decisions to be considered for an installation of offshore wind farm?What are the challenges faced in the installation of the different components of wind turbines and how do the identified challenges arise?What are the persisting challenges? Why and how can they be mitigated?Two cases of “inner sea” wind farms are studied; Anholt and Lillgrund. Anholt is situated in Kattegat, has a capacity of 400 MW, was inaugurated in 2013 and is operated by DONG. Lillgrund is situated in Øresund close to Malmö, has a capacity of 110 MW, was inaugurated in 2008 and is operated byVattenfallVindkraft. The paper is structured in the usual way, commencing with theory for answering our research question, method, then the two cases, an analytical discussion and finally a conclusion.

2. Theoretical framework

The framework is developed through combining concepts of operations management and-strategy, supply network strategy and more experience based on general concepts of offshore wind farm construction.

2.1 Operations management and strategy

Operations management is the activity of managing the resources that create and deliver services and products (Slack et al., 2013). The principal process is transforming inputs into outputs. Be it services

or products. In construction projects, construction sites are the points where the final products of the construction industry are produced, by transforming material resources using the human workforce, equipment and technologies. Managing a construction project needs to be done by considering various aspects involved in the construction industry such as human interaction, transformation of matter, institutions, lean and performance. The aspects of the construction processes have both tangible and intangible effects and also impact the economic efficiency and productivity.Slack and Lewis (2011) define operation strategy as; ‘‘The total pattern of decisions which shape the long term capabilities of any type of operation and their contribution to overall strategy through the reconciliation of market requirements and operations resources.’’ In the management of operations resources, strategic decision have to be made in four areas which include; capacity strategy, process technology, product development and organisation development,supply networks, procurement and logistics(Slack and Lewis 2011). These areas are described in the following starting with strategy of capacity. Capacity refers to the resources available to perform required activities within a given period of time. Capacity strategy is concerned with how capacity and facilities are configured and calculating required capacity level, when changes in capacity should be made (Slack and Lewis, 2011). Capacity levels influence an organisation’s ability to meet and respond to customer demands and also affect the product lead time, ability to compete and operation costs. Low capacity limits growth whereas high capacity levels lead to underutilisation of labour, machinery with consequent high costs and low profitability (Slack and Lewis, 2011, Aswathappa, 2010). An appropriate level of capacity has to be maintained during operation. Capacity planning activities involve; forecasting capacity needs for products, identifying sources of capacity to meet needs and developing capacity alternatives (Aswathappa, 2010). Operations management is also concerned with the coordination of manufacturing activities in its broad sense. This is done through production planning and control, as well as supply chain management. Scheduling is one of the functions performed under production planning and control. It is concerned with setting the production time as well asstart and finish for activities. In offshore wind farm operations, the scheduling is performed based on available labour and equipment. The schedule is developed based on the estimated time taken to install parts and the processes involved in installation operation from pre-assembly to installation onsite (Thomsen, 2014).Scheduling of offshore installation activities is highly dependent on weather conditions, requiring schedulers to make optimal schedules based on the installation scenario selected (Scholz-Reiter et al., 2010).Process technology involves the choice and development of systems, machines and processes that transform resources into finished products and services. Thomsen (2014) highlights the installation vessels as being important items that are necessary for timely installation of offshore wind farm components. The schedule of the installation process is heavily reliant on the capacity and operation of the installation vessels, meaning that a failure to timely contract with vessel suppliers would most likely jeopardise the project schedule. A variety of vessels are available for use in the different phases of the installation process. A trade-off however has to be made between the costs and risks imposed by the different combinations of vessel fleets (Kaiser and Snyder, 2010). Finally, but in a sense first in the operation processes,a strategy for product development should be developed and deployed.The product development is significantly affected by speed, scale of market and technological changes, which impact on the appropriate process to be used (Slack and Lewis, 2011). This also includes offshore wind power. As the number of competitors increases, the customers become more demanding in terms of products and services. A good planning technique in terms of time and resources, management skills and tools combined with a proper organisation enable the achievement of the resulting performance objectives (Koch 2014).

2.2. Supply network strategy including procurement and logistics

Lambert (2004) defined supply chain management as ‘‘the integration of business processes from end user through original suppliers that provides products, services, and information that add value for customers”. And logistics management is the part of supply chain management that plans, implements and controls the efficient, effective flow and storage of goods, services, and related information between the point of origin to the customers (Slack and Lewis, 2011). Logistics management deals with supply and demand planning, order processing, materials handling, storage andinventory management. The installation of offshore wind turbines has to take into account the different lead times, sizes of the different wind farm components as well as weather dependency of offshore operations.For storing of material and resources in order to exploit good weather periods for intensive installation work, minimise delays in transport, handling and installation of offshore wind farms it is suggested to have logistical planning and renting an appropriate staging area in a port that is favourably close to the offshore site (Thomsen, 2014). The offshore supply chain must be flexible organised so that the installation is not delayed by material shortages. A continuous supply must be guaranteed for the whole process. Gerdes (2010) suggests and line production outline of the installation procedure and supply chain out.

2.3. Wind Turbine transportation and installation process

The components of wind turbine; foundations, tower, nacelle and blades are to be fixed together to complete the installation. As part of the installation process, the components need to be transported from either the point of manufacture or a port to the installation site. The installation of foundations and turbines of offshore wind farms requires the use of a variety of marine vessels dependent on system generation capacity, water depth, soil conditions at site, costs and risk exposure (Kaiser and Snyder, 2012).The installation vessels are used for transfer of support structures and turbines to offshore sites, provision of stable platforms for lifting and installation operations and accommodation for ship crew and personnel (Leanwind 2014). Critical characteristics are maximum lift height and weight, speed and number of turbines carried (Kaiser and Snyder 2012).Installation encompasses four elements; foundations, turbines, cables and substations. There are four basic types of foundations that can be used in offshore wind farms namely; monopile, gravity, tripod and jacket foundations (Kaiser and Snyder 2012). The choice of foundation used is dependent on specific conditions on site such as water depth and sea environment, maximum wind speed, soil type, and distance from port (Leanwind2014). Installation of turbines, which follows the foundations and turbine installation, is highly sensitive to weather conditions and requires lifting of heavy components up to the height of the hub. Vessel requirements for turbine installation are dependent on; turbine weight, hub height, and installation and transportation (degree of pre-assembly) strategy adopted (Leanwind 2014). Depending on the degree of pre-assembly onshore, 6 common installation strategies are available (Leanwind, 2014), ranging from one involving low degree of onshore pre-assembly and a large number ofoffshorelifts, to that involving pre-assembly of the entire turbine onshore and one offshore lift (Kaiser and Snyder 2010). The former strategy is often suitable for sites located far from shore to maximise use of space on the transportation vessels. The latter strategy involves transporting the assembled turbine and can be challenging and requires employing heavy lift vessels with large capacity cranes. A number of methods are available for the installation of cables, such as remote operated vehicles, under water ploughs or through excavation. An offshore substationconverts generated electricity for transmission to the onshore grid (Barlow et al., 2015). The installation sequence for offshore substations is similar to the

turbines. Summarizing operations management and strategy to producewind farms, involves strategic decisions in sevenmain areas; capacity strategy, process technology, product development and organisation development, supply networks, procurement, installation and logistics. Importantly this type of operations involves a strong dependency of the final location of the product and its features, i.e distance for shore, water depth etc. A feature that distinguish it fromoperations management in manufacturing and is similar to those of more complex engineering construction products such as civil engineering and process plants.

3. Method

The research was conducted to identify the challenges in the installation phase of offshore wind turbines and focused on learning from completed projects at ”inner sea” conditions. A qualitative study design, using personal interviews with offshore wind power professionals, was employed,to map the encountered challenges in practice. Offshore installation as understood as an operation, and theory about operations management, operations strategy, supply chain as well as concepts on offshore wind farm development were adopted and used for sensitizing the data collection and analysing and discussing the collected data. A literature search was conducted using Chalmers library search engine “Summons” and Google Scholar. “Summons” is an aggregated search engine combining a number of sources including Science Direct, Proquest, and Scopus. Specific keywords such as wind turbine, offshore wind power, offshore oil and gas industry and challenges in offshore projects were used to gather relevant academic articles. A total of 52 academic journal articles, books and reports were screened out of which 39 were considered and read.The obtained literature and other information concerning previous experiences from offshore wind farms were studied to compile the theory and develop an insight of challenges faced in installation of offshore wind power projects. Supplementary information was obtained through conducting interviews and email correspondence with professionals in the industry, and from websites dedicated to offshore wind, such as 4Coffshore.Case studies were selected from wind farms constructed within the Baltic Sea, the Gulf of Bothnia and inner Danish-Swedish waters such as Kattegat, Øresund, Storebæltover the past 10 years (2005 – 2015). The considered farms are shown in Table 1. With the exception of EnBW Baltic 2, the rest of the wind farms could be categorised within the 20-20 segment (i.e. constructed less than 20 km from shore and in water depth of less than 20 m) with the four gravity based foundation structures and three monopile. Also some older farms such as Middelgrunden (2001) and Sprogø (2003) was deselected to assure contemporary operations management methods.

Table 4: Existing ”inner sea” offshore wind turbine parks

EXISTING

Wind farm	Capacity (MW)	Turbine capacity (MW)	Construction year	Depth Range (m)	Km to shore	Foundation	Developer	Owner	Country
Anholt	400	3,6	2013	15	20	Monopile	DONG Energy	DONG Energy	Denmark
EnBW Baltic 2	288	3,6	2015	23-44	35.4	Monopile & Jacket	EnBW Baltic 2	EnBW Energie	Germany
EnBW Baltic 1	48,3	2,3	2011	16-19	16	Monopile	EnBW Baltic 1	EnBW Energie	Germany
Rødsand II	207	2,3	2010	6-12	9	Gravity	E.ON	E.ON	Denmark
Lillgrund	110	2,3	2008	4-13	9	Gravity	Vattenfall	Vattenfall	Sweden
Karehamn	48	3	2013	6-20	7	Gravity	E.ON	E.ON	Sweden
Sprogø	21	3	2009	6-16	10	Gravity	Sund&Baelt	Sund&Baelt	Denmark

A mapping of the planned ”inner sea” projects was also carried out, to evaluate the potential for learnings from existing ”inner sea” parks. This mapping showed that the national areas of Denmark, Germany, Poland and Sweden together have some 6300 MW planned “inner sea” offshore parks in the greater Baltic Sea area.Semi structured interviews were conducted with selected professionals; most of them being project managers, from companies involved in offshore wind farm development activities, but also service providers and other experienced professionals. The interviewees were involved in installation of Anholt or Lillgrund wind parks working for developers, contractors or service providers. Most of the interviewees were suggested by their respective companies. A total of six interviews was done related to offshore wind farms particularly in North and Baltic Sea. An interview guide was developed based on the research objectives, questions and hypotheses derived from theory. Obtained results on challenges encountered in wind farm installation were gathered and discussed. The differences and similarities were highlighted and the most often occurring challenges were identified together with their effects and current status. Depending on the status (mitigated/unmitigated) of the identified challenges, suggestions were made on what considerations can be made by developers and contractors to minimise their occurrence.

4. Case: Lillgrund

Lillgrund wind power plant is located in the Öresund area 7 km off the southern coast of Sweden in a water depth ranging from 4 to 12 m. The wind farm has a capacity of 110 MW generated from 48 Siemens 2.3 MW Mk II turbines. The shallow water and proximity to the coast were advantageous. They enabled easy access during construction and maintenance, use of a short export cable and control of the foundation cost. The wind farm was constructed 2006-07 with support from the SEA. The project was executed under two major contracts; one for foundations and seabed preparation (Pihl-Hochtief joint venture) and the other for wind turbines and electrical system (Siemens wind power). Lillgrund is founded on gravity based concrete foundations, with a hollow structure, which are filled with ballast once placed on site. The farm also has an offshore substation(Flodérus, 2008). Due to the varying water levels on site, five different heights of foundations were produced ranging from 10-14 m and a base width of 19 m. The foundations were prefabricated directly on rented transportation barges in Poland in the harbour of Swinoujscie (Jeppsson et al., 2008). Foundation production works were carried out simultaneously with dredging works on site. The dredging worksinvolved cutting the seabed to required profiles .Divers were employed to check that the dredging works were properly done before the foundations could be placed. The foundations were towed to site on barges and placed on the seabed by means of a crane barge supplied by Eide contracting AS. The foundations were protected from scouring due to ocean currents by placing a layer of rock fill (Jeppsson et al., 2008). Each turbine consists of a 73 m high cylindrical tower weighing 134 tonnes, an 82 tonnes nacelle and 60 tonnes rotor. The turbine nacelles, blades and tower were transported by road from the Siemens’ factory in Brande, West Jutland in Denmark to the installation port at Nyborg. Some degree of onshore pre-assembly was performed specifically the attachment of the three blades to the hub at the installation port. The preassembled blades, the tower pieces and the nacelle were transported to the installation point on a jack up vessel called Sea power (A2SEA). The vessel has the capacity and sufficient area to install three wind turbines from one trip (Jeppsson et al., 2008, Flodérus, 2008). A total of four lifting operations were employed during the installation. The installation time including the transit time to the installation site by the installation vessel for the three turbines that the sea power would carry was five days. The actual installation time for three turbines on site was however two days (Flodérus, 2008). The installation sequence described above has since become out fashioneddue to the fact that it requires

a large space on the installation vessels to transport a fully assembled rotor Larsen (interview, 2016-03-10). At the time of constructing Lillgrund, it was problematic to lift a single blade when operating offshore since it was highly weather sensitive. However, according to an interviewee from A2SEA, the method adopted for installation is sometimes dictated by the turbine manufacturers. In early days, it was not possible to turn the rotor shaft while the turbine was not balanced by 3 blades, but it has since become possible to install single bladeswith the introduction of the blade gripperJohannsen (interview, 2016-05-03). This ensures optimum use of space on the installation vessel and minimises the number of trips between the wind farm and the installation harbour. Lillgrund cabling consists of a 130 kV electrical system whereof 7 km isan export cable at sea and 2 km cable is on land, connected to E.ON'sonshore station (Jeppsson et al., 2008). Siemens subcontracted the cable supply and installation work package to ABB which used four subcontractors, responsible for export cable installation, diving, transport and inter-array cable installation (Unosson, 2009). Two vessels were used for laying the export cable and inter array cables respectively in 1 m deep trenches. A Remotely Operated Vehicle (ROV) and divers were employed to ensure that the cables were properly laid in the excavated trenches (Unosson, 2009).The offshore substation was built by Bladt industries andSiemens was subcontractors on the electrical part of the substation.

5. Case: Anholt

Anholt wind farm is located between Djursland and the island of Anholt located in Kattegat Sea in Denmark and operated by DONG. The wind farm consists of 111 3,6 MW wind turbines. The total farm capacity is 400 MW. It is located at a sea depth of 15-19 m. A transition piece connects the tower and a monopile foundation of a diameter of 5 m driven into the seabed. The port of Grenaa at a distance 20 km away, was used during both installation works and is used for maintenance. The project also includes a substation and submarine electricity cable connected to Grenaa. The major soil types encountered during geotechnical study were gravel, sand, clay and in some areas small organic content - which fit with steel monopile foundation. The construction works took place 2012-13. The offshore substation, the power export cable to shore, and the connection to the main power grid on land is provided by the state. Main suppliers to DONG energy were Siemens Wind Power A/S for wind turbines, Siemens A/S for offshore substation electrical equipment, MT Højgaard for civil engineering, AH Industries for wind mill towers and nacelles and Nexans Deutschland GmbH for array cables. About 23 other sub-contractors participated (Pau, 2015). They include Ballast Nedam Equipment services for the foundation installation vessel, A2SEA for wind turbine installation vessels, Visser& Smit Marine, infield cables and HvideSandesSkibsbyggeri for two service vessels. GEO Engineering Consultant was hired to carry out geotechnical and geophysical investigations and Ramboll made environmental,maritime studies and design of offshore substation and foundation. About one hundred vessels were involved in the construction and a total of 3,000 employees 1,000 fulltime (Pau, 2015). During the installation period the wind turbine components were stored at Grenaa port and transported to site by a barge and a vessel. Foundations consisting of a 37-54 m round steel pile with a diameter of approximately 5 m. The 111 monopiles foundations were installed by MT Højgaard A/S using Ballast Nedam heavy lift vessel-Svanen, and the transition pieces by the heavy-lift vessel Jumbo Javelin rented from A2SEA Company. The steel monopiles were manufactured by Bladt Industries. To install the monopile, the first step was to install plugs and rigging at harbour then launch the plugged monopile to the water using sheerlegs. The plugged monopile was able to float on water surface and towed to site for installation by a vessel. It took about 7-8 hours to drive the monopile into the seabed. A transition piece was then installed by using a vessel, capable of carrying 9 pieces on each load. On site the 170

tons' transition pieces were lifted and grouted on top of the monopiles. The turbines were supplied and installed with nacelle and three blades. To erect wind turbines, a crane mounted on the jack-up vessels was used to lift the wind turbine components into place in six lifting operations. The lifting operation consisted of 2 pieces of tower, 1 nacelle, 3 blades and no pre-assembly was done onshore. The jack-up barges or installation vessels, "stand" on the seabed and create a stable platform. Four different turbine installation vessels from A2SEA were deployed at the same time during the installation, carried out in the following processes: The vessel loaded components for one or two turbines at the port and transported them to the site. At the site the vessel jack-up and start installation of one turbine starting from lower part of the tower, upper part, nacelle and three blades. Once a turbine is completed the vessel goes down to the floating level, starts sailing to the next turbine location, and jack-up again to installation of the second turbine. When finished, the vessel sails from the site back to port for new loading (Thomsen, 2014). Energinet.dk was responsible for establishing an offshore substation and power export cable to shore.The whole structure,a concrete gravity base of 4,000 tons together with steel jacket structure of 800 tons was floated and towed to the Anholt site from Copenhagen. A 160 km buried submarine array cable, connects the 111 turbines to the offshore substation. From the substation, the 25 km long submarine export cable, buried in 1 m into the seabed, transmits the power to Grenaa (Pau, 2015).

6. Discussion

From the two case descriptions three main challenges at Lillgrundand Anholt are discussed. At Lillgrund, firstly the export cable installation was delayed two monthsbecause of bad weather conditions at sea and the breakdown of the thrusters/propellers of the vessel Nautilus Maxi. It was needed to re-open the trenches which had consequently been refilled with mud during the period of inactivity. Second the tight tolerances of the bolts for the tower-foundation interface proved problematic. Third unevenness in the concrete foundations rendered some bolts too short. Therefore, cutting of the concrete had to be done to achieve the required bolt height. These challenges relate a lot to the dependency of location and confirm its crucial role in this type of operations management. But it also relates to process technology and product features.At Anholt the three main challenges were, first the soft seabed in the north part of the park identified by the geotechnical survey. The use of vessels with jack-up function, necessitated the abandonment of some turbine positions, causing the change of the final park layout in a non-optimal manner. Second irregular supply by the turbine supplier, forced the vessel operator to change planning accordingly. Third World war II subsea mines delayed geophysical surveys of the seabed. Lastly special attention was also needed to handle gas leaks from the sea bed.These challenges relate for a large part to the particular location, but also to the manufacturing of the windturbines. Some similar challenges also occurred in the two cases. As the turbines become larger, they also require massive foundations. This leads to challenges of lifting heavy and big size components. The heavy weights render the currently available vessels insufficient for lifting. Additionally, logistical challenges arise since the components can no longer be transported by road. The challenges found in the two cases can thus be categorised as both site specific and crosscutting. Some of the general challenges arise from nature like weather conditions and difficulties in fully predicting ground conditions whereas other technical challenges such as heavy weight components originated from the production of larger turbines. The site specific challenges such as irregular supply and inability to produce in accordance with the required standards are attributable to a limited number of suppliers. The managers involved in the installation phase of Lillgrund and Anholt considered preparation and planning as vital elements(Gerdes 2010 and Thomsen 2014). The planning

involved making decisions on the type of vessels for the installation, the interpretation of both weather forecasts and geotechnical investigations, the form of contract, procuring contractors and selecting appropriate installation harbours. The planning activity was also guided by among others knowledge and the experiences gained from previous operations. In order to minimise ambiguities the planners attempted to use methods that have been proved previously for instance the method for selection of wind turbines and installation process used at Lillgrund. Since the installation of wind turbine involved various contractors and service providers, both developers and contractors agreed to work in close cooperation. Such kind of cooperation was highly needed from design phase to facilitate the early identification and mitigation of problems that could arise in the later phases of the project. For instance to avoid lifting challenges that might occur, the designers would need to be aware of the availability of appropriate lifting vessels on the market. Both Lillgrund and Anholt had an installation period that was, according to interviewees, short and with a strict time frame therefore they were forced to use any available weather window for installation activities. Slack and Lewis (2011) suggest that in the management of operations resources, decisions have to be made in four areas capacity, process technology, supply networks and organisation development. All interviewees agreed that the choice of right installation vessels with the right capacity was the first step during a planning of a wind farm installation. For example to avoid the heavy lifting challenges that could occur, at Anholt, the contractor chose to tow the foundation to site instead of loading them on vessels because it was not quite easy to lift the 460 ton monopile whereas at Lillgrund, the gravity foundation were directly manufactured and transported to site on the barges.Due to favourable sea conditions, it was possible to use one type of vessel for the installation. The contractor chose the same equipment that had been used in harsher conditions at Horns Rev 1 in the North Sea. Contrary to Lillgrund, vessel selection and planning at Anholt was highly demanding. It was necessary for the contractor to find a unique and flexible solution. One of the fascinating solutions was using a flexible fleet where the contractor planned and achieved turbine installation using four different installation vessels. Adopting this flexible fleet of vessels shielded the customer fromadditional costs of vessel capacity.The interviewees confirmed Slack and Lewis (2011) and Kaiser and Snyder (2010)'s point about flexibility in operation resources in that they had a variety of vessels available. Literature reviewed pointed out the shortage of purpose built vessels. However, from the interviews conducted, the interviewees asserted that there was sufficient capacity of vessels. Notwithstanding this assertion, the vessels were also in demand from other sectors such as telecommunication and oil and gas sectors. Consequently, there was uncertainty on the availability of vessels due to variability in demands from the different sectors. There was also concern over low installation speed due to the use of non-purpose built vessels, which not always are fully appropriated to the tasks. As far as logistics is concerned the interviewees strongly emphasised that the installation harbour was problematic, which is in line with Thomsen (2014). The absence of sufficient purpose built harbours for offshore operation hindered the installation process since priority was given to commercial vessels over offshore vessels. A purpose built harbour further away from site is thus preferable than a non-dedicated harbour located close to site. In the Baltic Sea region and its neighbouring waters, attempts have been made to resolve the harbour problem by building purpose built harbours such as Nyborg and Grenaa. The question that remains is whether they will remain suitable for handling heavy turbine components for future developments as well as to accommodate large size vessels. As the construction of offshore wind farm requires onshore space for pre assembly, loading, unloading and lifting activities of heavy and larger components for a long period it is challenging to find appropriate spatial facilities that can be occupied for a period up to three years. According to some of the interviewees, it is expensive to build purpose built harbours for every wind farm activity. It is not economically feasible to construct a harbour for each wind farm; a more appropriate solution would be

to develop a number of strategically located harbours that can be used as need arises. With regards to product development, most interviewees recognised the need for strategic development and organisation in their respective companies in order to compete with future challenges that may arise. The interviewees posited that future offshore installations would be in more challenging conditions than previously, the reason for continuous development of processes and equipment to overcome the expected challenges. The weather dependency was highlighted as one of the major constraints by all interviewees. Contractors and developers have attempted to overcome this constraint by among others scheduling of activities in autumn and summer. For instance turbine installation and cable laying are done in autumn and summer. In recent times however, purpose built vessels and technologies such as the blade gripper have been developed to facilitate offshore installation works in harsh weather conditions.

7. Conclusions

This paper set out to study the challenges faced in the installation of offshore wind farms constructed under ”inner sea” conditions.To support this endeavour we mobilized a framework of understanding of operations management and –strategy concepts and selected two wind farms for qualitative study. The framework suggests a focus on capacity, process technology, product development, manufacturing and transportation. A number of challenges have been identified and discussed, broadly occurring in all parts of the framework. Challenges include failure of mobilized machines to perform work and presence of unknown items on the seabed such as unexploded objects left in the sea due to earlier human activities. Turbine sizes are increasing as the industry players seek to effectively tap the wind resources offshore. This however results in larger and heavier components which require larger vessels equipped to handle heavy loads and render road transport unfeasible. These changes necessitate cooperation between the players that participate in this fragmented sector. Some challenges are site specific, for instance seabed conditions, thus requiring each project to be carefully planned as a unique case. Solutions to site specific challenges may also come from experiences from similar projects. The installation activities are weather dependent and include frozen water in winter, high wind speed and sea tide. For these persisting challenges, it is recommended that their impact should be considered during the planning of activities, having appropriate risk sharing and allowing time contingency in scheduling. Logistical challenges can be reduced through the location of turbine manufacturing facilities close to sea, which is especially feasible at ”inner sea”locations.

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Learning how to grow - Management Competences in play at an International Acquisition by a Medium-Sized, Swedish Engineering Company

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Abstract

It has become increasingly important for also medium-sized building companies to internationalise. Many of these companies are not ready for that development and top level management need to learn how to carry out steps of internationalisation. The aim of this paper is to create a competency model for top management teams of medium-sized, building companies and then second investigate a case of a Swedish Engineering company, 3000 staff, doing an expansion to Norway. The analysis leads to a further developed competency model for top management. The framework of understanding consists of an overarching category, competency, and four further; leadership and teamwork, uncertainty, risk and resistance, international expansion, and cultural issues.Then empirical material, enables insights and arguments that supports and/or contradicts the theoretical data for each of the identified competences. Three additional competencesis derived from the case study, leading to a total of ten competences: learning during change, strategic leadership, dealing with risk and contingencies, embrace and redirect resistance, synergy orientation, managing local responsiveness, cultural mindsetappointing qualified personnel, efficient communication and business mindset.Missing competenceswere acquired through external consultants or recruitment. To achieve the desired synergies,management uses detailed checklists and processes, and place a person with a very strong internal network as responsible for the integration project. Additionally, the findings indicate some management focus on organizational culture.Managementassumed that through learning and adapting to the organisational cultures, one automatically takes the national culture into account.

Keywords: Globalisation, Competences, Consulting engineering, Top management, Norway, Sweden

1. Introduction

As the world economy is becoming an arena for an increasing number of companies, it has been claimed that the globally present networked and disperse company organisation is the future dominant form of business organization (Hätönen and Eriksson 2009). Such organizing risks to involve many managerial challenges such as clashes of cultural differences (Gesteland 2013), mistrust (Jarvenpaa and Keating 2012) and contradictions between local markets and corporate synergies (De Wit and Meyer 2014).The main aim of this paper is therefore to inquire into what are the most prominent competences required by the top management of a Swedish, medium-sized engineering company to successfully manage an international expansion? Our first sub-question is, how can the top management of the case company acquire the competences they do not already possess before an international expansion? The second sub-question, how can the desirable synergies between the existing organization and the new one be achieved? The method has emphasized the conceptual development with a literature review of selected contributions. A 3000 staff international company was selected as case study because of its recent expansion to another country and its routine in doing so (the company is called Hansson here). Interviews with central players in top management has been carried out. Through making a single case study we obtain closeness and understanding of context, yet cannot generalise our results.The paper contributes to the overall discussion about the role and influence that top management has on the success of the internationalization of its company, and develop an understanding of the internationalization of consulting engineering and the top management competences it involve. The case enables an appreciation of both routine elements and contextual accommodation of management activities and competences.The structure of the paper is the following. In the presentation of our framework of understanding we emphasize the conceptual part through going through each of the competences. The description and analysis of the case has then been integrated here to save space and to appreciate the closeness of competences to activities in the expansion process. The paper ends with a discussion and a conclusion.

2. Framework of understanding

This section develops our theoretical conceptualisation in response to our main aim. The framework consists of one overarching dimension competency theory and four further elements; leadership and teamwork, uncertainty, risk and resistance, international expansion, and cultural issues. We have selected three elements to be discussed here, and only resume our understanding of uncertainty, risk and resistance. Finally, we summarize the framework and extend it to answer to the two sub-questions.

Competence theory defines competencesin several ways. Gilbert (1996, p16) defines it as the "function of worthy performance, which is a function of the ratio of valuable accomplishments to costly behavior". This differs slightly from the definition of competences presented by Dubois (2004, p.16), who argues that they "are characteristics that individuals have and use in appropriate, consistent ways to achieve desired performance. These characteristics include knowledge, skills, aspects of self-image, social motives, traits, thought patterns, mind-sets, and ways of thinking, feeling, and acting". Competences are success factors that "specify what … [is] needed in managers and executives to help grow the organization" (Stamoulis 2010 p.37). Rothwell and Graber's (2010) theory focus on the two different ways how individuals can improve their competences; competency-based training and learning. Competency-based training "is intended to help individuals acquire or build the necessary characteristics to match the skills of good or exceptional performers" (ibid, 2010, p.2). There is a

sufficient level of correspondence between the competency definitions, to allow a combination of them to be used here. Competences are characteristics of individuals, but often acquired in shared relational contexts. Competences are needed to achieve a performance that meets the organization's demands. Additionally, here the topic of interest is how to do successful international expansions, which can be defined as: "execute the expansion in a structured way, on a limited budget and without losing control of the business both at home and in the target market" (Simpkin 2010, p.13).

Studying senior executive assessment is a way to encircle senior executive competences. Stamoulis (2009, p 63) point to factors that relate to the leadership and management style as well as the personality of the candidate, and argue that "creating vision, setting strategy … thinking critically [and] ensuring tactical success and driving results" are a few examples of these senior executive capabilities. These also include efficient networking skills, a high level of motivation, self-awareness and reflectivityto be a successful top management group member. Another angle is the fit of the candidate's experience, ethics, industry experience, cultural orientation to the company and even managerial experience compared to size and scope of the company. Moreover also a strategic outlook dimension of long-term demands of top management as the company strategy might unfold. By adopting new learning strategies, senior executives leave their comfort zone and thereby expose themselves, becoming vulnerable. Gaining new knowledge and skills will temporarily decrease the efficiency and effectiveness of the executive's performance, or could even lead to a complete failure at first. This is particularly challenging or difficult for managers that have been very successful in the past, thus being recognized and reputated as star performers (Bunker et al. 2010). In correlation with Keller's (2012) statement, our conceptualisation also follows the path towards a set of specific behaviours or competences of the top managers that are related to successfully expanding internationally, which represents the desired strategy of Hansson. Therefore, as a conclusion, it is meaningful here to further pursue the structuring and creation of a specific competency model. Summing up the overarching category of competency, as initiating, and learning through both external and internal development are crucial to the success of the top management one competency will be labelled as *openness to learn and change*during an international expansion as well as future organizational undertakings.

Moving on to the dimension of leadership and teamwork, strategic leadership signifies that an individual or a group manage an entire company and not just a unit in an organization. This might be done by combining and allying several positions and functions in the organisation in a relational and interpersonal shared manner, and not only from the top (Finkelstein et al. 2009). Strategic leadership consists of the ability to "anticipate, envision, maintain flexibility, think strategically, and work with others to initiate changes that will create a viable future for the organization"Bolden et al. (2013, p.84). Strategic leadership support the creation and implementation of the organization's goals, vision, mission and strategies by offering direction and inspiration. Strategic leadership should cover "building core competences, team building, communicating, and goal-setting" (ibid, p.84). However, this list of behaviours and tasks places strategic leadership within the individual and not in a group (Bolden et al 2013). This is opposing a goal of strategizing as "to unite the beliefs, goals, and activities of a whole group of people" (ibid, p.84), which also defines the future vision that must be shared in the company. Additionally, an organization and therefore top managersmust set up a global or international vision before they start to internationalize (Bolden et al 2013). Staying with a local vision when internationalizing is one risk, and imposing of a vision onto the employees is another (Bolden et al 2013). Strategic leadership has been criticized for being too top-down, focused on means-end thinking and maintaining and legitimizing organizational inequalities. Therefore, a more inclusive approach is

suggested to create a shared organizational vision. Especially the organizational procedures concerning the recruitment, training, customer service and product development mustbe adapted to the vision for it to be credible (ibid).

The top management group is the highest managerial level or 'the apex of an organization', and the group is a "relatively small group of most influential executives" (Finkelstein et al. 2009, p.10). The senior executives within this team include the CEO as well as the persons responsible for reporting to him or her. The group usually consist of up to ten people at the very top of the organization. Nevertheless "top management typically is a shared activity" (ibid, p.10), and the claim here is that we need to move beyond examining the individuals to the group.Forexample, investigating how and whether they act as a team. Strategic leadership can still be possessed and developed by the individuals within the team and therefore increase the overall performance of the top management team, whereas only the international experience and perhaps the functional background can be improved by the top management members. Thus,*strategic leadership* will be understood as a competence. The importance for expanding internationally must be emphasized, as the vision, mission and strategy of an organization should adapt or change when making the global move. The strategic-orientation with all its tasks, goals and responsibilities, and the leadership aspect of senior executives are both crucial to expansion success. It also derives that we choose to describe the competence through the associated activity.

The dimension of international expansion refers to the process of increasing the company size or scope by establishing operations in a country where it has not previously been permanently active. By doing so, the company is becoming more global. Globalising is "deciding on which geographic areas the organization should be involved in, is [labelled as] the issue of international composition… and… the process of increasing international interconnectedness" (De Wit and Meyer p.297, 298). They also present three different definitions of the term global: as worldwide scope, as worldwide similarity, and as worldwide integration. The third refers to a corporation operating across the world as a linked system, which causes geographically different markets to be a vulnerability. Depending on the daily business and vision for the future, different companies will exhibit different definitions, which might explain how they develop. Further, when a company is setting up its business in a new country, it should decide its mode of entry. It can be acquisition, purchasing an existing local company, or a greenfield entry, where the company starts from scratch. The company can either work independently or through forming an alliance with a local player (ibid).If it turns out that a company is lacking capabilities to establish itself, there is the option of using contractual agreements as entry form.When entering a new market, the company will most likely have a resource gap, representing a need for local market knowledge. This gap needs to be filled, preferably by forming an alliance with a partner who possesses the required knowledge and experience in this market (ibid). Organizations should manage their international expansion process, and therefore deal with the 'border-spanning nature' of operating in two or more countries (De Wit and Meyer, 2014). Internationalization brings along a lot of difficulties and costs to effectively run an organization. As stated by Zaheer (1995), there are inherent costs or disadvantages called the 'liabilities of foreignness', due to the organization's non-native status. These costs concern the geographical distance, e.g. costs of travel, transportation and coordination over distance and across time zones, the organization's lack of knowledge of the new market, the host country's environment, e.g. lack of legitimacy of foreign firms as well as the home country's environment (Schweizer, 2015). Looking at these costs, De Wit and Meyer (2014, p.302) argue that "the simplest solution would be to organize all operations on a country-by-country basis, and to leave

all country units as autonomous as possible". However, they further claim that the economic rationale behind internationalization is that it "only makes sense if enough cross-border synergies can be reaped to offset extra cost of foreignness and distance" (ibid, p.302). Following this statement, organizations consequently need to adopt 'international integration mechanisms' that enable or ensure the fruition of cross-border synergies. Further, the authors (2014) list three of the most important,and well known, integration mechanisms; standardisation, coordination and centralization. The key question when it comes to the international standardization and adaptation to local requirements, between which there is a tension, is "whether international firms have the liberty to standardize or face the pressure to adapt" (De Wit and Meyer, 2014, p.305). Problems arise when international companies attempt to fully adapt locally, while leaving out their internally developed strengths, resulting in that they are still not better than the local companies, while being weighed down by the costs of operating internationally. Following the demand of global synergy, organizations and top managers also need to consider the demand for local responsiveness. Depending on the products and/or services, the requirements from the customers in the offering itself, the price, the place of sales, and the promotion can change immensely and should be addressed and fulfilled to some extent, with the strategy of the company in mind. However, as described above, internationalization is only viable if there are cross-border synergies, which would mostly exclude a very specific country-to-country approach. Summarising, the identified competencesare *Synergy Orientation & Managing Local Responsiveness.*

The last part of the theoretical framework, the cultural aspect, is mainly built on the theory of Gesteland (2013) who defines several cultural characteristics, representing the areas in which they differentiate from each other. However, we also draw on Alvesson (2003) which adopt a relative complex understanding of coexistence of similar integrated, or different or even ambiguous fragmented cultures. Depending on how much the "home" cultures differs from the country a company wants to establish themselves, cultural differences are something that may cause problems throughout the expansion project's life cycle. The impact of cultural factors such as language barriers, time differences, and socio-economic, political, and religious diversities may result in a normative pattern prescribing a range of permissible actions so as to encourage self-interest. Earley and Mosakowski (2004) present three sources related to what they refer to as cultural intelligence. The first is that a cognitive understanding of what makes a culture unique is required, driven by a person or a team's curiosity and general attitude towards learning. The second is the ability to process culturally determined gestures, referred to as behavioural flexibility. The third source is a person's or a team's confidence to believe that they can understand people from other cultures, referred to as having a high self-efficacy (ibid). According to Thomas and Inkson (2009, p.16) "[c]ultural intelligence means being skilled and flexible about understanding a culture, learning more about it from your ongoing interactions with it, and gradually reshaping your thinking to be more sympathetic to the culture and developing your behavior to be more skilled and appropriate when interacting with others from the culture." The first thing required is to be aware of the principles of cross-cultural interactions, in other words have general knowledge about cultures, how they vary, and their impact on behavior. The second part emphasizes the importance ofcoping with cross-cultural situations in a reflective, knowledgeable, creative and emphatic way. This is referred to as being able to practice mindfulness (Thomas and Inkson, 2009). We summarize this dimension as the competence of a *cultural mindset*.

2.1. Summary and extension of the competence framework

Drawing on competency theory, our research identified seven main competences: openness to learning and change, strategic leadership, deal with risk and contingencies, embrace and redirect resistance, synergy orientation, manage local responsiveness, and cultural mindset. We readily admit that some of these competences appear more like activities, but claim that this is an inherited feature stemming from the literature in the area. Withinthe risk elementthe first competency islabelled as *dealing with risk and contingencies* covering aspects of uncertainty, volatility, complexity and ambiguity. This is aggregated into the term 'contingencies'. As for the resistanceelement the second competenceis labelled as being able to *embrace and redirect resistance*.To conceptualize our sub-questions, we also draw on competence development theories in understanding how to acquire missing competences. This point toexecutives development and corporate synergies. First executives should either develop their skills, acquire skills, recruitpersons, and/or develop the diversity of the top management group. Secondly, when it comes to desirable synergies, corporateintegration mechanisms include standardization, coordination and centralization as described by De Wit and Meyer (2014).

3. Case: Hanssons expansion to Norway

This paper focuses on one expansion project made by a medium-sized engineering company with its headquarters in Sweden. The company, Hansson, purchased a minority share in a Norwegian engineering company about ten years ago. Recently, Hanssontook over the Norwegian company, by a second purchase of shares. This triggered an integration project that is currently ongoing. An integration team was established, that is responsible for managing the integration into the Hansson organisation. The Norwegian company is the first acquisition made byHanssonin the Norwegian market. (the company is called NorwCo here). Hanssonhas operations in many countries. The company is listed on the stock market. The expansion was split into two phases, the analysis or due diligence phase and the integration phase.The two phases were conducted by two different teams. First, top management set up an analysis team who looks at the market environment and its conditions, search for fitting companies to acquire or potential partners to merge with. Second top management hands over the responsibility to the next team, the so-called integration or 'SWAT' team. This team has the responsibility of integrating the acquired company into Hansson organisation and to communicate Hansson 's agenda, including its vision, mission, strategy, and goals, and managing resistance.

Below we describe and analyse the similarities and dissimilarities between the seven theoretically identified competences and the findings in the enterprise. Concerning the first competency, *openness to learn and change*, one interviewee (labelled 2 below), is a long term employee that have been positioned in a lot of different roles, ranging from design engineer to a group and department manager. He presently works with business development. His internal network within Hanssonextends into the divisions of Germany, UK and India. This helped him to learn how the company operates, and hisnetwork is helpful when doing projects. It was the head of the business area in the Nordic countrieswho chose him to be responsible for the integration after the acquisition of NorwCo. He knows the CEO and the members of the top management, so he can personally contact them if he needs to. This characteristic can also be identified at another interviewee (labelled 3 below), the head of the Nordic business area who has not been in Hansson as long, but has nonetheless worked in a broad range of work roles, for instance within household appliances, IT, electronic wholesales, and recycling. Additionally, he worked in five different countries, which match this competency's characteristics.

This great variety in industries and national backgrounds also shows the importance of self-awareness and reflection as each new environment is set up with new values, beliefs, mindsets, etc., which he had to be sensible to and rethink and adapt his way of working to perform.The interviewee further confirms the importance of a variety in roles and environments for people within the top management and the integration team, and thus also the need to be open to changes. This supports the theory of competency learning by Rothwell and Graber (2010). In conclusion, the competency of *openness to learn and change* is supported by the interviewees and found as an aspect of top management, analysis or integration team member duringthe expansion. However, the empirical material alludes that it is more important for members of the integration team as they are working in a unique, time and resource limited project, which at some point ends, leaving the members to find a new position.

Concerning the competence, *strategic leadership,* top management and the analysis team were analyzing the environment of the Norwegian market for long time. A greenfield acquisition was considered, but dismissed due to counsels received on a another market, the US, where using an external M&A consultant is another example on how the company complemented their own knowledge through external sources. While the acquisition as such appears an ad hoc decision, Hanssondid wait for the right opportunity, while gaining valuable information. Interviewee 3 states: "We have been waiting for the opportunity, because of the downturn of the oil and gas business in Norway…..So at this point we decided that enough market conditions have changed…. that we would like to be in". This resonate with Bolden et al. (2013) and Fernandes (2009) as itshows the ability to anticipate, envision, maintain flexibility and think strategically, and also other possible consequences, which here was the boost in export sales due to a depreciation of the currency.

Upon the acquisition, interviewee 2 mentions that one of the first things they did was reorganizing and cost cutting. The reorganizing focused on the management team, while cost cutting targeted project monitoring, control and overhead costs. An external consultant was placed as a temporary CEO of NorwCo. Further, the former biggest private owner, who had a lot of influence and worked full time as an advisor, was removed, so that they would have the discretion for change. In spring 2016 it was the temporary CEO, Interviewee 2, 3, and a controller who are in charge of the integration process with the assistance of the IT department.We positthat Interviewee 2 possess the traits of strategic leadership (Bolden et al. 2013).This also emphasizes the importance of the top management ability in choosing the right people in charge of this kind of projects. Interviewee 1 stated that "[t]he baseline is, that you have people in the management team who are senior enough to have done these kinds of projects before. That is the main thing for us. To be senior, to have done transactions before, to be able to evaluate the people and more, because it is all about people business…". Top management look for previous experience, knowledge and seniority correlating with what is the vacant role when they recruit.

These doings of strategic leadership show that the senior executives should be highly analytical to make strategic decisions (Bolden et al. 2013 and Fernandes 2009). Interviewee 3's statements on the acquisition above also support Fernandes (2009) in that they both emphasize and place *strategic leadership* in the top management level. The integration team on the other hand was not established yet at the time and was not concerned with the analyzing of the market and the strategic decision to acquire. This shows the difference of importance of this competency depending on the phase of the process. Having supported the analytical part of the *strategic leadership* competency, communication economic controlling and culture should be added. On day one of the acquisition of NorwCo, the integration team communicated the vision, mission and strategy the Hanssonhas with the purchase of NorwCo to its

employees. Interviewee 2 pointed to some lessons learned. He mentioned that he would have preferred to bring in the economic controller from day one to help with the financial analysis. Additionally, he states that Hansson, in general, should focus more on the national culture when preparing an expansion.In conclusion, several points confirm and further reinforce the importance of *strategic leadership* as a competency for senior executives and people involved in the expansion project. Here they also analysed downturn of the oil and gas business, they communicated the vision, mission and strategy to NorwCo employees, they ruled out a "greenfield" expansion and took into concern the development of the currency. However, here the strategical perspective was of higher importance within the top management and analysis team than in the integration team.

The competence of *dealing with risk and contingencies* came to the fore when departing from their usual expansion practice. The company normally only enter a new country if abig customer invites them. Therefore theHansson management consults their customer base when conducting the analysis, to identify more current customers in the new country. They would start discussing with the different business area managers, and look into characteristics of the employees. They then create an analysis team of those that are deemed fit, with the task of conducting a due diligence. Identifying people that are familiar with the new market to reduce the level of uncertainty and risk. Alsoexternal legal consultants are hired.A further point is that the strategy is to expand to new markets diversifying the customer base. Before HanssonacquiredNorwCo, their focus was solely on the oil and gas industry. Due to the downfall of the oil price, their turn over and overall business decreased. Top management acted on that issue by setting up cooperation projects, sharing their own customer base, exchanging knowledge and expertise through job rotation between Hanssonand NorwCo. This shows that it is crucial for the people involved with the expansion to identify, handle and minimize risks, of the new joint company. However, dealing with contingencies should not harm the long term strategy. Interviewee 1 commented on international expansions and M&A-s: "you need to work with a long-term strategy and stay fixed on that one. You cannot jump from one direction to another direction, because that would take too much time ….. That's a trap, if there is constant change in the management team and the board". Adding to this, interviewee 3 stated that the success of the integration process is set by the time it takes to integrate NorwCo into Hansson.In conclusion,the importance of *dealing with risk and contingencies* within the top management, the analysis and the integration team has been supported by the interviewees. It is a core competency in order to make strategic decisions that will manoeuvre the whole expansion project from the early market analysis to making the acquisition, managing the integration and ultimately the new entity within Hansson's network on a long term perspective.The speed of the acquisition decision created *resistance* and tensions in the existing management team of NorwCo, and some left immediately after. Interviewee 1 argues that "from one perspective it is good that they left, because some of them did not share the same values. But from another perspective it was not so good." These are people that top management would want to stay because they need their knowledge and skills, more specifically the engineering competences. The integration (SWAT) team did hear of some tensions at the general assembly, which took place with the owners immediately after the acquisition. Apparently there were many who thought that Hanssonwould use NorwCo as a front office to meet with customers, and then send all of the work to the Sweden. The 'SWAT' team responded to this by regular communication; many meetings and weekly emails. Thus, compared to our theory, the integration team acted well, dealing, embracing and redirecting resistance. Concluding, the competence*embrace and redirect resistance*, the theoretical competency is supported by the interviewees as a crucial trait of senior executives. However,the integration team has to be more

hands-on, dealing with the resistance on-site, where the analysis team does 'homework'. No senior executive was involvedmanaging resistance at NorwCo.

Concerning *synergy orientation,* the synergy between NorwCo and Hansson, there has been some work with renegotiation and realigning the agreements with NorwCo's existing customers and suppliers. Further, Hanssonis attempting to take the best of quality management out of both companies. "The reason for this is because [NorwCo] has a history of operating, about 90 percent of the project internally, while our number is about 30 percent…. So currently the two persons responsible for quality management in our company and [NorwCo] are running a project to integrate the new management system" (interviewee 2). The reason for internationalization lies with the benefits gained from the synergy being higher than the costs of the expansion (De Wit and Meyer 2014). NorwCo is a technology-driven company and Hanssonhas a lot of focus on innovation and product development, and this synergy was important for top management. They will introduce the Norwegian engineers to interesting projects in Sweden and vice versa, resulting in the participation and support of cross-borders projects.The Nordic business unit manager also identified the *synergy orientation.* Looking at the most important integration mechanismof standardization (De Wit and Meyer 2014), it is strived forexample through the integration project of the two companies' quality management systems. The second mechanism, coordination (De Wit and Meyer 2014), is recocknized in bringing the two companies' engineers together in each respective country's projects. Concluding, the theoretical importance having *synergy orientation* in an international expansion is also supported by the interviewees. Again, the responsibilities and roles of the top management, the analysis and the integration team vary, with emphasis on the due diligence phase. Here the analysis team collects and analyzes the data it need to evaluate the possible synergies in order for the top management to decide on going forward. Yet, as stated by Interviewee 1, it is very difficult to handle these potential synergies, which also supports the competency of *dealing with risk and contingencies*. The integration team then follows the integration concept which was created with the desired synergies in mind and made actionable by a checklist of tasks.

On the issue of *managing local responsiveness,*the aspects that were highlighted as most important in the partner selection criteria by Gleringer (1991) andGlaister and Buckley (1997), was the 'knowledge of local market'. Followed by 'distribution channels' and 'knowledge of local culture', and 'links to major buyers'. This is something that resonate with the company's choices. Since they are planning on initiating a partnership with the buyer of the production facility that they are about to sell off, it is evident that all the above criteria are fulfilled. The *managing of local responsiveness* during the expansion process shows itself by the tightroping of the integration team while integrating NorwCo into Hansson, without changing too much. Therefore, the importance of keeping the way of working is crucial for the further success, as the customers have to experience that the high quality remains or increases with the integration. However, as Hansson's due diligence phase identified NorwCo's market position and lack of diversification, the analysis team could set up plans to deal with the local market environment and change in conditions. This also matched the top managements' core focus. All in all, *managing local responsiveness* has been supported by the interviewees of this case as an important competency for the three teams involved in the Norwegian expansion.

The differences in Swedish and Norwegian business culture, evoked the competence of *cultural mindset*. Manager 1 and 2 especially emphasized their different ways of problem solving. It was posited that Swedish people have more of a tendency of planning, structuring, and making an action list before

solving a problem, whereas the Norwegians are usually quick in making a decision. The Swedish lose valuable time, while Norwegian are less organized and ending up taking a bit of a zigzag approach. Sothe managers perceived some differences, but generally speaking they saw no major problems. Fortunately, as for the business cultures in Sweden and Norway, they do not differ in terms of communication, time culture, and egalitarianism to a large extent according to both the theory (Gesteland 2013) and the interviewees. This might also explain why Hanssondid not especially prepare to handle cultural differences as they would probably do on other markets. Their focus on diversity in group composition and drawing on personal competences sufficed.Another crucial point is analyzing the organizational culture, which is decisive when accelerating the integration of the newly acquired company, as emphasized by Interviewee 3. Since the Hanssonhistorically has not encountered any major issues concerning cultural differences, it is hard to make an evaluation. Through their reasoning on cultural aspects, in the NorwCo and other cases, all three interviewees show a clear cultural awareness, common sense and cultural flexibility, but mostly mobilise national cultural understandings. In conclusion, having a *cultural mindset* is of high importance in both theory and empirical context.

4. Conclusions

This paper set out to primarily inquire into most prominent top management competences at a medium-sized engineering company doing an international expansion.Our framework of understanding came to encompass seven identified theoretically based competences,namely, openness to learning and change, strategic leadership, dealing with risk and contingencies, embrace and redirect resistance, synergy orientation, managing local responsiveness, and cultural mindset. We posit that some of these competences appear more like activities, and acknowledge that this is an inherited feature stemming from the literature. Our empirical work, using qualitative interviews, enabled us, first to characterise the conditions of the case company's acquisition process, especially the organisational integration. Secon, we identified three additional competences related to appointing qualified personnel, efficient communication and business mindset. We found that the degree of involvement from the top management in the expansion can be considered as somewhat low. This compares to our assumption that the smaller the size of the company, the higher degree of top involvement. Answering to our first sub-question the absence of certain competences is solved through external acquisition by the case company.The competences that are not possessed neither by top management, nor by the expansion project teams were acquired through external consultants or recruitment. Whereas desirable synergies are achieved through thorough short and long term preparations, with assistance from a person who can connect the right people via his network (regarding the second sub-question). Running the new unit, realizing the desired synergies and being able to connect the right people within NorwConsult was a great challenge for the new CEO, especially the organisational culture issues, hence the identified CEO competence of organizational culture. As for theissue oforganizational culture, itwas assumed that through learning and adaption, one automatically takes the national culture into account. Nonetheless, taking measures concerning national cultures is recommended.The findings contribute to the overall discussion about the role and influence that top management has on the success of the internationalization in consulting engineering.

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Culture clash and cultural confirmation: Swedish – Chinese encounters on a Sustainable building scene

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Abstract

Studies on globalisation often focus on large multinational companies and their strategic options for expansion. However, statistics show, that also small and mediumsized companies are increasingly able to internationalise and do so. In a construction setting this is often related to participation or even initiation of building projects. In particular, Swedish building companies have a potential competitive advantage in the booming market for sustainable building, energy efficiency and energy renovation. This paper studies two cases of Chinese sustainable building projects in the Beijing region where a small Swedish consultancy company participate. The main aim is to study how culture influence in two selected energy efficiency building projects involving Swedish and Chinese partners?The framework of understanding draws primarily on culture theory, yet also more indirectly on small business, organization and management theories. The method is based on interview and project documents. Interviews is done with representatives from Swedish and Chinese companies collaborating in two Chinese projects. One project is creating new office premises for a Chinese client, the other is a green hotel project. Both projects are designed, build according to EU green building norms and also eventually obtain this certificate. The projects are interrelated and can be seen as first a potential niche, second a (larger) market for the Swedish company in China.Cultural similarities and differences transcend national distinctions and extend into company cultures related to the companies' different roles in the project. The pattern found is thus more of a multiple configuration of cultures than a dual culture clash. Nation, company and sector cultures interact and certain culturally based interpretations serve to confirm existing understanding of sustainable building projects. It is discussed how small companies are constrained by their cultural ballast, cultural capital. They continually base decisions on situational judgment within frames posited by their cultures, limited resources and network dependencies.

Keywords: Culture, China, Sweden, sustainable housing, multiplicity

1. Introduction

To create sustainable buildings is an important component of the global mitigation of climate change. This in turn give rise to an equally global problematization of "how to" realize sustainable buildings and even the answers to this question is becoming a global trend due to a number of dynamics; sustainable building concepts and methods such as BREEAM and passive houses globalise, building material suppliers globalise, contractors do, etc. The Chinese market for building is the world's largest, and the anticipation is even considerable growth in the sectors of new commercial and high-rise residential buildings (Dodge 2016). The Chinese market for sustainable buildings mirror the global trend for sustainable buildings (Dodge 2016). Clearly this market will be attractive to large local and global players, that most likely will take their share. Howeverthere will also be much space left for smaller players due to the growth, fragmentation and differentiations of the market(EU SME Centre 2013). Small companies are to an increasing degree internationalising(SAERG 2014), yet it is a prevalent concern that they might run into many of the same barriers large multinationals have previously experienced. One important is cultural differences (Lewis 2006). The main research question is therefore; how does culture influence on cross country collaboration in two energy efficiency building projects involving Swedish and Chinese partners?It is important to study the contributions of small companies to sustainable building. Small companies can be agile carriers of innovative transformation in direction of more climate accountable solutions. When they operate, small companies in particular are dependent of their cultural resources, due to limited other resources. Through their network opportunities and dependencies, they continually must decide and act upon situational judgment informed by their cultures. This naturally impact on their ability to create sustainable buildings.

2. Theoretical framework

Culture is produced through the development of shared meaning (Gertz 1993). In building projects the joint production of a building also involves production of shared meaning and one can identify the footprint of cultures in realized buildings. Not only the projects but also companies, regions and nations are cultural arenas in the local and global building sector that contribute to the production, maintenance and even occasional disruption of cultures (Alvesson 2002, Coffey 2010).Alvesson, Martin and others argue that cultures can be analysed in an integration, differentiation and ambiguity perspectives (Alvesson 2002, Martin 2002). The integration perspective search for cultural elements that unites cultural elements in one common culture, or as Martin (2002) coins it, harmonious culture. The differentiation perspective appreciate and search for cultural element that are different, belongs to different cultures and are in latent or overt conflict with each other (Alvesson 2002, Martin 2002). The ambiguity and fragmentations perspectives looks for cultural elements in internal contradiction (Alvesson 2002, Martin 2002). This framework thus understand potentially rather complex cultural constellations (Alvesson 2002). In the following each element of this framework is presented.

2.1. Culture harmony

The integration perspective focus on the recurrent elements of assignment of meaning. In the corporate culture literature there is numerous strong proponents arguing for that a well managed company should be characterised by on coherent culture, enabling managers and employees to refer to common values and shared meaning and get this understanding continually confirmed (Martin 2002, Peters and

Waterman 1982, Schein 1992). Some of these contributions could be viewed as merely prescriptive, but the unitary relatively harmonious culture also surface as empirical result in more critical culture researchers work (Alvesson 2002, Martin 2002).

2.2. Cultures in conflict

The differentation perspective find cultures that involve distinct assignment of meaning to apparently similar phenomena in organizations. A culture might even be constituted in opposition to another culture, but can also simply be constitute by another social and geographical origin. Differences in culture are often referred to as a challenge in international projects (Lewis 2006, Mahalingam 2005, Zhang & Liu 2006). And they can be conceptualised through dichotomies. According to Lewis (2006), there exist three types of important national cultures globally, which are Linear-active, Multi-active and Reactive. He advocates categorizing the national culture in order to avoid the unnecessary offend caused by cultural distinction and also to predict different people's behaviors. It is argued that these differences impact on how people behave in their work and many other parts of the international projects. One can extend Lewis (2006) categories by usingGesteland (2013)'s, five dichotomies ofso-called "people's common behaviour":

- Deal-focused vs. Relationship-focused
- Direct (low-context) vs. Indirect (high-context) Communication
- Informal (egalitarian) vs. formal (hierarchical) Business behaviour
- Rigid-Time (monochromic) vs. Fluid-Time (polychromic)
- Emotionally Expressive vs. Emotionally Reserved Business behavior

Gesteland (2013) argue that national background would tend to determine where people's culture are placed in these dichotomies. The deal-focused culture built on believing in that trading exchanges will bond people. Relationship-focused people on the other hand are people who choose the people from their personal network of contacts to get things done. Relationship-focused people would tend to avoid doing business with "strangers". Deal–focused people are found in Europe, North America, Australia and New Zealand. Relationship-focused cultures are found in Latin America, Asia, the pacific region, most of Africa and the Arab world (Gesteland 2013). In both cultures the central assignment of meaning relates to the event of initial contact with a potential future business partner. In the deal-focused culture, formal introduction is not needed, the contact can be establish through "canvas" contact.The relationship-focused national cultures in contrast, would interprete is as necessary to go through an introduction, for example through other existing business partners that can act as a third party and recommender. And preferably the introduction should be a copresent one, rather than through telecommunication. After the introduction it is then instrumental to spend time establishing the business relationship. According toGesteland (2013), this explains why it apparantly takes a longer time for the negotiations in relationship-focused national cultures compared to deal-focused. The relationship versus deal dichotomy relates to the second dichotomy; direct versus indirect communication. PerGesteland (2013) it is one of the greatest causes of the misunderstandings; i.e cultural conflicts. Deal-focused people usually state their opinion without any implicit meaning, while representatives of relationship-focused culture would expressmeaning along with some implicit meaning by using the word "maybe" or "perhaps". Even the third dichotomy of hierarchical and egalitarian cultures links to the two previous. Hierarchical national cultures are globally widespread and include Europe countries, Asia, Arab World and Latin America (Gesteland 2013). In these cultures, showing respects and

addressing people formally is important. In contrast the egalitarian national cultures informal and direct addressing in interpersonal processes are appreciated. One fin egalitarian national cultures ins countries such as, Australia, Canada,Netherlands, New Zealand, Nordic countries and USA. In the two kinds of cultures, rigid-time vs. fluid-time, representatives have different awareness of time. In rigid-time cultures, Schedules are usually interpreted as fixed and punctuality is highly valued. Rigid time cultures can be found in Czech Republic, Germany, Hungary, Northern Europe, North America and Japan. On the other hand, schedules and time is interpreted in a more lax manner in fluid-time cultures. Which can be found such as Africa, the Arab World, Latin America, and southern Asia. Representatives of reserved cultures are more soft-spoken, and can adopt a mute attitude during a conversation, to allow others to talk. Expressive cultures are carried by people that attracks attention through raising voice to emphasize what they find are important points. They tend to enjoy lively and overlapping discussion and even be slightyuneasy about silent passages of the conversation. Reserved and expressive cultures are expressed verbal paraverbal and nonverbal bodily language, such as touch behavior, eye contact and gestures.

2.3. Ambiguous cultures

Cultural manifestations may occasionally be ambiguous. Due to differentiation or fragmentation of cultures in a domain, actors might interprete and perceive cultural expressions differently. This lead to a lack of clarity. Potentially, there are differences in meanings, interpretations of symbols etc., which are incommensurable and irreconcilable (Alvesson 2002). Moreover, in the continual process of creating and recreating meaning, members of different cultures might orient themselves differently at different times. This perspective can be ascribed an acknowledgment of the uncontrollable uncertainties that provide the texture of contemporary life. Alvesson (2002), however, warns against too easily assigning cultural phenomena to ambiguity. Thus pointing out that ambiguity might originate from social structures or social practises. When disussing the dichotomy of rigid versus fluid time perceptions Gesteland (2013) posits that some national cultures are “in-between” the rigid-time and fluid-time cultures, which opens up for ambiguity in the interpretation of for example how serious a schedule is to be tanen. The type of ambiguity is found in Australia, New Zealand, China, and Russia, most of East-Central Europe, Southern Europe, Singapore and South Korea (Gesteland (2013).

2.4. Multiple cultures in constellation

A lively discussion among organisational culture researchers, lead to an appreciation of rather complex coexistences of culture (Alvesson 2002, Martin 2002). National cultures active in organisations would tend to coexist and sometimes clash with local production of shared meaning according tonations, professions, gender, location (re one floor of an office building versus other floors). Alvesson proposes a multiple configuration as concept for this co-presence of cultures. He argues that cultural similarities, differences and ambiguities exists in complex patterns, and that these are contextually specific, thus departing from single conflict perspective as Lewis (2006) and Gesteland (2013)views cultural conflict through dichotomies. We therefore use the combined understanding of these culture scholars to inspire the case work in a relative open manner ex ante and even through revisiting the culture theory after having done a first round of analysis. Rather than pre-assuming that one type of culture would be the prevalent, we conceive as an empirical question.

3. Method: the art of the possible

The framework of understanding builds on an interpretive sociological approach appreciating a strong empirical orientation. Our understanding draw on organization theory of culture, and indirectly on small international business, supply chain and. In line with the research question the focus is on cultures in multinational construction project and the theoretical framework combines several culture conceptualisation (Coffey 2010, Gesteland 2013, Lewis 2006) tied together by Alvesson (2003) multiple constellations of culture framework.The paper built on research carried out by (Li & Zhao 2016)and also draws on Koch et al (2017). It relies on and extend previous collaboration with the Swedish SME Deltate. This particular piece of research included several aspect of two energy renovation project in china involving a Chinese Swedish collaboration. The two cases were selected out of four collaboration project carried out by the Swedish -Chinese partners. The two case was selected because they are the most recent. For this paper, we selected the cultural aspect for a more focused scrutiny.However the study also looked at how communication, risk, cultural and stakeholder management interplay with culture. Insights and results from these other elements of the study was also used in this paper.For the empirical material we selected one of two cases studied in (Li & Zhao 2016), because the cultural aspect of this case was particularly interesting. We use the other case as background and contribution to our analytical framing, although we do posit that the case is a single qualitative insight in a particular constellation of cultures (Alvesson 2003).Data collection was carried out by two of the authors. Initially pre-research and informal interviews were carried out to develop the research question more. A document study of project documents were carried out. Material documents from the case projects were provided, includes case project tender, contracts, design, work emails, and all necessary relevant documentations. This providedan overview of case projects to defiled case projects' information. The authors have went through all those materials to have a comprehensive understanding of the case projects which is base for interviewing and for analyzing the case projects. Further, continual communication was kept withtwo reference case project manager in Sweden and China for necessary answers of questions. In an early stage this was also a part of preparation for the interviews.The key players of the case projects, representing the main stakeholderswas selected for interviewing. Most of them was interviewed,some of them on skype, but due to practical circumstances it was not possible to interview the clients and main contractor of the case projects. the themes of interviews were, in line with the studys main themes, information on the two projects, the interviewees role in the project, the relation between stakeholders, communication, stakeholders, risk, knowledge transformation, and culture. Two interviews, The one with the project manager from DELTAte and the chief architecht from BCKJ, the small architectural design firm, was evaluated as particular important, and was transcribed, whereas information from the other was feeded direct into the analysis. The analysis of culture, which is the focus here drew on all elements of the interviews. The case analysis also drew on the theoretical framework of understanding literature review.When writing up the case study we allowed ourselves to mix more overall with more detailed information to provide sufficient content for our analysis. It can be viewed as a type of "zooming in and out" as recommended by Barrett & Barrett (2003).It is a limitation for the study that it has not been possible to visit the Chinese players involved in the studied projects. Neither was it possible to interview the clients or the main contractors of the projects. Especially with a cultural issue study this is an important limitation, and does underline that also this research is the art of the possible. We have attempted to utilize that the author group encompasses two Chinese and one other nationality author.

4. The Hang Xing project

DELTAte is a small Swedish consultancy company. BCKJ is a small architectural design firm in China. DELTAte's rolein the Hang Xing project was to provide the indoor climate system design solution with BCKJ. The Hangxing Technology Center project is a Chinese energy efficiency building project located in Beijing. The Hangxing Technology Center project is realising a new office building for the owner Hangxing Machinery Manufacturing Company. BCKJ is responsible for the building's architectural and HVAC system design. The new office building of Hang Xing Technology Centeris at 33.500 m2, and it was the first project to aim at obtaining an EU green building certificate in China. The project organization consists of a project manager(from Sweden), two engineers (Swedish),Three consultants, one Chinese. Another project manager is Chinese and based in China. Further personnel in China is twochinese HVAC engineers. The only player placed in Sweden were DELTAte (service provider). The players in China were Hangxing Machinery Manufacturing Company (client), BCKJ (service provider), Construction Contractor (contractor), Construction Site Workers, HVAC Engineers (supplier), Nokia (building user), IBM (building user), Beijing Planning and Construction Bureau (regulation agency), Beijing Architect Design Institute (regulation agency). A more peripheral player is the European green building council (regulation agency).The overall process went through three phases: Design and construction, optimisations and operation, In the first phase of design and construction, the project applied for European Green Building certification to the European Commission. BCKJ was responsible for the primary material preparation and explanation for the application to the EU. DELTAtewas in charge ofthe EU application of the Hangxing office building, including related consulting work and translation of text. The second phase focused onoptimisation, where adjustments was made on the completed building to improve its performance. Here the consulting project group provided services on energy controlling, adjustment and optimizing ventilation, heating and cooling systems of Hangxing Technology Center. The third phase is the operation. The building's power management was in this phase operating through remote controlling of ventilation, heating, and cooling systems. When operational problems occurred DELTAte specified solutions to these. Zooming in on the first phase, the Hangxing project commenced with a one week workshop in Sweden.Dongmei (the China project manager) and three other employees of BCKJ came to Sweden for this workshop, also making a study visit trip. Assembled at the workshop the project group discussed how to mitigate the climate challenge of buildings in China and how to design a ventilation system combining a natural ventilation system with a fan ventilation system. Being knowledgable of Chinese building regulations Dongmei as the design manager and the HVAC engineers became responsible for translating the ventilation system design to fit with the Chinese quality standard, whereas Deltate more gave input on the technical solution possibilities. After the workshop, the Deltate and BCKJ teams workedin parallel in Sweden and China, each on their part of the project. Project coordination was mostly handled withemails, but also with an online conference system meetings and telephones between the two project teams. One member of the Swedish team was Chinese and became responsible for the communication as he spoke both Chinese and Swedish. The communication with emails worked well and as intendedaccording to the interviews. But neither of the teams had access to communication with the site workers. This turned out to be an important impair in the collaboration. The Chinese site workers were not able to read the drawings and they made some mistakes during the building. There were not many instances interpreted as culture differences between Swedish and Chinese primary partners of Deltate and BCKJ during the project. Rather one important challenge was to translate the design to comply with Chinese regulation. The Chinese design manager had the responsibility for this and met with the local government administration authority to explain

the design. At the time the Hangxing buildingproject was the first to apply for the European green building certification. The process resulted in that the building was successfully certified with the European green building certification. The most important challenge for the project group was the interaction with client. The future users of the building,belonged to future renters of office space and the client and building owner did not manage asatisfying communication. The project group interpreted it as and issue of the communication between the building owner, the future company tenants and the tenants' employees (the end users). The representatives of the end users of the premises denied the acceptance of the indoor climate system. They did not trust the system, they preferred the old indoor climate system and wanted to substitute the new with the old system. As this issue grew in the interactions and became more negotiationlike interaction, the project grouptook the position to refuse to change "anything" that was designed previously (interview), a position which rendered the building owner unsatisfied. As a result, the building owner refused to do the project follow up work when construction was finished. Thus, the design team was blocked in carrying out the project follow up planned for the optimisation and operation phase.In the Hangxing project the project manager from design side plays a significant role in the project process. Even the indoor climate system has been designed by the consultant to comply with the European green building and Chinese requirements. The project management had to explain and answer all questions from and to the Chinese regulation agencies that involved in the project since it was the first time the two set of requirements were used together. Further, the client was not familiar with the design either. So the design project manager also needed to negotiate and explain the design to the client. The design must fulfill both the client's needs and the regulation requirements. Moreover, there was a lot of design details that effected the product result. In the construction process, the contractor needed to work carefully on it. Client's customers (building user) made the process very challenging because they did not trust the design. Thus, the project manager from Chinese side has a lot of extra work on professional communication and interest mediation.

5. Ding Xiang Gu Green Hotel Project

Ding Xiang The Dingxianggu Hotel project is located in the Beijing Badaling forest. The project includes hotel rooms, service center, and the entire area's planning and design. The hotel facilities are mostly made of wood and can be used in the all four seasons. Dingxianggu Hotel has European Green Building Certification for the hotel part, but not the service center. The customer is Badaling Tourism Company which is a local government organization. The project was made jointly by DELTAte and BCKJ Architects. The project group was also joined by an HVAC engineer. The project idea is to create a smart, comfortable and eco-building model for China with EU green building standards. This means to have good air tightness and insulation performance, especially use recyclable building materials; To increase energy efficiency, use of renewable energy and reduce CO2 zero-emission; to use organic waste and energy systems with the solid waste and waste water recycling system will re-use by-products. BCKJ was responsible for the project's space design and planning with DELTAte. DELTAtewas only involved in the project's early design and planning phase to provide general solutions for the whole system. BCKJ is responsible for more detailed solution based on DELTAte's technical suggestion and calculation result.The project started in 2013. The BCKJ representative linked up with the DELTAte representation and established cooperation because the customer of Dingxianggu Hotel also wanted to get the European green certification like the aboe described "Hangxing" project. The location was special, the customer wanted to build the hotel that made of wood and can be used in the all four seasons, and kept good capacity. At the same time, BCKJ and DELTAte also cooperated

on another project in Sichuan. In Dingxianggu project the cooperation was in two parts, one was the integration of the systems, the same as what has been done in Hangxing project, DELTAte designed and BCKJ completed and adjusted based on their design. DELTAte did all the calculations and some initiate designs, then BCKJ did the equipment and external piping design. Another part was to get the European Green Building Certification for the hotel part, not including the service center or any other building in the valley. The whole process was pretty smooth. They did not face so many issues in this project. Based on the interview, the communication through email work well as other project they have done together. With the experience from the first project "Hangxing" not much other issues appeared during this project. Dingxianggu project has already got the certification even if the project is not completed. Deltate did not need to take responsible for the delay of the project because of the financial problem between the contractor and the customer.When it comes to professional communication and interest mediationthe same situation occured in Dingxianggu project as in Hangxing. The positive part is that the client trusted the design and had a better communication with design project management which made the process more smooth.

6. Discussion

The theoretical framework posits that similar (integrative), different and ambigious cultural characteristics and behaviours between the Swedish and Chinese parts of the project should be analysed. This is done in three similar steps. By analyzing the two cases, the cultural characteristics of players, Chinese and Swedish, could be categorized based on Alvesson (2002), Lewis model (2006) and Gesteland (2013). We carry out this analysis across the two projects as they were closely related.In an *integration perspective*, the consultants, engineers and architects draw on similar understandings, shared meaning on what a building design collaboration between engineers and architects is about. The intersections between engineers and architect in building design involve well-known opportunities and challenges and also well-known processes. This culture cuts across national differences.Moreover although Swedish and Chinese are from different continents, they still have some similar cultural practices, based on the feedbacks from case and interviews. When either Chinese or Swedish building professionals, as in the cases, are seeking for cooperation partners, professionals from both national cultures appear to value two aspects, namely the relationship and working abilities. In these regards, they have similar features. This result relativiseGesteland (2013)'s characteristic of Sweden and China as being dealbased versus relationshipbased, which can be due to the more long term B2B relation necessary when designing, building and operating buildings.Moreover also the rigid time and emotional reserved aspect appear as commonalities between the two culture in play here (see table 1). The latter occurred as in the projects both parties experienced difficulties expressing direct refusing proposals. Saying "no" was difficult, but for different reasons. Following Gesteland (2013) Chinese usually hide their emotions during the communication, while most Swedish like to show their feelings and emotions. However, based on the interview feedback, interviewees mentioned that Swedish also start to hide their feelings in the meeting, thus behaving in more emotionally reserved manner. In a *differentiation perspective* one can first, refer to table 1, showing our interpretation from the cases inGesteland (2013)'s dimensions of the cultural behaviours comparison between two national cultures shown below. As noted about we find less differentiation on the deal-relationship dichotomy than Gesteland (2013) expects.

Chinese culture	Swedish culture
Relationship-focused & Deal-focused	Deal-focused & Relationship-focused
Indirect communication	Direct communication
Formal business behaviour	Informal business behaviour
Rigid-time	Rigid-time
Emotionally reserved	Emotionally reserved & expressive

Table 5: Comparisonbetween Chinese cultural and Swedish cultural behaviours in Lewis dimensions

We find some differentiations on personal characteristics between the participating Chinese and Swedish. According to Lewis (2006), Chinese belong to the reactive culture, which implies that Chinese people would tend to exhibit features like quiet, introvert, patient and respectful. These are traits we also find in the two projects. Swedish (including our project participants) are more oriented towards the linear-active culture, which for example implies less hierarchical organizations and work practices. Observing the direct/indirect dichotomy, Chinese are used to use implicit words or indirect communication during the conversation, while Swedish prefer to communicate in a direct way. Further, as hierarchical cultural people, Chinese people regard using formal business behaviors as important during the cooperation, while Swedish prefer informal business behaviors since they belong to a flatter culture. These dichotomies can thus be said to have been found in the two projects.Neverthelessthe differences between the various chinese players involved in the project turned out to be more prevalent in terms of differentiating cultures, even in a conflicting manner. Based on the study of two project cases, an interesting phenomenon had been found. According to the interviewees' responses, the cultural difference Sweden /China was not regarded as the hardest part to handle in the two projects. Unexpectedly, they mentioned that the communication among different stakeholders or cross-professional culture issues were much more difficult to control than the communication between different countries. Take Hang Xing project as an example, one of the cross-professional culture issues was the project client refused to allow architects and design consultancy to execute the project follow-up activity due to different value prospects and insufficient communication during the whole project. Conversely, although the cross-national issues indeed existed in the project, they did not make any serious effect on the project itself. As result, the issues between stakeholders were mainly from insufficient communication and inadequate stakeholder management. Different national culture did not cause more problems than the professional culture, and different national culture background had fewer effects on project processing and project result. The professional culture here including professional skills, information transformation, and green building standard specifications, etc. had considerable influence on project's success. Further, responsibilities between stakeholders were not clearly defined at the beginning of the project. And various stakeholders *did* have different interests in both projects. To understand their interests and balanced their interests was also important.Collaboration between client and his end-user, with construction workers and more,thus showed some typical differentiated culture elements for Chinese construction, what is often called fragmentation in studies of the industry (Chih et al 2016, Gao and Low 2014) and even comparable to other countries' cultural fragmentation in construction (Coffey 2010). Moreover this even runs counter to findings on project culture in the Chinese building industry (Zuo et al 2013, 2014). Zuo et al (2013, 2014) finda number of integrative elements across players, yet also point to some mechanisms for why fragmentation might occur in

projects. Zuo et al (2013) thus point to that their interviewees valued project success and relation to the client higher than relationships with the rest of the project team, due to the strong role of the client in the Chinese market.When it comes to *ambiguous* cultural elements, there were also some cultural behaviours or personal characteristics that were ambiguous and hard to be clearly categorized. On the relationship to time, Swedish were significant more strict in this project context. Chinese also have a rigid time attitude. But unlike Swedish, there can exist some flexible changes on their schedule, which was only reluctantly accepted by the Swedish in the projects. This contradicts however how Swedes in other building project might operate considerable time flexibility and might be explained by the intercultural setting and the insecurity that produce in terms of assuring the progress and timely finalisation of the projects. Such ambiguity troubles too easy interpretation of differences. When it comes to the fragmentation and different cultures between companies and actors in the project, this is moreover a reminder of the risk of confounding structural differences of interests with cultural differences. In the present research set up we are not able to however, to distinguish one from the other.

7. Conclusions

The main objective of this paper was to inquire intohow culture influence on cross country collaboration in two energy efficiency building projects involving Swedish and Chinese partners. The theoretical framework drew on Martin's and Alvesson's advocacy for integrating several culture conceptualisations, including (unitary) corporate culture, complex multifaceted organisational cultures and differentiated international cultures using the approach of multiple constellation of cultures. The most important resultwas that cultural differences, clashes, in the Chinese supply chain of companies were more important than national distinctions Sweden-China, thus replicating experiences of fragmented building processes elsewhere. The cultural pattern is thus indeed more of a multiple configuration than a dual culture. Even if it difficult to underpin this in a two project case study it appears that nation, region, company and sector cultures does interact also here. Certain culturally based interpretations by the participants serves to confirm existing understanding of sustainable building projects, the rules of the game on this scene. Putting these results in a wider perspective one can observe that small companies that internationalizein particular are dependent of their cultural resources due to limited resources. Through their network opportunities and dependencies they continually have to decide and act upon situational judgment informed by their cultures. The small Swedish company emerge into more projects in China. The authors studied two of them. The two sustainable building projects followed each other in time and can be seen as steps towards further encounters, making a niche for the Swedish company in China. Thus transforming them to more permanent contributors to sustainable buildings in China. As such, also in China, they can draw on their experiencesof fragmentation in building process.

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Small players - large challenges -energy plus renovation of public housing in small towns

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Abstract

Public housing is often built in large quantities and in concentrated areas. The original focus on cost efficiency represents a challenge of creating sustainable buildings in contemporary society. Large portfolios ofbuildingsneed renovation appreciating future demands of energy consumption and economic, environmental and importantly social sustainability. New energy producing renewable technologies represent an important opportunity to meet these challenges.However, apart from the dominant agenda of large companiesin suburbs ofthe larger cities in Europe and Swedish towns, a series of small public housing companies exists which have parallel challenges, but receive far less attention from institutional players such as government authorities, researchers and policy makers.

The aim of this contribution is to analyse challenges and opportunities of doingenergy plus renovation of small public housing companies in Sweden and to develop a possible roadmap for meeting the challenges.The theoretical framework draw on organisation, management in construction, political science and economics and energy renovation literature to conceptualise small organisations characteristics, and building processes of renovation.The empirical material has been done in collaboration with one company, literature study and interviews over a period of a year.The results show that the limited resources of small public housing companies can be tackled by providing extra manpower in the purchasing process and further in the renovation process. And by purchasing, organising and using a network for knowledge, including energy producing and energy saving technologies. If the rental is to be kept stable, it requires a new financial model for the public housing company. The roadmap developed in the project for doing energy plus renovation is presented, involving all phases of purchasing, design, building and operation. It involves systematic participation of tenants. It is structured in seven main phases to support the roadmaps role as a tool.

Keywords: public housing, social housing, renovation, energy plus, small towns,

1. Introduction

A large number, some 200, small public housing companies, with less than 2000 apartments each, are operating important parts of the existing building stock in Sweden (SABO 2017). In Gothenburg, as in Sweden in general, these buildings are in a state of suboptimal energy performance (Mangold 2016) and the renovation of them is a big challenge, also regarding costs (Lindén, 2015). Ambitions of creating energy plus buildings adds to the complexity. Many places in Sweden energy renovations has led to an augmentation of rent. There is a risk that this leads to gentrification and social exclusion. One central explanation of these unbalanced results lies within the complex character of the renovation processes. To operate them demands up to date professional competences and practical experience from all parties;owners/developers, architects, engineers and contractors. Especially parts of the building situated in rural areas of Sweden pose a huge challenge for their small owners, the public housing companies. If municipal politicians and public housing companies are to be successful in these renovations a new and innovative methods should be adopted. Adding to this complexityis the contradictionsin the legal governance. The new legislation from 2011, governing public housing companies demands that a public housing company operates commercially creating turnover and profit. Moreover, it is supposed to act as independent subsidiary with standardized market (Blomé, 2012). Focus of this paper is the many small municipalities and theirpublic housing companies, which is working within the new legal governance but with less financial and managerial resources compared to the larger companies around Gothenburg, Malmö and Stockholm, which after all only constitute 17 out of 300 public housing companies nationwide (SABO 2017). This leads this paper to pose the following questions:

What challenges and opportunities are commonly addressed by the smaller public housing companies whilst executing a renovation program aiming at energy plus performance?

What kind of actions are feasible in anenergy plus renovation process?

The second main question further leads to the following sub-questions:
1) How to manage relevant knowledge that strengthen thepublic housingcompanies' role as client in the renovation process?
2) What content should a strategy have, when to be usedby a small housing company in order to create a driving force and willingness for collaboration between all stakeholders?

The notion of public housing is used to represent the Swedish model for public housing, where public housing companies are supposed to lever a general social responsibility of providing accommodation for less fortunate members of society and where these companies are owned by the municipalities and from 2011 supposed to create profit (SABO 2013, Wahlström et al 2016). This type would internationally also be called public housing.

Energy plus performance of a building is understood as a building that produce more power than it consumes (Dávi et al 2016). To realise that, there need at a time be alowenergy consumption of the building and some kind of energy production (Davi et al 2016).

The paper commences with developing the research method. Then the theoretical framework of understanding is given. Method and theory is aligned to respond to the main questions of the paper.

Two major sections answers to the main questions of the paper, through identifying challenges and opportunities and addressing how these can be tackled. Also, the second section contains a presentation of the roadmap guiding smallpublic housing companies in energy plus renovation. The paper then ties the elements together in a final discussion and a conclusion.

2. Research Method

In order to answer to its main objectives, it draws on research on organisation, management in construction (Bresnen 2007, Kadefors 2002, Lu et al 2008, Nyström 2007), political science and economics (Blomé 2012, Lind 2014) and energy renovation literature (Alhourani and Saxena 2009, Davi et al 2016, Granderson et al 2016). Literature searches have been carried out to understand and conceptualise the notion of a "client", "energy plus renovation", "energy renovation building processes", "procurement", "collaboration" etc. The empirical part has been developed in a partnership with one small public housing company starting autumn 2015 and during 2016. The company plans to renovate one settlement with 160 apartments distributed on 8 building blocks typical for the Swedish "million program" (Johansson 2012). The collaboration was supported by the Swedish Energy Agency. This collaboration travelled through a series of dialogues and common analysis, using the settlement as a thoroughgoing orientation point. To add to this collaboration, we did nine interviews with experts with knowledge of municipal companies implementing energy renovations andthe installation of energy producing technologies. Assembling this material made it possible to identify a few central challenges and develop a strategy depicted in a roadmap. It is a limitation that our research has been carried out with one public housing company mainly. However, this can be seen as a condition of possibility as the collaboration enriched the project with knowledge of the challenges and resources of small public housing companies. We consider the study to be exploratory. This paper draws on Koch & Lutteman 2017.

3. Theoretical Framework

The theoretical elements juxtaposed to respond to the aims of the paper includes a conceptualisation of characteristics of small building clients, facing energy renovation and other challenges and the corresponding needed building processes. There is a paucityin the literature on small and medium sized building clients, which is even more outspoken when it comes to small public housing companies. We therefore draw on literature on small and mediumsized companies assuming that small building clients in many ways can be compared to other SMEs, includiing building SME.This approach posits that small building clients, as SMEs, they lack internal resources, they have an informal internal organisation (Hardie 2010, Lu et al 2008, author reference) and energy renovation is an area were these organisations have limited experience(Alhourani and Saxena 2009. Granderson et al 2016, Schleich and Gruber 2008). They therefore, as other SMEs, need to build and maintain external networking and they need to procure competences such as client advisers.Energy plus renovation is moreover not only an issue of learning, which derives from the limited experiences, but also a process of making choices. Making choices is understood as intra- and interorganisational politics and the building process is thus a political process (author reference, Pettigrew 1985). Formation of strategy is moreover seen as an issue of manouvering in a paradox of deliberate versus emergent strategizing (De Wit and Meyer 2010). This is taking issue with many conceptualisation of building processes, characterised by instrumental rational thinking and linear stepwise phase models (an example is Sutt 2011). Moreover, a recurrent, albeit often implicit, assumption is also that a building client have endless resources. Such approaches

thus tend tounderestimate the importance of iterative search processes, and the role of latent and overt differences in interests in and ideas for renovation. The public housing company for example should do an early choice of the form of contract for the procurement of the services needed for renovation. Normally clients opt for either a design-bid -build, design-build or partnering contracts (Bresnen 2007). Design-bid-build can be understood as an instrument for handling risk as it provides the client with a clear milestone in the process separating design and production, this mean negotiating time and resources in two steps. Design-build and partnering contracts in turn make it possible to involve the contractors' competence in the design phase, and controlling the cost through negotiating the building sum (Sporrong and Kadefors 2014). The recommended framework for the strategy of the public housing company is, despite the critique above, constructed as a phase model, because this provides an attractive order of the activities and recommendations. The model can be understood as an organized repository supporting a learning and decision process which is expected to be meandering (see figure 1 below).

4. Challenges and opportunities

There are three important challenges to be addressed, which in turn can be understood and developedin opportunities: The dialogue with tenants, collaboration with partners and legal issues related to energy use.

4.1. The dialogue and collaboration with tenants

The public housingcontext is characterised by a central role of the tenants, who's codetermination is a central value for the Swedish variant of social housing. Energy renovations is no exception for this (Friesen et al 2012). Nevertheless,there are examples of The Swedish Union of Tenants along with local tenants have raised issues and influenced renovation projects in processes that could be interpreted as unnecessary delays. Such experiences emphasise why many housing companies have engagedwith the tenants and given them a strong influence on the renovation process. Contrasting to this there are examples of renovations where the interaction has become so fruitful that tenants themselves became the main driving force, which is the perspective of organised co-determination.Giving tenants the opportunity to choose the level of renovation standard is a mean to make the tenants be a part of the renovation process. This kind of engagement from the public housing companies can be interpreted as paternalistic management glitchto get a smooth and efficient renovation process. There is indeed a need to strike a balance of involvement and influence versus the overall needs of a renovation process. Thus, there is a risk that public housing company management engage in a zig zag course due to the contradictions of this issue (De Wit and Meyer 2010).

There are indeed tenant dialogues that have proved to work. On those occasions it has for example been a key person who have had special knowledge and skills to manage the tenant dialogue. If the company does not have such a resource available, a tenant dialogue run the risk of being counter-productive instead. Through a fruitful tenant dialogue, it is possible to reach binding compromise agreements in which representatives of the public housing company, the procured contractors together with the local tenantsagree on the renovation projectabout costs, future rent, quality and time for the energy plus renovation.

4.2. Collaboration with building professionals

Coordination and collaboration in renovation has at a time a central role and has often proved to be complex. One challenge relates to that due to the set of competences needed, different partnersget involved in different phases, making transition from phase to phase and its coordination and knowledge transfer crucial. To transform these challenges to opportunities, the method of "partnering" can be used as inspiration (Bresnen 2007). At the core of the partnering concept is the focus on a good collaborative teamspirit in a building project. Following the concept initially means that theclient/developer and the contractor agree to work together for a common goal and where the risks and benefits are shared in a organised manner through a written agreeement. In the renovation processes it is important to create practices that establish and maintain personal relationships and trust. To strengthen the collaboration, it is a good idea to establish procedures for conflict solving, and to do this in the beginning long before any tensions arises. Alsokeeping an eye on achievement of common goals, can be done be setting monitoring activities in place. Collaboration should aim at two different objectives accommodated with monitoring. The first is measurable goals related to the project's economy, energy efficiency of the buildingsand/or social betterment of society. The second is objectives on how the stakeholders in the projectact and behave in their interaction. This can include goals for responsibility, how much information one should share with each other or targets on how to improve cooperation. Partnering cooperation objectives and procedures should commit all persons with central roles in the planning, design, construction and maintenance. This includes project managers, craftsmen, the client/developer representative, the owners and the public housing company management, the clients counseller and other consultants (Kadefors, 2002).Several other supplementary approaches can be used. One is "open books",where participating companies and parties openly share their accounting on the projects. This provide insight for each participant in the partnership, trust and frank dialogue. Another is to agree on and incorporate incentives in the collaboration contract. The incentive can be financial targets attractive for contractors and consultants and motivating them to work more efficiently and more rational to receive bonuses or share of profits.Moreover, sharing of losses can be foreseen and become a mutual responsibility. There are thus many attractive aspects of partnering. In an actual renovation process, there might however be barriers that blocks for using partnering. It is therefore important to "extract" the main advantages of a collaborative team environment, which can indeed be created under several forms of contracts.

4.3. Legal and financial barriers for energy efficiency?

Law, finances and burocracy are complex challenges that often appear to create barriers in renovation processes. Technical options for reducing energy consumption and creating efficiency comes at a cost and needs to be legally compliant. The building code of Sweden exhibit trade-offs between the requirements on emergency exits, ventilation requirements andother technical aspects which in some cases stands in the way of the most energy efficient solution. In such situations, it is important to understand and collaborate between administrators and stakeholders within the municipality so that the right technology is selected with respect to legal aspects. Moreover, the cost aspect need to be aligned with financial frames derived from factors such as discount rates and depreciation.This alignment is about setting monetary figures into the investment calculations which is the base for evaluating future profit and success of the project (Johansson, 2012, Lind, 2014, Lind et al. 2015). To achieve set goals within a renovation the small company will be faced with various choices and trade-offs. It is the final goal and mission set by the developers along with the chosen time horizon that governs the size and

type of the investment trade-offs.The following six factors should be considered: first the social responsibility of the municipality, the property's tenants and in principle the municipality's population) (Lind et al. 2015). Second laws, regulations and directives that govern the company's properties. Third environmental responsibility regulated by the owners and the state. Fourth the discount rate that is controlled by the internal and external market factors. Fifth depreciation requirements iscontrolled by the timing aspect of choosing the investment horizon(Byman and Jernelius, 2012). Sixth evaluating in qualitative or monetary terms the improvements coming from investing in soft social values, assuring that they are assigned with the right weight in the decision processes.

5. How to manage challenges and pursue opportunities -strategy formation

Three main elements of a strategy is prevalent for obtaining an energy plus renovation of public housing in a small company, and small town context: organising knowledge, ensuring forwardgoing dynamics and following a road map.

5.1. Organizing knowledge to strengthen the developer role in the procurement

Small housing companies need to organize, evaluate and use knowledge in and around their organization. Vertical and horisontal cooperation and transfer of knowledge between the different stakeholders throughout the renovation process will have a positive effect on the efficiency of the process. It should be organized in such a way that there is an on-going communication about issues regarding construction, energy, value and cost. The creation of knowledge and its subsequent incorporation in solutions must be done jointly, also drawing directly on practice at an early stage of the renovation process (Author reference). Evaluating quotes during tendering is not only a value and cost concern but also involves knowledge aspect related to various techniques that should be compared, while also assessing the skills of contractors and designers. The procurer who acquires the ability to combine their own skills of assessing technical aspects in combination with contractor's ability and at the same time can enhance cooperation throughout a renovation process and reinforce the client as a strong and robust procurer. Alsoa certain amount of strategic thinking is needed (Author reference).It is important as client to define energy demands that are achievable. There must be specified margins of energy so that contractors will be able to meet the requirements. If the client does not set reasonable standards it could mean that important tenders fail to be submitted, or that it provides room for future conflicts that lead to higher costs. It must be that clients understand the principle of give and take to reach their own goals. It is also important to create specifications which clearly defines the requirements that must be measured *after* the renovation is completed. The skills of contractors should be examined. An excessive focus on the lowest price in the tender evaluation is however counterproductive towards incentives for cooperation and business opportunities (Bresnen 2007, Kadefors 2002). And ability to cooperate, teamwork, and a good track record are all factors that will beat a low price. By understanding and knowing the Public Procurement Act,(the Swedish law is derived from EU-directives) the client can in a procurement situation gain an advantage. A well-informed client knows how to strategically use the knowledge in a tender and procurement process (Sporrong and Kadefors, 2014). The performance factors of contractors can be checked using track-records of past performance.The public housing company must be up to date on the industry's energy requirements and allow investment in internal and external training. Contemporary knowledge is a basis for thinking in new and different

ways. One proposal is to co finance and recruit clients who have a long track record of working with these issues within other municipalities. Contracts is a means for sharing risks and opportunities. It may be better with positive signals about future profit motivation than to threaten with punishment and sanctions. Add incentives of increased profits through further agreements if, and only if, certain requirements are met. By posing relatively high requirements early it is possible to shortlist contractors. It is important that this exclusion is done in the right way according to the Public Procurement Act. Some important parameters that are measurable in such exclusion criteria might be historical data on the number of complaints that remain after the final inspection. The length of reference projects for completion, the amount of delivery of projects on time and the number of penalties for delays. These figures can be demanded from the interested contractors, and supplemented with secondary information from elsewhere.

5.2. Ensuring progressive dynamics

As all other projects, the forward going, progressive dynamic is a key success factor for renovation projects. Since many different players are normally involved in a renovation project, it is important to capture opportunities, overcome barriers and anticipate delays andhandle misunderstandings that occurs along the way. To maintain and enhance the progressive dynamics in the project the following core areas can be emphasized:

• Promote and enable political decisions from owners that can frame the work and that gives as clear information as possible about the size of the renovation budget for energy savings and size of resource allocations.
• Complete and clear goals and plans for where the housing company is heading.
• A completed climate plan for the property portfolio at a general level has been shown to increase the likelihood of implementation of energy-saving measures when carrying out renovations.
• An environmentally profiled building standard in the municipality on which the housing company can lean on.
• Make sure the issue and topic of energy renovation has been well established among officials and politicians in other parts of the municipality departments. This is particularly important when testing for building and other permits, and resources needed by the officials.
• Strive for clarity in the internal project team about what to do, and what the conditions are. To achieve this, the group should have conducted a feasibility study of the renovation project to conditions, limitations and resources are well known. A joint basic philosophy and thought about working in the project is a strong basis.
• Strategic thinking. The person in charge of the project andofficials from the public company, should in detail identify, and adopt, the established rules, objectives and possibly recommended procedures and tools stemming from the municipality and from the housing company. In this strategic manner, general goals and project goals can be aligned.
• It is important to either have, or try to create, motivation of employees in the project. A good way is to teach themselves and others in the project to understand so many different parts as possible in an energy renovation / energy efficiency.
• Identify and contract a client'scounseller. A person who is knowledgeable and experienced in the many different areas prevalent in a building project and who possess the ability to absorb new information can make a critical difference for a small public housing company. The person should also be able to create alliances and networks and preferably have a large existing network including within

and adjacent and similar municipalities and public housing companies.Also, confidence building characteristics and the possibility of swift change of action are central.

Regular follow-up meetings on milestones, following both measurable objectives and value creating targets, reduces the risk of distrust of management and other partners. Moreover, regular meetings can be used to adjust and create new common goals and incentives. As mentioned a partnering agreement would include such incentives where the profit from the cost savings are shared per agreed metrics. To create a collaborative framework, raise proactively issues such as ethics, morality and discussions on conflict resolution and meeting culture (Nyström, 2007). Some important points are: (1) Determine together the procedure for handling early signals of conflict. (2) Establish procedures within the renovation project that will feedback to the projectleader in the event of deficiencies or breach of goals regarding soft values within the project. (3) Create routines for how to register and manage defects, such as thoseof materials, installed or no installed, without pointing out or blaming persons or contractors. It is important to clarify the difference between practical / physical errors and other values-related issues so you can distinguish between practical issues which need a solution and personal or organizational issues. (4) Create a shared document that describes in detail how the parties should manage, solve and act in the execution of objectives, targets, and potential conflicts. Make these routines reciprocal between the stakeholders in a continualtwo-way communication. Execute workshop to formulate a partnering declaration that express the agreed vision of the project which all participants sign. The aim is to create a moral obligation to work towards the common objectives and to do this by some predetermined norms and attitude, respect, trust, openness and honesty. It is important to stress values such as good communication and mutual support(Kadefors, 2002).

5.3. The strategy roadmap

The strategy road map is proposed as a tool for the smallpublic housingcompany when acting as a client and developer. It is organised in structured phases, like pearls on a string. This is however due to usability of the road map as a “to be” tools. The renovation process is likely to occur different, but still with many of the activities as shown in figure 1.

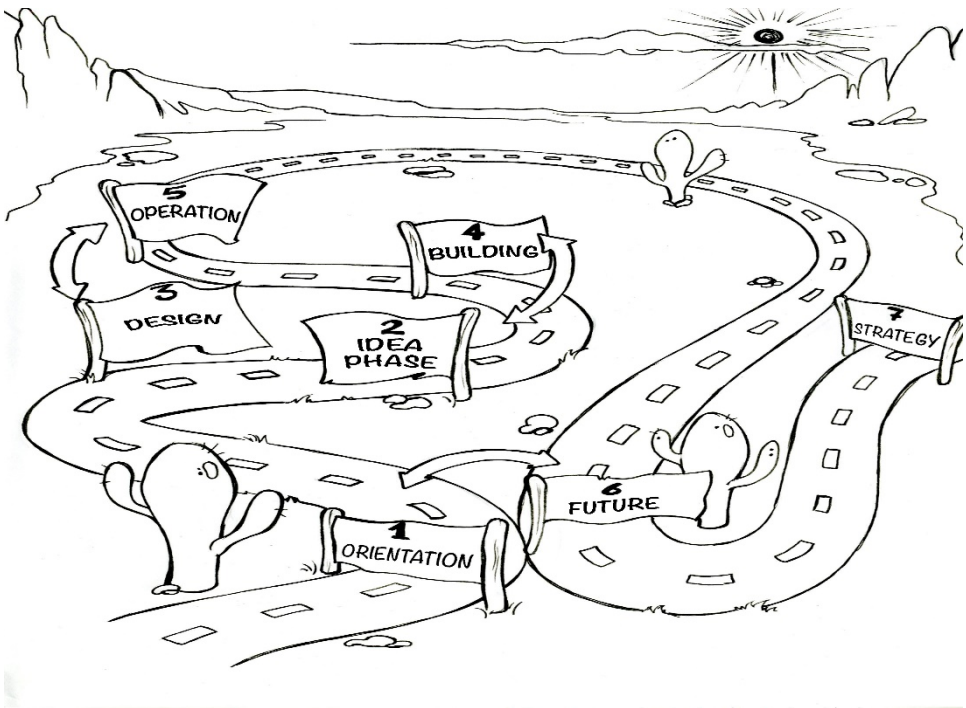

Figure 5: An envisioned roadmap "as is" (own development)

The seven suggested phases are: *Phase 1* orientation, which is the initial future and strategy oriented activity (illustrated by the double arrow) *Phase 2*: Ideas, survey and development of projects: This phase involves working to produce data needed to make a renovation plan. In this phase it is important to find out what purposes the renovation will have. It also includes to point out what financial and practical resources exists and in what physical condition the property is in. *Phase 3*: Design, planning and tendering phase: In this phase one should evaluate techniques and requirements in detail. Project together with architects and engineers go through different specifications, requirements and design proposals. The evaluations will be the basis for system documents containing details of design, materials, systems for air and heat, and possibly other energy systems. *Phase 4*: Building and implementation phase: In this phase the renovation is carried out and implementation of energy-producing technologies. The work is driven through the renovation fase based on a detailed planning and control plan. Various energy-producing technologies are being installed. Throughout the practical renovation a variety of checks on contractors, planners and subcontractors are being carried out. *Phase 5*: Operation and maintenance: Operational phase work begins with trying to optimize the property and all newly installed energy producing systems.It is through inspections of the property´s systems several years after an energy renovation that faults and errors has been found and the goal is to make the running time as long as possible. In addition, this is a delicate phase in which there is a risk that the skills, knowledge and other important staff can be lost in the transition from the completion of the operational phase. Two further phases*Phase 6 and 7*, is added for future strategy placing the single renovation process into the future work of the public housing company.

6. Discussion

The results of our collaboration with the small public housing company show that the limited resources of such companies are indeed a major challenge. It is therefore difficult to transform this situation into one of opportunities. It also became clear over 2015-2016 that small and mediumsizepublic housing companies in Sweden do struggle inparallel and that few have taken the steps into the future of

sustainablepublic housing. It was difficult to find experiences to draw on. The challenge of keeping low resource tenants is also considerable and should be mitigated through developing a new financial model enabling the rent to stay stable.To assure the process the small public housing company need to organise extra manpower in the purchasing process and a network for organising knowledge, identifying energy producing and energy saving technologies for the renovation.

7. Conclusions

This paper had two main objectives related to small public housing companies doing energy renovation. First what challenges and opportunities would the companies meet whilst executing a renovation program with energy plus ambitions? Second what kind of actions is feasible to in such a renovation process, when looking at how to manage knowledge in order to enhance the public housingcompanies' role as client in the renovation process? And what kind of strategy can be adopted considering owners demand, legal and bureaucratic processes and collaboration between all stakeholders? The challenges we identify, answering the first question is the dialogue with tenants, collaboration with partners and legal issues related to energy use. These also constitute the opportunities.Answering to these challenges, exploiting the opportunities and thereby responding to the two questions we suggest to systematically organise knowledge to strengthen the clients and to form a strategy here presented as afour-step roadmap.The collaboration with the tenants should be a constructive collaborative process. We also emphasize the need to enhance skills of the clients in relation to negotiations with contractors and consultants.To improve energy performance through renovation of the existing building stock is a highly important societal issue to mitigate the climate challenge. Much public and semi-publiceffort in Sweden rely on large players, but smaller playersneeds more attention if Sweden's contribution to EU and UNpolicies of energy efficiency are to become comprehensive.

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Sweet tooth, soothsaying or serious business? Forecasting the building activities in a town area

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Abstract

Urban developments are in many ways in a continual tension between fragmentation, dispersion and controlled plans and many actors, with vested political interests are contributing to these tendencies. The building industryare interested in, have an appetite for growth and/or at least maintaining their share of the upcoming building projects. The Gothenburg area, with some 1 million inhabitants, are no exception to the above characterization. Numerous plans and developments are flourishing, and in the debate, actors state from 78 to 125 million euros in investments in infrastructure, new public institutions, dwellings and housing etc.

The aim of this paper is to generate a forecast for the needed manpower given the planned building activities in the Gothenburg area. And to critically scrutinize the context, the method and the results.The paper's conceptual framework build on approaches to forecasting urban, industrial and labour market developments. The paper describes these different approaches, with different scope and conceptualisation of the dynamics. We take issue with forecasts building on implicit linear prognosis, with their inbuilt modern ideology, and introduce concepts of fragmentation, dispersion and emergence to better account such elements in our forecast.The material for the paper comes from a collaboration with the local industry. Generating the forecast encompasses a host of methodological challenges. Triangulation of other previous investigations were used and these adopted different concepts and scope in time and geographical area. A critique of the value of the gathered material and our own platform will be carried out. Are even this forecast merely an expression of the local industry's taste for growth, which come to represent a candy for them?

The result shows a very considerable need for new manpower over the next ten years. Using combined forecasts the calculation reach estimates between 17 and 25,000 new employees per year. A large uncertainty mirroring the shaky basis of the forecast. The contributiondiscuss mitigation strategies which include education, mobilizing refugees, and global sourcing. When taken as serious business the local community with all its players have work to do, if the region is to live up to demands of future welfare society.

Keywords: Urban development, Gothenburg, labour market, forecasting

1. Introduction: Gothenburg as a magnet

Sweden is amongst the most concentrated countries in the world, with 80% of the population living in urbanized areas (UN 2014). Most of the population lives in southern Sweden and three urban areas alone, Stockholm, Göteborg and Malmö, account for 38% of the population. Only Stockholm are constituting a city (Economist 2013), but Göteborg and Malmö are large urbanized areas (Economist 2013). Nevertheless, these urban areas are growing steadily. Gothenburg is thus expected by urban planners to grow from 1,1 mio to 1,3 mio in 2035 (GöteborgStad 2013). Even if such a demographic development clearly is a prognosis, the expectation matches that of a range of other urban areas (UN 2014). A growth in building activity has followed. In 2015 the turnover in the Swedish building industry grew with 8% (STD 2016). For a local building community of building industry players and other involved stakeholders, with their political agendas and interests, this constitute a burning platform, a strong driver for change (Kotter 1987). However, it is also a pleasant type of condition that gives appetite for growth, and even profit hunger, i.e. the sweet tooth. But how can an urban area like Gothenburg tackle such challenges? Thus, this paper come to ask:How much are to be built in Gothenburg the coming years?,What resources will this demand?, How much resources are available? The aim of the paper is therefore to generate a forecast of the needed manpower in the light of the planned building projects and activities in the Gothenburg area. The local building community consist of a range of players building project developers, clients, architects, consulting engineers, contractors, real estate companies, government institutions, education and research institutions, professional associations and consultants. Thus when the questions is asked on behalf of this community the interest is very much how many headcounts in terms of architects, engineers, carpenters, plumbers, electricians, civil engineering workers etc. will be needed, compared to how many are provided into the local labour market.The study was carried out under the auspices of the Center for management in Building (CMB) a joint industry- research association financed and governed by predominantly industry. This organization initiated a productivity think tank in 2016 gathering industry representatives from first architects firms and consultants (roughly 10 representatives), and second contractors (roughly 2 representatives). The authors participated in the meetings of the think tank and developed the forecast discussed in this paper. This paper follows a classical structure. Commencing with a framework of understanding combining approaches to forecasts of urban development, industry development, and labour market development, problematizing the content, assumptions, basis and differences of most forecast. Second a method section present our approach to developing a forecast. The discussion than develops the implications of the study, reaching the conclusion.

2. Framework of understanding

Our main research question asks for a framework for doing a forecast, a conceptual understanding of a combination of urban development, industry development, and labour market development. Forecasts in these three areas feature shared features, yet are also different. Forecasting are formalised projections of the future, that are approximately right (Vanston 2003).

2.1. Urban Development

The development of an urban area is constituted by many contradictory social dynamics. Urban planners are only in partial control of this development (Flyvbjerg 1987). Usually competitive city dynamics are very strong (Choe and Roberts 2011, Economist 2013). This can be understood in terms

of main factors like the economic strength, institutions, human capital, the physical capital (infrastructure), and financial maturity (Economist 2013), and to a lesser degree, also involve the global appeal, social and cultural character and environmental hazards (Economist 2013). Most forecast of urban development adopt economic growth as value (UN 2014), and tend to view urban development in a linear fashion, which exhibit a recurrent modern ideology, which socially constructed character can be illustrated by studies showing the opposite; shrinking cities (Wolff et al 2017). Sustainability trends are far more peripheral (Ghahramanpouri et al. 2013). Forecast of urban development often involve implicit or explicit assumptions and estimations of industry and labour market development. An urban area is an ill defined unit also in terms of delimitation, yet many studies appear to not view this as problematic,- think about the phenomenon of urban sprawl (Hamidi& Ewing 2014). This leads to the observation that the study delimitation relate to social boundaries given by the client mandating such forecast.

2.2. Industry development forecasting

Industry forecasting has a very long history, and a plethora of approaches exist (Asplund 1979, Chambers 1971). Forecasting are carried out on a number of levels and scopes including regional industry sectors. Also here one can get the impression that delimitations are institutionally defined by target groups and clients for the forecast. When it comes to the building industry market, the project based character of investments, design and operation is moreover posing special challenges. Moreover extensive mobility is a long exercised tradition and transport means to realise it almost the central piece of equipment.Forecasting is also under continual scrutiny and criticism (Vanston 2003). Vanston (2003) outline a continuum from quantitative linear or other mathematical projections to pure qualitative approaches. Linear and other projections as well and qualitative based approaches frequently tend to rely too much on predicting the future through mapping the past. Harty et al (2007) echoes these criticisms in their study of thirteen construction futures projects. Forecast of industry development often involve implicit or explicit assumptions and estimations of labour market development in the studied industry sector.

2.3. Labour market development

Also within labour market development studies a plethora of approaches exist. The labour economics approach seeks to understand the functioning and dynamics of the markets for wage labour with a neoclassical approach the functioning of markets (Becker 1993). According to this approach labour markets is based on the interaction of employees and employers. Labour economics study this interaction between the suppliers of labour services (workers), the demands of labour services (employers), and attempts to understand the resulting pattern of employment (and price mechanisms for labor). An alternative approach “human capital” (Becker 1993) study the skills that employees possess, not necessarily their actual work and propose dimensioning of educations to assume balance between demand and supply.According to Boswell et al (2004) projections was then derived from forecasts of the workforce and expected flows from the education system. Labour demand and supply were then compared to derive projected gaps, and these were used as a basis for readjusting education policies. Boswell et al (2004) point to systematic theoretical, methodological and data collection problems in these approaches such as an underappreciation of the complexity of labour market development.What is also missing from most labour market analyses is the role of unpaid labour as well as non declared work (moonshine). This include unpaid internships where employees with little

or no (recognized) experience are allowed to work a job without pay so that they can gain experience in a particular profession. A system that become prevalent in economies with large groups of non included immigrants. Even though this type of labour is unpaid it can nevertheless play an important part of integration mechanisms and labour market development. Forecast of labour market development often involve implicit or explicit assumptions and estimations of industry and regional development, bordering to urban development forecasts.

In summary forecasting models or urban, industry or labour market despite their differences in focus and scope are overlapping and share features such as linear assumptions or perfect market assumption. They are weakened by their systematic erroneous predictions (Asplund 1979, Boswell 2004, Vanston 2003). Their modern ideology fits poorly with a social entity like a city, an industry or a labour market which all tend to develop in a fragmented, emergent manner and with vague boundaries. We therefore revert to a method based understanding combining existing forecasts, which is a well-established approach levering trustworthiness (Armstrong 2001, Batchelor, & Dua,1995,Clemen, 1989) and using an appropriated scenario technique (Wang and Lan 2007), where labour demand growth is set in three different estimated relying on available data and prescriptions, rather than trying to develop a theory for the combination of urban, industry and labour market development. And we use triangulation between studies carried out with different approaches (Armstrong 2001).

3. Method: Gothenburg as a Gelly Fish

To answer the main research questions we have used a combination of desk studies of major important reports in the areas of Gothenburgs urban development, its construction industry development and the building sector labour market. We have combined these desk studies of the reports with a series of interviews with experts in these areas.A main methodological challenge is to delimit the area of study. Given the mobility patterns of both citizens and building sector companies and professionals, both demands for buildings projects and their impact on employment is not easy to delimit geographically. Yet most studies and statistics actually operates on this premise, i.e. that spatial delimitation is possible. We label this phenomenon “Gothenburg as a gelly fish” since the phenomenon appear to equally difficult to crasp and have equally fluid boarders with the sourroundings as gelly fish.Fourreportsbecame central for our argument: *Report 1*. Investeringskartläggning, Göteborgsregionen fram till 2035. (investment mapping Gothenburg region to 2013, BRG 2016). This report maps the regions planned building projects from 2016-2013 with a size larger than 1 mio SEK. This is predominantly based on the employers association SBI analytical unit’s work, which continually publish forecast for building investments (see report 3 below), but also on interview with a series of local players.The mapping and calculations are done by Swecos mandated by Business Region Gothenburg (BRG), a publically owned consultancy firm. The main aim for the report and for BRG is to inform the sector and the politicians of Gothenburg of future challenges. The report uses the geographical delimitations of a ”labour market region” defined by the national agency for statistics SCB. In terms of municipalities this includes Gothenburg, Falkenberg, Varberg, Kungsbacka, Härryda, Partille, Öckerö, Stenungssund, Tjörn, Orust, Ale, Lerum, Vårgårda, Bollebygd, Lilla Edet, Mölndal, Kungälv and Alingsås. This study is a combination of industry development forecasting, and urban development forecasting referring to our categories in the framework of understanding.*Report 2*. Näringsliv och Tillväxt 2015, Analys och utmaningar för tillväxt i Göteborgsregionen, Business Region Göteborg (Business and Growth, BRG 2015).In this report the Gothenburg region is extended to the entire West Sweden. This implies that the growth figures estimated are reduced compared to the labour

market region definition (around 10% BNP/capita), according to the authors of the report. This study is an urban development study.*Report 3*. Fakta om Byggandet, SverigesByggindustrier (facts about building, SBI 2015).This report covers the entire Sweden. It is an annual report from The Swedish Construction Federation, representing contractor employers. It is made by an internal analysis unit, that continually follows the building sector's development both nationally and regionally. They gather information through the member of SBI and their network. This is an industry development study. *Report 4*. DenFramtidaPersonalförsörjningeninomByggochanläggning, tillgångochrekryteringsbehov till år 2015 (Future personell supply with building and civil engineering, supply and recruitment demands, AMS 2002).The report builds on national statistics. This report is made by a national government body, the agency for labour market (arbetsmarknadsstyrelsen AMS). The body was reorganized in 2007. It contains calculation on productivity and invested million / employment ratios. This is a labour market development forecast.Complementing these four reports, several further has been included, notably Josephsson (2013) which is a project by project productivity study with dwelling and office buildings. The large number of projects studies and their geographical dispersion allow Josephsson (2013) to calculate differences in productivity in different parts of Sweden, including the greater Gothenburg area.

Four main *interviews* have been carried out. One with representatives from Gothenburg City municipality, the office for urban development. Second an interview with a representative from UCI, a consultancy company owned by Swedish municipalities and social housing companies. Third a representative from SWECO, a large engineering consultancy company,involved in report 1 (GBR 2016). Fourth a professor in real estate economics from Royal Technical University in Stockholm.Apart from formal interviews, also further informal dialogues have been carried out with representatives of the National agency of statistics, SCB, The Swedish Construction Federation, SBI, and a series of other actors and experts related to the sector. The informal dialogues was used to further the understanding of elements of the methods and calculation used by the experts, typically upon studying the forecasting reports.

The main method in the calculation on resource demands builds on several calculation methods in combination and a combination of data. This means first triangulation of results from reports, second from data and third extending this with material from the interviews (Rothbauer 2008).

As interviewees was predominantly authors of the reports mentioned above, the interviews could be actively used in sharpening the use of the reports. Through dialogue and discussions with the authors we have attempted to incorporate some extra factors in the key projections. This include issues such as development of productivity, efficiency, cost increase within manufacturing.The planned investments are here mapped through appreciating project by project plans of the urban and building community. From planned investment in buildings and infrastructure a calculation is made on how many man years is needed to realised these investments. Here productivity is central and we draw on Josephson (2013) and AMS (2002) to do so. Finally, we use three growth scenarios to increase the trustworthiness of our estimations. By considering variation and limitations in validation of the figures, calculations and reports we hope to increase the result credibility. Moreover, doing estimations of the future should involve margins and several development trajectories rather than just a single unilinear prognosis (Harty et al 2007).Our approach inhibits many*limitations.* We inherit this from the reports we use as basis, including the large uncertainty. At a time, our combination, triangulation and scenario approach increase the trustworthiness of our argument (Armstrong 2001). In a sense our limitations can and

should be compared to other forecasting and projection studies. Some of the main limitations are: first elasticity of the building market and the related labour market. Citizens and Building sector professionals are prepared to travel long for projects and employment. Second the Competition of adjacent towns and cities (Stockholm, Oslo, Copenhagen) are not in calculated. Third the impact of migration is not calculated, Swedish studies do evaluate this as marginal (Engdahl 2016). Fourth the impact of illegal labour is not discussed. Studies made before the 2015 wave of migration calculated this to be 9% of the Swedish building sector turnover, not estimating "do it yourself". Fifth the output from educational institutions is not considered (Boswell et al 2004). One interviewee did note that the AMS (2002) study failed in its prediction of this output and that impacted on the construction labour market up through the 2000nds.

4. Developing the forecast

The geographical delimitation made refer to the labour market region of Gothenburg. Which is Gothenburg municipality and 17 neighbouring municipalities as discussed under method (report 1, BRG 2016).The first step in the analysis was to develop a compilation of planned building projects in this region. (GBR 2016). The horizon is until 2035.Sweco includes renovation in the compilation, but as Mangold (2014, 2016) provides a far more detailed estimation of the renovation needs in the municipality of Gothenburg, this estimate is extended to the larger Gothenburg area studies here and juxtaposed with BRG(2016). Sweco point at a series of civil engineering works; Trafikverket plan, Gbg. City, roads plan (2025) Gbg. Harbour, new built, Landvetter new built. The next step is then to transform these planned projects into need of labour. The approach uses is "created work per million invested krona". Each project area involves different productivity. And also, each area of Sweden does (Josephsson 2009). When it comes to new built of houses, dwellings and the like Josephsson (2013)'s figures for man hours per new built squaremeter was used triangulated with the AMS (2002) report and SCB (2012). This cover the categories of "new built general", "industrial new built", commerce new built, office, new built, hospitals and health care new build, public Schools new built and university new build. With respect to offices, Josephsson (2013)'s figure for offices is used.

Table 6:Planned Investment projects 2016-2035.

Investment projects	Total annual Investment Mio SEK
New built general	400
Renovation	55
Swedish Transport Administration plan infrastructure	70
Gothenburg City, roads, (2025)	32
GothenburgHarbour, new build	8
Landvetter Airport, new build	7
Industrial new build	17
Commerce, new build	14
Office, new build	58
Hospital, healthcare	30
Public Schools new and renovation until 2035	24
University new build	9
Total	724

When it comes to renovation (estimated to 55 mio. by Sweco),Josephssons (2013) figures for cost is used in combination with Mangolds (2014). From Josephsson (2013) is extracted figures for work hours per finalised squaremeter, which is then combined with data on the total volume of dwellings that need renovation (Mangold 2014). Together it creates an estimate over future needs for labour at renovation and new built of buildings.Concerning civil engineering works, figures from the AMS (2002) estimations and the railroad project the east link (STA 2012). This latter report contains estimations for cost of civil engineering works on overhead bridges, track support bridges, tunnels as well as the railroad tracks (STA 2012).This estimation of man years employment per invested million is used on the mapped projects of "Trafikverket plan", Gothenburg City, road, (2025), Gothenburg. Harbour, new build in the airport Landvetter, nybyggnation. In several of these reports, mappint or estimations are done on the need of different types of human resources, white collar and blue collar.Josephsson (2013) thus provide figures of the relation between white and blue collar man hours and square meters builtThis lead to the following basis calculation in table 2. These figures can be compared to that in 2012 there were 55.000 employed in the building sector in the "VästraGötaland" region, and 38.000 in Göteborg plus 18 sourrounding municipalities. The latter is the area geographically closest to the one uses for the prognosis.

Table 2: Labour Resources needed 2016-2035.
STA is Swedish Transport administration. Gbg. is Gothenburg

Investment projects	**Total Inv.**	**New employm./year (2015-2035)**	**Blue collar**	**White collar**
New Build general	**400**	11317	9507	1811
Renovation	**55**	3451	2899	552
STA plan	**70**	887	745	142
Gothenburg City, road	**32**	871	731	139
Gbg. Harbour new built	**8**	226	190	36
Landvetter, airport new built	**7**	198	166	32
Industrial new built	**17**	481	404	77
Commerce, New built	**14**	396	333	63
Office, New built	**58**	1641	1378	263
Hospital, health care	**30**	849	713	136
Schools 2035	**24**	679	570	109
University new build	**9**	255	214	41
Total	724	**21251**	**17850**	**3400**

4.1. Growth Scenarios

A number of factors will impact on the actual development of a local building sector. One thing is a planned investment of buildings and infrastructure and another is actual execution of the projects. The financial conditions might change, the prices of materials and human resources might change etc. we there develop three different growth scenarios to encalculate such factors in the prognosis:*Scenario 1. Recession*: The sector and the society does not enjoy the investment tempo foreseen above and/or various bottlenecks such as lack of competences, poor integration of migrated labour and the like. This adds up to that few or fewer building projects are started och demand on human resources and materials drives wages and prices up reducing the profits. According to economic theory a BNP growth on less than the "normal" 2% growth leads to a recession in employment with about minus 1% per year. We

estimate that in the Gothenburg building context would equal a level of 500 billion SEK investment volume in the period 2016-2035(one billion is one thousand million here).*Scenario 2. Normal:*The sector realises a status quo, a zero growth. This occurs for example because society to a certain extent handles a flow of investments and mitigation of the bottle necks. Productivity improvement are occurring but might be neutralised by less pensioning and exits from the laboutmarket than entries leading to a zero growth of employment. We estimate this normal, medium scenario of investments at 750 billion SEK 2016-2035.*Scenario 3. Growth:*The sector realises a high growth. The society supports with competences, human resources, and a growth promoting governance framing. Investments grows and the sector employs a classical work intensive production with less emphasis on productivity improvement. Moreover positive international developments implies that Sweden shows higher BNP and the employment grows with +1 % per year. We estimate this to investments at 1200 billion SEK 2016-2035.Table 3 show the three growth scenarios and their employment effects:

Table 3:Three scenariosand their employment effects 2016-2035

TotalEstimatedEmploymentEffect	**Total/year (2015-2035)**	**Bluecollar**	**White collar**
Basis calculation	**21251**	**17850**	**3400**
Scenario 1, -1% growth	17381	14600	2781
Scenario 2, 0-growth	21251	17850	3400
Scenario 3, +1% growth	25930	21781	4149

5. Discussion

Our predictions of a future investment volume between 70 and 125 million euros and a recruitment need of between 17,000 and 26, 000 in a region of around 1 million inhabitants and 55,000 employees in the building sector is clearly a very positive one. At least it reflects a very positive spirit among the urban and building community players. As one noted“it is like the happy sixties have returned” (interviewee in BRG 2016, p4).Evidently such a result immediately lead to the mobilization of skepticism and healthy criticism. Nevertheless even taking the result at 50% does asks for serious interventions. We discuss that below. The mobilization of scepticism and healthy criticism also “almost always” lead to criticism of method and underlying assumptions. We have thoroughly attempted to clarify the limitations of our exercise, but the bottomline is that we have adopted many of the same methods frequently used in forecasting and added triangulation between the methods. It has often been attempted to reduce forecasting to pure soothsaying (Asplund 1971, Harty et al 2007). Nevertheless the discipline of forecasting of urban development, industrial development and labour market development enjoy a well embedded institutionalization in society and to entirely disregard the results is not what leading players such as policy makers would normally do (Boswell et al 2004). And they even find their way into many types of research.Quite the contrary it appears that a series of the building community players in Gothenburg are taking the previous forecasts that we use here quite serious (even if their broader receipt and appraisal is not studied here). The employers association, SBI and Business Region Gothenburg, thus generate forecasting on a continual basis, and in these years they take character of sweet tooth, a type of prediction one would like to have more of.The forecasting results thus invite reflections on necessary interventions. We have methaphorically spoken about Gothenburg

as a gellyfish (Swedish “manet”) and as a magnet. So the handling of a need for Gothenburg to recruit between 17 and 26,000 would probably go through these types of interventions: Inland recruiting, foreign recruiting, the education system, basic and vocational, aborting building projects, improving productivity.*Inland recruiting* might be carried by the attraction effect, the magnet, of Gothenburg. As the demographic investigation show a considerableinflux every year one can hope for that this also involve building sector professionals that settle down in the area. Second the inland recruiting can be through companies otherwise mostly operating in neighbouring areas (such as for example Karlstad, Jönköping) would be attracted by the offers of the Gothenburg building market and start operating here.Finally the present unemployment among Swedish young adults should be mentioned.The *foreign recruiting* is more of the gelly fish argument, that present invisible boarders and delimitations in the building market will be broken down. Foreign companies have already for several years been encouraged by the development of the building market in Sweden and sought to establish themselves here. This goes for architects, consulting engineers and contractors. Second individual professionals especially from Eastern Europe has developed into a significant factor. Third as a smaller possibility, virtual collaboration means that architectural and engineering services might be done elsewhere on the globe.The *education system* might be ”geared” to contribute with more skilled peopled. This goes quantitatively with more educational places, but also with new offer of basic and vocational education also tackling the needs of newly arrived migrants and refugees. Improving the *productivity* in the building sector should also be considered even if present and past performance does not invite it.Developing and implementing new technology such as robots, IT and industrial method. New forms of organization, incentives and management and even restructuring the capital units of the sector into more integrated ones are all attractive examples.For cynics, predictions like the ones developed in this paper is merely a fetish for those doing them. Some previous “prognosis” makers we interviewed claimed that nothing had happened after their own prognosis had been launched. It is quite likely that the building industry will continue its “high noon” practice meaning that only in the last minute before a project becomes realized will companies consider recruitment and new methods. Actually, as a counter to this possibility Boswell et al (2004), i.e. literature on implication of foresight outside the building industry point to the risk of “self-destroying prophesy” of any predictions: if policy-makers, employers, the labour force or other stakeholders adjust their decisions on the basis of forecasts, then the outcome will diverge from what was predicted (Boswell et al 2004:19).Another reflection is that macro-economic research would often claim a causality between infrastructure investments and societal growth. These effects are dependent of specific circumstances and it is sometimes claimed that the effect is smaller in mature and developed economies like the Swedish.

6. Conclusions

This paper set out to study how an urban area like Gothenburg can tackle challenges of urban growth, in terms of buildings and infrastructure.Thus the paper asked:How much are to be built in Gothenburg the coming years?What resources will this demand?And how much resources are available? Our frame of understanding draw on urban development, industrial development and labour market development studies. Even if many previous studies of this type exist, they still suffer from theoretical, methodological and data collection issues. We therefore adopt a combination approach, where method and result triangulation is used to calculate the estimation of future growth in building projects and their impact in increased employment.Based on a compilation of reports and a series of interviews, we established a calculation method using triangulation and growth scenarios to develop answers to the research questions. We developed three growth scenarios with investments of buildings and

infrastructure spanning from 500- 1200 billion Swedish Kronar, equal to 70 and 125 million euros covering 2016-2035. We calculate this to equal a span from 17,400- 25,900 extra employees per year compared to an employment in the region at 55,000 employees in the local building sector.This kind of prediction tend to operate as a pleasant confirmation of the building community's desires and give appetite for more. But we have argued that predictions are more than just sweet tooth. Moreover, criticisms of methods of forecasting trying to reduce it to mere soothsaying is after all missing the point. That one philosophically can point to fundamental flaws of predictions should not lead to complete dismissal of doing forecasts, but rather introduce a healthy criticism and adjusted appraisal that can transform it into a serious business.

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Homines Oeconomici or Moral Saints? On the Purpose of Educating Civil Engineers

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Abstract

Understanding one's own role as a professional – and the role of one's profession – within society at large is crucial for good conduct and practice. The ambition of this paper is to address 1) how we can envisage how to develop the reflexive capacity of students of Civil Engineering to undertake critical scrutiny of their own practice and, 2) to what extent are Norwegian civil engineering students are educated to incarnate such a reflexive capacity today. The main basis of the research consists in a content analysis of the formalized guidelines governing the education of Civil Engineers at the Norwegian University of Science and Technology (NTNU). In addition to a scoping literature review, insights from theory on what constitutes a profession and the role of professions in general were used as analytic tools. The findings indicate that limited attention is given to transmitting the understanding of the role the students are to fill in their professional lives. Even less attention is given to actually articulating such an understanding. Particularly interesting, however, is the limited attention given to considerations of a more principal nature concerning the ability to transcend (in a positive manner) the limits within which one normally operates. The research carried out has implications for the organisation of the education of Civil Engineers in general. Equally, it highlights concerns that professional bodies within the field ought to examine in order to carve out a thorough understanding of the role of the Civil Engineer in society today.

Keywords: content analysis, engineering ethics, construction industry engineers, education

1. Introduction

In Fraggle Rock (a children's puppet television series created by Jim Henson), three anthropomorphic species form most of the action: Fraggles, Doozers and Gorgs. The Fraggles and Doozers live in a system of natural caves called Fraggle Rock. Outside Fraggle Rock lives a small family of Gorgs, farmers with a rustic house and corresponding garden patch. Fraggles are considered pests by the Gorgs, as they often steal radishes from the garden of the latter.

Fraggles live a generally carefree life, spending most of their time (having a thirty-minute workweek) enjoying themselves. They live on radishes and the material the Doozers construct. Not surprisingly, these colourful nonconformists constitute the main attraction of the series. Doozers – small, industrious beings – are in a sense anti-Fraggles; their lives are dedicated to work and industry. Doozers spend their time busily constructing throughout Fraggle Rock, with an edible material greatly enjoyed by Fraggles.

In episode 6 of the first season (February 14th, 1983), this order of society is threatened. One of the main Fraggle characters, Mokey, decides that on moral grounds it is not proper for Fraggles to eat the constructions the Doozers work so hard to build. Disgruntling, the others Fraggles accept this, with hunger and discontent amongst them as a result. The consequence of this policy being enacted is predictable. With Fraggle Rock being limited in space, and both supply of construction materials and the endeavour of the Doozers being limitless, the space available for construction is soon occupied.

The interesting part here concerns in effect the Doozers. Whilst the Fraggles live as artists and small-time pinches, parasitic if charming idlers and dreamers, the Doozers resemble to a large degree professionals of the AEC-industry, incarnating high levels of production output and lean construction capabilities. When their manner of existence – that is, constructing continuously – is put under strain, however, they are paralysed. How can we understand this?

One striking characteristic of the Doozers is the *automaticity* of their work. It is not that they do not carry out formidable work – anyone having seen the TV-series will remember astonishing bridges and other constructions defying the law of gravity. Neither does there seem to be anything blameworthy in their work procedures. The Doozers are highly competent, efficient and with a strong focus on HSE-aspects of their work. Still, this does not seem to suffice when put under strain by radically altered framework conditions. In other words, they lack the capacity to transcend the limits of their habitual manners and ways of work.

The idea we pursue in this paper is that what the Doozers actually seem to lack is a proper sense of their function within society that surpasses the idea of solely constructing, and that it is this lack of understanding that render them vulnerable to the consequences of Mokey's new policy. They are, so to speak, "doers" without a reflexive capacity (that is, a capacity for meta-cognition wherein their own manners of action are judged) sufficient to assess the higher-order (that is, moral in a broad understanding, including norms, values and unspoken rules of behaviour) sense of their activity and therefore unable to tackle the new situation they are left in. The example of the Doozers is evidently caricaturised *ad absurdum*; still, it resonates with strings observable in the community of professionals of the AEC-industry. What more is, it seems to resonate with how civil engineering students are educated within the Norwegian context today.

Whilst their ability for construction is strong, the reflexive interrogation on the reasons for one's activity (based on the impression of the authors) seems in fact to be scarce among students – as is the case with the Doozers. They are (educated to be) builders; therefore they build. It is the opinion of the authors of this paper that a university ought to guide its students towards an understanding of higher-order sense of their professional role – that is, moving from being purely technicians to being conscious members of a profession with certain inherent ethical standards. How and in what form this happens today is, however, far from evident and little investigated. Consequently, the research questions we address in this paper are:

- Of what nature can we envisage the higher-order sense (that is, moral in a broad understanding) that enable students to surpass the state of Doozers-to-be?

- How is the need for understanding this higher-order sense reflected in official university documents outlining the goal of engineering education?

First, we outline two extreme (yet quite common) figures of thought that can be envisaged as constituting a possible framework for such an analysis of higher-order purposes. These figures of thought are both taken from the field of ethics, notably the "homo oeconomicus" and the "moral saints". Further, we explain why none of these figures of moral thought in the larger sense seem adequate as guiding principles, and outline why insights from virtue theory better can serve. Finally, we propose to show the limits of an explicit purpose for the education of the students (and outline a reason thereof) as it appears from the governing papers of the NTNU (Norwegian University of Science and Technology). The NTNU is by far the most significant actor in educating Masters in Civil Engineering in Norway, as approximately 80-90% of all MSc-students within this field are from this university, thus making the NTNU the very cornerstone of the professional ethos of the profession.

2. Research Methods

The methodological approach of the research behind this paper was twofold in nature. First, a scoping literature study of general literature was carried out in accordance with the procedures described by Blumberg et al. (2011) and Arksey and O'Malley (2005). Secondly, a content analysis of the university's formulation of outputs, goals and purposes for the education of civil engineers at NTNU was carried out according to the procedures outlined in Krippendorff (2013). The overall ambition of the methodological approach has thus been to elucidate the formal (written) guidelines governing the education of MSc-students within the institution.

3. Theoretical Framework

In the literature, the state of the Doozers is typically described as so-called moral blindness. By this is understood a state of unawareness or insensibility to moral issues pertaining both to oneself and to one's relations to others (Bauman and Donskis, 2013). The utter lack of understanding of the why's of their actions – being essentially occupied with the how – indicates that the Doozers are unconscious of their function within a larger whole. The question of understanding one's function within a larger whole is fundamentally of an ethical nature, since it implies a demand to understanding how to behave in society.

Understanding the why of one's actions is, in fact, crucial to attain what Mirsky et al. (2014) maintain as the most important topic to the future of the AEC industry, notably "honourable, professional practice" (Mirsky et al., 2014:vi). Recent years have witnessed an increasing interest in the field of applied ethics in general and in professional ethics in particular (Christoffersen, 2010). Different professions establish rules and regulations, and the number of publications is ever increasing. The authors of this paper have so far not seen this trend reflected strongly in publications concerning the AEC industry in general and engineering students in particular. As Walker (2014) comments, "[t]here is a dearth of papers related to ethics in PM even though the PM discipline should maintain a strong and enduring interest in ethics to encourage project managers to deliver value in a more holistically manner that is consistent with being a member of a profession". This (ethical) understanding of being a member of a profession of the AEC-industry ought particularly to be felt by engineers. According to the literature review leading up to the research presented here, codes of conduct (ethical frameworks) do in fact exist (amongst which from the PMI, RIBA, AIA, ASCE and IPMA); such codes of conduct are, however, typically general in nature, and tend not to take practical moral challenges into concern. This is particularly grave, considering that, as Bredillet (2014:548) comments, "the underlying ethical approaches supporting the field, and consequently the practice, have immense impact". Notable exceptions from this general statement include the writings of Bowen et al. (2007); Bröchner (2009); Collier (2005); Corvellec et al. (2010); Fellows et al. (2004); Hill et al. (2013); Ray et al. (1999); Bredillet (2014); Walker (2014); Lloyd-Walker (2014); Kvalnes (2014); Lohne et al. (2017). The general picture of a lack of interest must, however, be said to still be intact. Based on this sombre analysis, we maintain that the framework for education of the ethos (from an ethical perspective) of the students is weak.

Several models could serve as examples for such an ethos. In the following, we explore the principles on which an engineer ought to base his action in society on via two figures of thought, notably those of the homo oeconomicus and of the moral saint.

3.1 Homo Oeconomicus

Proponents of the idea of the homo oeconomicus typically portray humans as consistently selfinterested agents who pursue their ends optimally. The homo oeconomicus consequently attempts to maximize utility out of self-interest. He is thus rational in seeking to optimise utility given perceived opportunities. One famous fictional character incarnating this idea is Gordon Gekko in the movie picture "Wall street" (1987), with his publicly expressed motto "greed is good". Not surprisingly, the model of the homo oeconomicus has received severe criticism for being unrealistic, that is, not corresponding to actual human behaviour. On psychological grounds, already studies of Tversky and Wakker (1995) followed by Tversky and Fox (1995) questioned the assumption that investors – typically taken to be the utmost proponents of economic rationality – are actually acting according to this idea of rationality. Both studies demonstrate the tendency of these to make risk-averse choices in gains, and risk-seeking choices in losses. This violates the idea of economic rationality outlined above. The homo oeconomicus has equally been criticized for being conceived as an actor with too great an understanding of forecasting in decision-making. The importance of uncertainty and bounded rationality has thus been highlighted in the analysis of economic decisions (for a philosophical argument concerning the boundaries of human rationality, see Gadamer (1960)); typically, addressing such factors rather than relying on the rational man who is fully informed of all circumstances

impinging on his decisions are found to be crucial. Proponents of such criticism maintain that perfect knowledge never exist, which means that all economic activity implies risk.

Beyond arguing that the model is unrealistic, the major question within this context concerns whether we really wish to promote homines oeconomici to fill professional functions as civil engineers and the like. On personal grounds, it might seem of little attraction to have co-workers sworn to egoistic optimisation of personal goals at all times. Likewise, in a collective of professionals, such individuals must necessarily be considered to contribute little to common priorities. There does in fact seem to be little reason for the homines oeconomici to involve in the "honourable, professional practice" sought after by Mirsky et al. (2014). Beyond the question of general dislike, critics of the homo economicus, (e.g. Frey, 1997), point to the excessive emphasis on extrinsic motivation (rewards and punishments from the social environment) as opposed to intrinsic motivation. The main point is that too much emphasis on rewards and punishments can discourage intrinsic motivation: paying children for doing household tasks may push them from doing those tasks "to help the family" to doing them for the reward. Within the perspective of the AEC-industry, it is difficult to understand why homines oeconomici would involve in work for the benefit of an entire profession. The question of the resilience of the homo economicus to radically altered framework conditions – or perceived opportunities – can be understood in this light. Given the propensity to act on extrinsic incentives of the homo economicus, radically altered framework conditions – that is, radically altered extrinsic incentives – will provoke radically altered patterns of conduct.

Katz (2011) outlines a thought-provoking example of this fragility in an essay describing how engineers, architects and other technological professionals of the AEC-industry designed the genocidal death machines of the Third Reich. As he underlines, the death camp operations were highly efficient, so these technological professionals knew what they were doing: they were, so to speak, good engineers. Beyond that many of these engineers were convinced Nazi-adherents, the fact remains that many simply acted according to the altered extrinsic incentive structure of the Third Reich. Without proper intrinsic resilience, the pressure to accept new extrinsic incentive structures can prove insurmountable.

In sum: The homo oeconomicus pledges enlightened self-interest as the sole basis for rational decision-making. Apart the psychological improbabilities, this renders him both oblivious to the larger professional body, and fragile towards altering external incentive structures. Thus, the homo oeconomicus appears as a little desirable purpose or which to educate civil engineer students. At the entire opposition of the homo oeconomicus can be found what Susan Wolf has named "moral saints", loving and compassionate beings, filled with the utmost love for others.

3.2 The Moral Saint

The characteristics of the moral saints Wolf outlines in her eponymous essay are extreme in nature by their self-sacrificing nature. By *moral saint*, Wolf understands "a person who's every action is as morally good as possible" (1997:79); thus, the moral saint is a figure of thought incarnating pure altruism as opposed to the pure egoism of the homo oeconomicus.

A moral saint consequently must "have and cultivate those qualities which are apt to allow him to treat others as justly and kindly as possible. He will have the standard moral virtues to a nonstandard degree.

He will be patient, considerate, even-tempered, hospitable, charitable in thought as well as in deed. He will be very reluctant to make negative judgements of other people. He will be "careful not to favour some people over others on the basis of properties that they could not help but have" (1997:81). We are truly facing a saintly figure, with undeniably laudable characteristics. Whether these characteristics can serve as the foundation of the education of civil engineer students is, however, not evident.

When Wolf maintains that a "moral saint will have to be very, very nice", not having interest motivated by other things than the welfare of others, in sum, a "dull-witted or humourless or bland" figure. At first glance, this proves not to be a fundamental problem within the context of AEC-industry professionals. A society can well live with dull engineers. This is not, however, the main point of the argument. The *crux* is, in fact, that there "seems to be a limit to how much morality we can stand" (p. 83). Engineers *solely* occupied by the well-being of others will for instance in general prove highly inadequate in business. Creating and reaping the benefits from creating seems necessarily to imply concerns of self-interest of some sort.

Wolf points, in effect, to a perspective "generally ignored" by contemporary moral philosophy, notably that "a person might be perfectly wonderful without being perfectly moral" (p. 95), referring to comedians with an edgy tone, musicians playing for their own benefit, philatelist enjoying solitude etc. If we rephrase this in light of professionals of the AEC-industry, it seems more likely that they are good professionals if not their sole focus is being perfectly moral. This insight seems in fact to be captured by actors within the industry. For instance, none of the ethical frameworks examined in Lohne et al. (2016) professed anything like moral sainthood as a purpose for which to strive.

3.3 Virtue Ethics

Virtue-based ethics takes a different stance to the question of judging what is estimable than the purity (of self-interest or altruism) observed in the two figures of thought discussed before. Rather than focussing on abstract principles from which rules of conduct can be determined, virtue ethics in the tradition from Aristotle and his Nicomacean ethics (~ BC 400) focuses on what it calls the character of the actor. The question haunting fourth century BC Athens – how can one assure that citizens act in an ethically sound manner – in fact resonates deeply with today's societies in general – and the professions that form the AEC-industry in particular. This character is typically sought developed using examples, exposing the ethically good and blameworthy behaviour.

If, then, we are to educate students to not only satisfy project delivery objectives and user requirements (goals), but also being capable of fulfilling and identifying higher-level objectives (purpose) of their practice, the question imposes itself: what are, in effect, these higher-level objectives? In what do they consist, and how are they to be transmitted? The question of the purpose to which the students are being educated can be posed in light of the roles they are to undertake. At first glance, to outline the role of the professionals-to-be does not seem so complicated. The preponderant role of the NTNU within the industry assures that a large number of the students go out to fill senior and leading positions. In addition to the production-oriented leadership (project managing, design managing etc.), former students of this institution constitute the core strategic leadership of most organisations within the Norwegian AEC-industry.

Most private sector organisations are characterised by a strong professional awareness, and both operational and strategic leadership functions are filled by civil engineers. In public organisations, the picture is somewhat more mitigated (other professions tend to blend into the strategic level) but the general impression remains – civil engineers dominate the industry at all levels, from workplace operations to strategic decision making.

Such a general mapping of what roles the students are educated to fill does not, however, provide us with sufficient tools for understanding of the higher-level objectives of their education. As was the case for the Doozers, an intuitive comprehension of own role and function is vulnerable for external pressure that dramatically challenge traditional role of the engineers.

The example of the professionals in Nazi Germany illustrates the need of engineering to be good engineers in a moral sense. Bloom (1987:26) makes this point utterly clear within the context of the educational institutions: "Every educational system has a moral goal that it tries to attain and that informs its curriculum. It wants to produce a certain kind of human being. This intention is more or less explicit, more or less a result of reflection; but even the neutral subjects, like reading and writing and arithmetic, take their place in a vision of an educated person". If we accept that we need students with a moral vision, that this vision needs some kind of principles being established, and that the comprehension of the role which they are to fill is essential in this undertaking, a scrutiny of the role of civil engineers within the Norwegian context imposes itself.

3.4 Civil Engineers and Their Role within the Norwegian Society over the Last Century

What constitutes a profession is far from clear, and has been subject to much debate. Whether engineers constitute a profession is even more debated, leaving some to call engineering "the failed profession" because engineers are relatively unorganized and have not been able to completely monopolize their area of expertise (see for example Brante (2011) and Nygaard (2014)). Still, most scholars seem to agree that a profession is a term that applies to certain occupations held by people with specialized training based on higher education (Molander and Terum, 2008). Thus, engineering seems to fit at least the lowest common denominator, if not all of the criteria normally applied to define a profession.

Another common assumption about professions is that they possess a certain work ethic, and have a particular obligation to work for the common good (Abbott 1988, Macdonald, 1995; Molander and Terum, 2008; Brante, 2011; Slagstad, 2014). One therefore expects professionals to be guided by a code of conduct that will override narrow considerations of self-interest (utility maximization) when confronted with ethical dilemmas. It is also assumed that the professional integrity of the professional will protect him or her against possible abuses based on employer's managerial prerogative (Slagstad, 2014). Professions are furthermore politically constructed occupations (Molander and Terum, 2008). Their jurisdiction is based on state policy that privileges people with a certain education the right to perform certain tasks on behalf of society. It can therefore be argued that professionals have a special obligation to serve the common good. It can also be argued that in an education system like the Norwegian one, where higher education is free of charge (at least in principle), the obligation towards serving the common good is greater than it would otherwise have been.

In Norway, the education of engineers started as part of the industrialization process from the middle of the 1800s (Nygaard, 2014). The efforts culminated with the establishment of NTH (The Norwegian Institute of Technology, now called NTNU) in 1910. NTH has played a key role in educating engineers in Norway ever since. From the beginning, NTH was inspired by German engineering ideals with a high emphasis on theoretical education in natural sciences. At the beginning of the 1900s, the role of the engineers as a managerial profession within the Norwegian context started to form. Engineers exercised their craft as managers both in industrial enterprises and in technical areas of the public sector. This happened despite the fact that the educational programs of the NTH did not prepare engineering students for the tasks involved in leadership and management of organizations. In the same period, engineers together with other professions took on the huge societal tasks of improving peoples living conditions in the cities, and connecting the country through new infrastructure (Skogheim, 2014).

The period following the end of WWII is sometimes called the golden age of engineers in Norway (Nygaard, 2014). After WWII, they played vital roles as industrial leaders in the efforts of rebuilding the country (both literally and figuratively speaking), and as advisors on policy issues. The post-war efforts towards further industrialization and modernization united the labour movement and the engineering profession, and put this latter literally in the lead of this joint effort towards the common good. The understanding of engineers as natural leaders took a dramatic turn in the 1960s, when studies showed that the majority of civil engineers were uninterested in administrative tasks, and that engineers were not educated (or suited) for leadership (Nygaard, 2014). In the 1970s, critique was heard against the consequences of post-war industrialism and modernization. The engineers, who had a leading role in the post-war societal development, were accused of not acknowledging negative consequences of their activity as professionals, and having a narrow-minded technology-technocratic view of their societal role (Nygaard, 2014).

Concerning the situation of how to understand the engineering profession over the last 30 years, the research literature proves rather sparse. This lack of analysis seems to pertain to both the outer (societal) role of the civil engineer and to the understanding of the inner (the ethos) role. In order to articulate how this understanding is reflected in the university's formulations of the ambitions for education of engineers, we in the following draw on insights from the Project Management literature.

4. Findings – The Education of MSc-Students at NTNU

4.1 Nature of the higher-order sense

The students should – in the opinion of the authors – come to a higher-order (profession-based ethical consciousness) sense that enables them to surpass the state of Doozers. They should come to a certain level of consciousness about their role, without getting too far in the direction of neither Homines Oeconomici nor moral saint. This can be illustrated in the following figure:

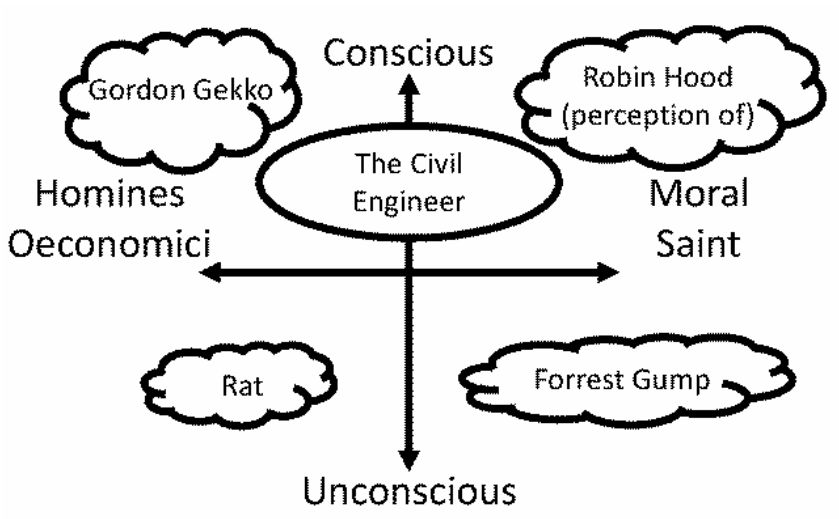

Figure 1: The nature of the Civil Engineer, illustrated by the dimensions Conscious/Unconscious and Homines Oeconomici/Moral Saints

The above figure outlines four figures of thought, fictional characters (for what concerns the rat, this fictional character is the popular representation of the rat in diverse media, not the actual rodent of unsurpassable opportunistic intelligence). As we shall see in the analysis of the formal guidelines examined, none of the four figures thus outlined correspond to the envisaged civil engineer to be. The general finding is, on the contrary, that the image of the coming engineer is highly inspired by lessons similar to those outlined in this paper under the virtue ethics heading.

4.2 To what extent do the education of MSc-students reflect the need for understanding the higher-order sense of their function

The MSc-study program at NTNU is highly compartmentalised, and characterized by a general division between the general natural science/mathematical subjects mainly thought in the first 45 semesters and the specialization courses of the following semesters (see table 1).

Accompanying this general plan of the courses provided, an overreaching outline of demands to the competencies of future civil engineers from the NTNU is provided (Table 2). In Table 2, we outline how the different demands are reflected in the course curriculum of the individual courses outlined in Table 1:

Table 1: An overview of the content of the courses provided by the Civil and Environmental Programme at NTNU

Sem-ester	7,5 Credits	7,5 Credits	7,5 Credits	7,5 Credits
10	Master's Thesis			
9	Non-Technologic course	Specialization (project + subject)		
8	Experts in Teams	Specialization course	Specialization course	Specialization course
7	Non-Technologic course	Specialization course	Specialization course	Specialization course
6	Technology Management	Specialization course	Specialization course	Specialization course
5	Calculus 4	Specialization course	Specialization course	Specialization course
4	Statistics	Fluid Mechanics	Geotechnical Engineering and Engineering Geology	BM 4 Design of Buildings and Structures
3	Calculus 3	Physics	Mechanics 2	BM 3 Transport Infrastructure
2	Calculus 2	Philosophy and Theory of Science	Mechanics 1	BM 2 Hydraulic and Environmental Eng.
1	Calculus 1	Inform. Techn. Intro.	General Chemistry	BM1 Building and Construction Materials

Table 2: Overarching demands to future civil engineers educated from the NTNU and an assessment of to which extent this is assured through the course curriculum

Knowledge	
Broad basic knowledge in Mathematics, Science, Technology and Computer Science as a basis for understanding methods, applications, professional renewal and adaptations.	This is assured through the fundamental mathematical-scientific courses.
Broad engineering- and research-based knowledge in Civil and Environmental Engineering, with in depth knowledge within a more limited area connected to active research, including sufficient professional insight to make use of new research results.	This is assured through the obligatory courses in construction engineering.
Knowledge in technological management, health, safety and environment in order to manage projects and other activities within the construction area in an efficient, economical and socially beneficial way.	Assured through individual courses in addition to some elements of most courses. The weight lain on this over the last years meet significant organisational opposition, as being perceived as hindering skills of technical mastery. Not measured.

Insight in selected social science, humanistic, and other non-technical disciplines of relevance to the exercise of the engineering profession, and as a basis for developing a broad perspective on the engineering discipline's role and challenges in the society.	*Sought assured through the courses in Philosophy and Theory of Science, and the course "Experts in team". I addition, two complementary courses are required for all – but in these courses, this content is included quite randomly. Both intention and possibility exist. Not measured.*
Skills	
Define, model and break down complex engineering problems, including choosing relevant models and methods, and carrying out calculations and solutions independently and critically	*The construction engineering courses form the basis for this, whilst critical distance is actively sought assured through the MSc.-thesis.*
Develop comprehensive solutions to engineering problems, including the ability to develop solutions in an inter-disciplinary context, and carry out an independent, particular engineering research and development project under academic supervision	*Sought assured through the project- and master theses, in addition to experts in team (first part of the sentence).*
Be able to work with modern Civil and Environmental Engineering methods and tools.	*Covered partly in all different construction engineering courses. Main reason for introduction was assuring BIM in the education.*
Be able to renew and adapt professionally, including develop professional competence on his/her own initiative	*Not measured – is not followed up in a structural manner through the course plan.*
General Competence	
Understand the role of engineer in a comprehensive societal perspective, have insight in ethical requirements and consideration of sustainable development, and be able to analyse ethical problems connected to engineering work, and contribute to innovation and entrepreneurship	*Understanding the role of the engineer not assured – random and dependent on choice of courses – not measured. Ethical requirements not assured – not measured. Sustainability concerns are included in several courses, both from technical and management perspectives. Analysis of ethical challenges not systematised – not measured.*
Ability to disseminate, communicate and cooperate inter-disciplinary on engineering problems and solutions to specialists and the general public	*The ability to cross-disciplinary cooperation is sought assured through experts in team, whilst the dissemination of results is sought addressed in the master thesis. No systematic follow-up, not measured.*
Understand possibilities and limitations when using information and communication technology, including juridical and societal aspects	*No systematic follow-up, not measured*
Ability to lead and motivate co-workers, including having an international perspective on his/her profession, and develop ability to international orientation and collaboration	*No systematic follow-up, not measured*

In sum: whilst the descriptions of the outputs and goals of the education of civil engineers is rather clear (improvements might evidently always be envisaged), the purpose for which the endeavour takes place remains vague.

5. Homines oecomomici or moral saints?

In the introduction, we outlined the ambition of this paper as being to address 1) how we can envisage how to develop the reflexive capacity of students of Civil Engineering to undertake critical scrutiny of their own practice and, 2) to what extent are Norwegian civil engineering students are educated to incarnate such a reflexive capacity today.

The findings presented above indicate that the Doozer-capacities (such as purely analyticalmathematical skills and even to a certain degree basic management and leadership techniques) of the MSc-students are well taken care of. On graduation, they are highly skilled in the natural science/mathematical disciplines, and are quite well skilled to take on the concrete tasks in the work positions they are destined to fill (typically as project managers, technical experts, consultants etc.). The higher-order goals (understood as their ability to reflect on their own practice), however, are less well taken care of, often being subjected to the whims and ethos of individual teachers and rarely measured. It seems, in effect, as if the overarching demands to the education are recognized – but that the practical follow-up in the education is much left to chance. It would seem that this renders the MSc. students fragile to logics of economic sub-optimisation etc. when they meet the working life of the construction industry; that is, becoming pure homo oeconomici, focussing solely on maximising own profit.

As pointed out by humanistic-existential psychology, man is not born with a predefined set of qualities or a moral codex – he simply is (Ryum, 2015). Both personal and professional development unfold in a reciprocal interaction with the social environment, which may nourish or hamper the growth of a positive identity, reflexive capacity and professional integrity (Ryan and Deci, 2000; Ryum et al., 2014). The development of the sought-after character strengths and virtues deemed imperative within a profession, such as humanity, justice and transcendence (Peterson and Seligman, 2004), needs to be cherished by educational institutions as important learning goals.

As described in the theoretical framework chapter, engineering is often referred to as the "failed profession". Approximatively 80-90 % of all Norwegian MSc-students in the field of Civil Engineering come from NTNU. The above results do not promise well for their future selfunderstanding as a profession. To verify the results, further studies are needed, especially aiming to examine the education of the large number of BSc-studens of Civil Engineering that also typically fill roles as project managers, consultants etc. within the Norwegian AEC industry.

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Assessing BIM performance in building management organisations

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Abstract

This paper presents a literature review into issues related toBuilding Information Modelling(BIM) performance assessment in building management organisations and proposes an agenda for future research addressing how such an approach can be further developed. Performance in use of BIM can be described as a measure or description of how capable and mature a project team or organisation is in terms of developing, using, evaluating or receiving BIM products or services. Although BIM is awell-known and established methodology in building design and construction organisations, when procuring and executing projects, the building management side, encompassingbuilding operations and maintenance, usually lags behind. Adoption of BIM in building management has become a challenge addressed in discussions on what the next step for BIM uptake will be. By adapting and using solutions that, to an extent, have already been developed for other stages in the construction delivery process, BIM can contribute to benefits for the operations/management phase of buildings. In order to prove efficiency and applicability of BIM as a methodology in building management operations, approaches to assess actual performancearenecessary.

Thispaper describes development of a possible approach of assessing BIM performance through self-assessment. It is identified that pre-requisites in the form of default performance indicators, referred to as BIM Performance Indicators (BPI) have to be established for such methodology to be possible. In order to distinguish these BPIs, new data through input from practitioners has to be gathered. This paper suggests that a case study aiming to gather data from practitioners for this development is a suitable vehicle for identifying these indicators underpinning assessment of BIM performance specific to organisations within the building management sector.The paper concludes thatappropriate dimensions in which significance for BIM use in building management organisationsshould be sought in a case study are (1) Technology, (2) Knowledge, (3) Communication, (4) Processes and (5) Organisational culture and motivation.

Keywords: BIM performance, building management, self-assessment, capability, BIM performance indicators, BIM maturity

1. Introduction

BIM has become the primary methodologyencompassing the digitalisation of the built environment supply chain. BIM is a digital representation of the physical and functional characteristics of a building and serves as a knowledge sharing vehicle for building information (Barlish and Sullivan, 2012). Incentives and use related to BIM have been increasing over the past few years, as explained by Azhar et al. (2012), "BIM has gone from being a buzzwordto the centrepiece ofAEC[4] technology". Although BIM is applied to a majority of large design and construction projectsit is still not common practice throughout the industry.However, design and construction projects are now proving to be more efficient in terms of cost reduction, quality improvement, time schedule adherenceand a better work flow between project participants. In addition, project owners have started realising other benefits deriving from BIM as a work method, such as easier quantity take offs, enabling easier calculations and visualisations for promotional purposesand ease of cross-disciplinary collaboration to name a few(Sanchez and Joske, 2016; McGraw Hill Construction, 2014).

In terms of object-based model information, the building management side is far from being as developed as actors working with executing design and construction. Building management includes use and maintenance during the operations phase of a building's life cycle.Van Berlo et al. (2012) presents a case study, evaluating and comparing the BIM performance of all actors in the AEC industry and operations [AECO].This study addresses that actors with client/owner and building manager roles have the lowest BIM performance levels out of all primary AECO stakeholders. A major reason for this is that traditionally the operations of a building have been seen as something separate from the production of it -construction. Following that pattern, the process of generating aBIM model is often divided in the same fashion as the physical asset which creates illogical hurdles for the information flow between project stages. This leads to a low level of inclusion ofbuilding management actors in design and construction of projects and subsequently low involvement in the development and adoption of BIM methodology as a whole.

At the same time, the degree of competitiveness on the market amongst building owners and managers has increased the need for optimisation of processes delivering a streamlined building operation (Zhang et al., 2009). As a consequence, implementation of BIM in building management organisations may constitute an effective platform for long-term strategic business outcomes (Love et al., 2013).BIM performance can be described as how capable and mature the project team or organisation is in terms of their BIM use and can mirror efficiency (Månsson and Lindahl, 2016; Månsson et al., 2016; Succar et al., 2012). Assessment of BIM performance can contribute to both preparation for efficient implementation and streamlining future use of BIM in building management. In order torealise this, a base methodology for assessing the BIM performance of the organisation is required.

To enable a methodology in which assessment of BIM performance of all stakeholders involved in and affected by BIM projects can be possible, potential ways of assessing the weakest link, building management, will needto be investigated. The research presented in this paper, will compile

[4] AEC: Architectural Engineering and Construction industry is defining the primary disciplines included in a construction project. (Azhar et al., 2012)

information related to BIM performance in building management organisations to build a foundation on which BIM Performance Indicators,BPIs, can be further developed.

2. Methodology

The aim of this paper isto gather insight concerning BIM performance assessment of building management organisations. Initially a literature review was carried out to establish a knowledge base aboutthe ways scholars are addressing BIM adoption in building management organisations.It was identified that literature concerning BIM performance assessment of building management organisations, with a comprehensive understanding was a scarce resource. To address this, a comparison between frameworks and tools for measuring and assessing various aspects related to BIM performance and value was made. A preliminary comparison addressing how these frameworks and scales divided their metrics into categories was made by addressing those that seemed most relevant for the study. The dimensions addressed related to frequency, within the reviewed frameworks, and estimated importance for BIM adoption in building management. Furthermore, a combination of interviews and follow up questions via email correspondence with four different building management organisations was made in order to verify that these categories were relevant for the study as mentioned above. The input gathered set the foundation in which a default set of BPIs can be developed and further tested empirically.

3. Literature review

BIM capability refers to the ability project teams or organisationshave to deliver a service or product related to BIM. BIM maturity addresses the quality, repeatability and depth in which these services and products are or can be delivered (Månsson et al., 2016; Succar et al., 2012).In order to prove the efficiency of BIM projects or evaluate an organisation's BIM deliverables and use, the performance has to be assessed.

There are several frameworks that aim to assess or measure benefits and performance related to implementation and readiness of BIM in design and construction of projects. BIM excellence, BIMe, further extended by BIM Maturity Index, BIMMI, and BIM Maturity Matrix are all developed by Succar for the purpose of assessing BIM. BIMe is an online tool used for assessing performance of organisations, projects and individuals in relation to BIM (Succar et al., 2013). BIM Quick Scan (Sebastian and Van Berlo, 2010)is intended for generating a performance benchmark at an organisational level through a multiple choice scorecard based on a series of KPIs. The BIM Quick Scan is performed by an external consultant comprising information from interviews and observations. The*BIM Planning Guide for Facility Owners* developed by Computer Integrated Construction (CIC)at Penn State University presents an approach in which building management organisations can plan for integrating BIM through strategic, implementation and procurement planning. (CIC, 2013). BIM Value is an online tool identifying metrics toevaluate BIM value and benefit outcomes achieved through BIM projects. The methodology is presented by Sanchez and Joske (2016) in a benefits dictionary published in *Delivering Value with BIM A Whole-of-life Approach*by Sanchez et al. (2016). Interactive Capability Maturity Model, I-CMM, a simplified version of Capability Maturity Model, CMM, measures the maturity of BIM when being implemented. The focus is on project level and mostly concerns technical aspects (National Institute of Building Sciences NIBS, 2007). The Virtual Design and Construction, VDC, Scorecard is a framework for evaluating VDC implementation through a series of measures

developed with emphasis on the design and construction phases (CIFE, 2013). The BIM proficiency matrix is an excel-based matrix scorecard created to assess the proficiency in which a BIM model is developed. It was developed by Indiana University originally to assess BIM projects and thus enhance building management (Indiana University, 2009).

An approach presented by Månsson et al. (2016) includes a self-assessment methodology using a crowd-sourcing approach to populate and autonomously refine the inclusion of parameters for assessing BIM performance of projects. The methodology includes the need for a series of default BPIs to serve as a foundation for continuous improvement. To enable this methodology, parameters for adequate performance assessment are needed. Generally, the process of refining parameters as shown in Figure 1 requires a preliminary set of BPIs followed by meticulous analysis and validation.

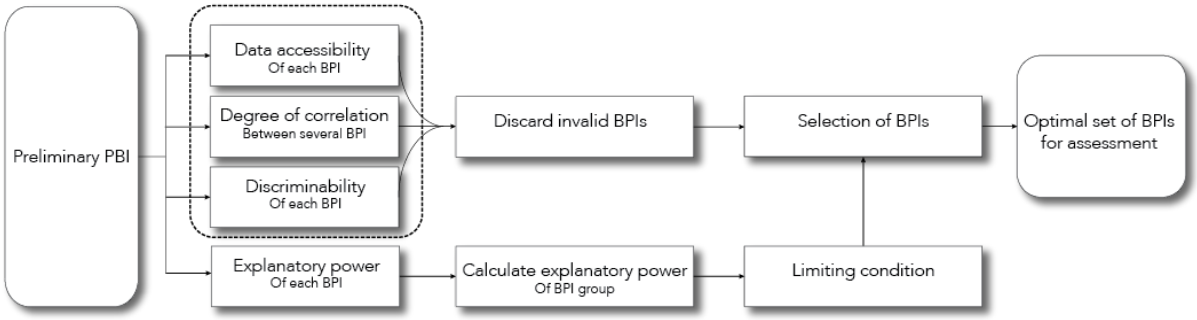

Figure 6:*Process of selecting BPIs for assessment of BIM performance, edited version (Mansson et al., 2016)*

Assessment of building management organisations' application, use and performance of BIM will be different from assessment of organisations operating in design and construction phases. There may be two main reasons for this. First, the low BIM adoption in building management organisations in general limits the insight into key success factors and, in the long run, variables effecting their performance. Second, the nature of practice differs from that of other actors involved in a project including the time span in which they are operating. In order to gain better insight, new data addressing specific requirement for building management organisations adoption of BIM is needed. A suitable niche to investigate is building management organisations owning and managing university buildings.University-focused asset portfolios can contain a variety of building types, ranging from standard office buildings to high-tech laboratories.Furthermore, it is likely that universities have high ambitions or willingness in improving building management efficiency through digitalisation considering that it is likely beneficial for universities to be perceived as innovative as well as acting innovatively. Lastly, efficient management of university buildings may contribute with a positive impact on education and research quality, making this field suitable and attractive to investigate. The following sections will explore BIM as support for building management and prerequisites for assessment of BIM performance specific for these organisations.

3.1 BIM as support for the built environment industry

Building management includes use and maintenance during the operations phase of a buildings lifecycle. BIM can function as a reliable basis for management and transfer of data and enables efficient decision making during a building's lifecycle including the operations phase.Kivits and Furneaux (2013) argues that the BIM methodology with a single rich model has the potential for improving the

construction and management of a building in a lifecycle perspective including improvement in sustainability.

Though the use of BIM as a methodology has been evolving over the past few years, there are distinct barriers to achieving an efficient integration of data transferfrom design and constructionto building management and operation. A tradition of perceiving the design and construction project as a separate entity from building management can be argued to be a reason for this. Combined with the fact that data formats have been varying depending on what specific CAD tool is used and who is populating the model, possibilities for solutions to carry significant project data from design and build to operation and maintenance has been limited. Kiviniemi and Codinhoto (2014) argue that this lack in interoperability combined with difficulties in keeping the information up-to-date are some of the main barriers to successful BIM implementation in building management. Industry Foundation Classes, IFC, a non-proprietary exchange format of building information between software and applications,was developed to represent information over the building's lifecycle. (Volk et al., 2014). Non-proprietary formats, like IFC, enable new possibilities for the development of solutions for handling project data deriving from the BIM process in a life cycle perspective. If used coherently,non-proprietaryformats may therefore be one key pre-requisite for development of new tools and ways of working with building and building management data.

As non-proprietary formats unlock the potential for new technical solutions for interoperable data flows, challenges for development and implementation will emerge.First, the building management organisation will have to identify and specify what data they will require. The Level of Information, LOI[5], and Level of Detail, LoD,[6]contained in model elementsof BIM models developed for the design and construction phases of the project is not optimised to be used for building management purposes. Trying to utilise already existing, sub-optimised, BIM models is not ideal for various building management functions. LoD and LOI is usually determined by the owner at the design phase and executed in the procurement and construction phases of a project (Becerik-Gerber et al., 2011). Project owners have to decide these levels before the project is initiated. If over-specifyingthe LoD and LOI, they risk spending unnecessary funds and likewise inferior LoD and LOI will lead to asub-optimised modelunable to serve its purpose (Bonanomi, 2016).

It may be easy to over focus on technological solutions as working with digital project information likely will introduce the building managing organisation to a higher degree of use and development ofsoftware tools. Rather than perceiving the BIM implementation as a technology adoption or development activity, it should be viewed as variationof businessroutines and procedures. To support this development,an understanding that technology alone cannot deliver business outcomes is needed (Love et al., 2014), stressing the importance for a clear strategy including all organisational dimensions affecting the implementation.As stated by Kivits and Furneaux (2013) managing this change will require an extensive management of knowledge, although they explain it as a further extension of current BIM practices. In contrast, it is likely that useor rather adaption of BIM to serve building management or a building's lifecycle will require re-development of the BIM process. Thus, to some extent BIM should be adapted to building management and the other way around.Organisations working in building management will require different information than the one used as project support,

[5]Level of Information, LOI, defines the amount of non-graphical information is added to a model element
[6]Level of detail, LoD, defines the amount of graphical information contained in a model element (BIMForum, 2017).

also building management firms may have various capabilities and goals. For example, new parameters and dynamic LoD level matrixes will be required to be clearly stipulated in the design phase.

3.2 Assessing BIM performance

To assess an organisation's BIM performance there are several different methods of collecting data required to do so. One efficient way is to perform interviews with employees directly involved with the organisation's operation. Furthermore, various analyses and surveys can serve as efficient self-assessment tools for assessing the organisation's performance (CIC, 2013). BIM in building management is not yet significantly established, consequently there is a lack of methodologies and parameters to assess the performance of actors in this field.

Månsson and Lindahl (2016) positthat there are several existing frameworks for measuring or assessing the performance of organisations or project teams tied to construction projects operating a BIM practice. None of which is specifically addressing building management-based activities. Although, some of them host parameters that can be used to assess the performance of building management-related organisations. By comparing how these frameworks are treatingthe different factors affecting the overall performance, perspectives on how to map factors for assessing performance of organisations or activities in a building management context can be identified.

BIM Excellence is an online tool that assesses the performance of organisations, projects and individuals in relation to BIM. This commercial tool is based on the research of Succar et al. (2013), and divides the assessment subject into eight main dimensions: technical, operational, functional, implementation, administration, supportive, research and development, and managerial. *BIM Excellence*is developed in coherence with the more extensive tool *BIM Maturity Index*, BIMMI dividing the BIM implementation into stages from object-based modelling to an integrated project delivery. Dimensions in which organisational BIM maturity is sought is divided into technology, processes and policies (Succar et al., 2013).

BIM Quick Scan developed by Sebastian and Van Berlo (2010) is intended for generating a performance benchmark. It divides the organisation into four categories consisting of series of parameters:organisation and management;mentality and culture;information structure and flow; and tools and applications.

The*BIM Planning Guide for Facility Owners* developed by CIC (2013) at Penn State University divides the organisation into six categories:strategy, BIM uses, process, information, infrastructure, and personnel.

Sanchez et al. (2016) have documented metrics for assessment of organisational BIM value. It has divided the organisation into four main categories: people, process, procurement and sustainability. *BIM Value* identifies possible metrics for evaluation of value deriving from BIM use not addressing BIM performance but rather the benefit outcomes of BIM activities.

Azhar et al. (2012) describes BIM as a combination of technologies and processes. However, when adapting the BIM methodology to building management, processes and technologies will change.

Furthermore, organisations have to take into account dimensions, considered to be soft, such as knowledge, communication and culture.

After comparing the above-mentioned frameworks and methods, this research willadopt five organisational dimensionsas a foundation for identifying relevant BPIs suitable for assessing building management oriented organisations. These are: technology; knowledge, communication; processes; and organisational culture and motivation.These dimensions are described in the following sections.

3.3 Technology

The technology dimension includes technical solutions serving and performing data management and use. Specifically addressing BIM technology refers to hardware and mainly software solutionsas addressed by Van Berlo et al. (2012) in BIM Quick Scanas tools and applications,further addressedin BIMe, BIMMI (Succar et al., 2013) and by Azhar et al. (2012). Technology assessment has two main approaches, first technology available for a specific need and secondly technology obtained by the organisation. While technology available indicates possibilities open to supplier capability, technology obtained can indicate the organisation's maturity comparing the deviation between the availability and the technology obtained.The dimension concerns firstly, what capacity organisations have to use the technology and secondly, what technology they are actually using. Thesecan be related with financial indicators (CIFE, 2013). Building management organisations have to make sure that the tools they are currently using will be compatible with the building information deriving from the BIM process. They also have to ensure that structure and formats of the building information can be used to serve operational needs.BPIs developed within this dimension should be able to assess whether the firm or team has all technical capabilities necessary to perform or receive required BIM services or products.

3.4 Knowledge

The knowledge dimension reflects the organisation's collective knowledge mainly in terms of competent staff members, information held and use of information addressed by CIC (2013) in the BIM Planning Guide for Facility Owners. BIM Quick Scan also addresses information as a category (Van Berlo et al., 2012).New organisational development such as integration or further utilisation of project data in building management oftenrequires rapid and effective knowledge integration throughout the organisation. This also includes strategies for knowledge integration over time and how implementation will be aided by the organisation's preparedness for change (Marsh and Stock, 2006). A critical factor can be a lack of competent staff to employ which can become a significant barrier to implementation of new methodologies. In short, what strategy does the organisation possess to obtain and manage knowledge? When implementing BIM, a new way of working with building information, building management organisations require hiring new staff as well as educating its employees. Supportive assessment of knowledge possessed and required related to BIM enables this.BPIs developed within this dimension should be able to assess whether the firm or team possess the knowledge necessary to perform or receive required BIM services or products.

3.5 Communication

This dimension includes the capacity to retain and share knowledge between projects and participants.It also addresses the efficiency of information flows between projects, project participants and

organisational departments. BIM Quick Scan emphasises information structure and flow as an important dimension to assess (Van Berlo et al., 2012).For a business as a whole, knowledge sharing is capturing, organising, reusing and transferring the vast and unique knowledge that resides within the organisation and making that knowledge available to others in the business (Reid, 2003). When implementing BIM in building management, effective communication between design and construction actors is key, as well as between building management actors. The required model content has to be established before the project is initiated. Furthermore, disciplines within the building management organisation may find new ways of internalcollaborating through digitalisation of building information stressing the importance of good knowledge sharing. BPIs developed within this dimension should be able to assess how capable the firm or team is in communicating and sharing knowledge supporting their performance and receiving required BIM services or products.

3.6 Processes

A good understanding of and a clear strategy for the causal relationships between organisational entities affecting new implemented methodologies is required for a successful implementation and use (Marsh and Stock, 2006). Furthermore, clarity about which events occur and what resources are used is needed. Processes are included as assessment categories in BIMMI (Succar et al., 2013), BIM Planning Guide for Facilities Owners (CIC, 2013), BIM Value (Sanchez et al., 2016) and by Azhar et al., 2012)If processes are not specified and followed, it may hamper change and adoption of new business methodologies.As new technologies and management of knowledge and communication will change through BIM integration in building management, processes in which to apply these has to be designed and followed. To make sure that they are effective, they have to be properly assessed.BPIs developed within this dimension should be able to assess how well the firm or team is supported by processes specifying how to perform and receive required BIM services or products.

3.7 Organisational culture and motivation

This dimension refers toopenness and responsivenessforchange of business procedures and adoption of new methodologies as well as willingness and capability to drive change.Organisational culture is describedby Martins and Terblanche (2003) to be deeply seated values and beliefs shared by the members of an organisation which will manifest its characteristics and affect the ability to change business methodologies.BIM Quick Scan addresses culture and mentality as dimensions for assessment (Van Berlo et al., 2012). BIM in building management may include a dramaticchange in how building organisations conduct their business, stressing the importance of implementing and testing new practices and tools. An environment in which risk taking through innovative and creative development is encouragedis necessary as business methodology changes and develops into new areas. Organisations have to take into account that some initial problems might occur when new procedures are implemented in the business and communicate a culture in which errors and initial mistakes are not discouraged (Martins and Terblanche, 2003).BPIs developed within this dimension should be able to assess how well the firm or team is supported by the organisational culture and motivation to develop, perform and receive BIM services or products. This could either relate to financial indicators such as, money spent on R&D tied to BIM, but also on the employees' experience of support from the organisation.

4. The case study approach

Efficient implementation and useof digital data, deriving from the project, in building management organisations will requireeffectiveimplementation strategies. To identify these strategies, key factors affecting the BIM progressionneed to be identified. A self-assessment approach to this will enable a way of evaluating implementation progress and efficiency. The BPIs needed for such a method have to be identified and validated. Since information related to this is very limited, new data to create a general framework for BPIs and in the long run successfactors specific for building management organisations will benecessary. Furthermore, complex processes and issues can be better understood as new data is gathered and evaluated. An efficient way of doing thisis by conducting a case study (Dooley, 2002). By applying a case study methodology when gathering and testing data, a deeper insight and understanding for complex issues will be possible to obtain. In addition, a case study can contribute to a greater confidencefor what isalready proven or identified in past studies (Dooley, 2002).

Developing a theoretical framework is central when performing a case study focusing on organisational research. Eisenhardt (1989) stresses the importance that a weak theory can result in weak ties between the theory and the testresults due to an overly widespread accumulation of case study methods. There are different approaches to conducting a case study research with varying approaches, all of whichstrive to explore an area/issue and seek to reveal patterns, aspects and core structures of it. Asthe theory and examples from practice is fairly novel and limited in this field, this paper is suggesting that a case study approach should focus on combiningavailable theory with qualitative interviews with representatives of industry actors.

4.1 Interviews

Interview-based case studies aim to collect qualitative information from people with connection to or likely valuable knowledge or opinion about the researched topic for further analyse. Interview outcomes can also serve as benchmarks to compare non-connected knowledge or opinions with connected ones to validate thesignificance of the information.Since using BIM in building management organisations is quitenovel, it is expected that detailed knowledge of its present or future useisdifficultto obtain directly from interviewees. An initial interview with each interviewee can be performed for the purpose of obtaining a general image of the organisation's present status, future use and perception of the implications connected to BIM use in building management.This paper suggests that acase study including interviews intended to map out the importance of the above-mentioned dimensions in regards to using BIM in building management organisations is a logical step towards obtaining a deeper knowledge and a positive way forward.

Furthermore, knowledge gained throughinterviews can help when developing and evaluating the importance of specific BPIs deriving from analysis of the interview outcomes. Ultimately a case study approach will enable yielding a default series of BPIs specifically suitable for assessing the performance of BIM usein building management firms. This can then enable the development of prerequisites for further research and development of BPIs relevant for assessing organisations working with BIM in building management. A case study is set to mirror reality, but there is a trade-off between level of control and degree of realism (Runeson and Höst, 2008).Since it is unlikely that building management organisations, suitable to partake in such case study already have an elaborate BIM practice, it is challengingto foresee the outcomes of such interviews. Therefore, the interview should

consist of open-ended questions aiming to cover a wide variety of topics.Also, the interviewees sought forsuchcase study should be working in strategic level functionsor specifically with building information.

5. Discussion

The BIM methodology has become fairly established in design and construction projects and has contributed to a more efficient way toexecutethe process (He et al., 2016). Still, there are many ways in which BIM can be usedto a greater extent inthe building management process. The information created in the design and construction phase of a project holds many possibilities to serve building management in terms of maintenance andmore effective use of buildings. Animpediment is that the information created in BIM projects often lacks essential data as it is not produced for a building management purpose to begin with. Therefore, the required LoD and LOI has to be extended and clearly definedby the building management organisation, who is often alsothe project owner. This mayenable a more standardised and repetitive structure of IFC models. Building management organisations naturally have different needs and abilitiesfrom those of organisations involved in the production of the asset. Improved development of IFC models may increase the potential in which they can be used for building management purposes. In addition, it may enhance data interoperability throughout the building life cycle and collaboration between project stakeholders.

Possible implementation, or rather, use of digital project data in building management organisations will create further challenges. There is no unanimous need stated for what aspects of BIM building management organisations demand, possibly since there has not been any service use presented to them or that possibilities for usingdigital project information has not previously been applicable. A starting point is that non-propriety formats such as IFC has been established enough in terms of content and applicability to major BIM software, enabling a good integration between software and development of new ones serving building management.However,other factors have to be taken into account such as those related to processes, knowledge and communication and motivation and culture.

A more elaborate and inclusive engagement of building management organisations in the construction project delivery process will enable a better insight into what information and functions areneeded and valuable throughthe BIM model. This will requirea more precise requirement specification necessary to identify needs and further develop solutions to meet these needs.

Furthermore, it is of importance that researchers and industry follow and engage in the development of digital data integration in building management and strive touse the digital building data from a lifecycle perspective and support performance assessment of the built environment.Through this,it shouldbe possible to develop an understanding ofhowactors are performing and how some hamper greater industry efficiency and the reasons behind the different approaches.

6. Future research methodology

This paper has investigated how the effective use of BIM for building management can be measured. A review of recent literature found that whilst there are a number of methodologies for evaluating BIM practices in design and construction, there are fewfor assessing performance of BIM in building management organisations. Furthermore, it is clear that at least some knowledge of BIM benefits has

encouraged the uptake of BIM by the AEC professions. To address the absence of BIM evaluation methodologies for building management, the research team proposes a programof research to identity appropriate measures in five key areas of building management practice, namely:(1) Technology, (2) Knowledge, (3) Communication, (4) Processes and (5) Organisational culture and motivation.

Future research will include interviews with building management organisations operating within a university segment in two countries, Sweden and Australia.The objective is to establish a deeper insight in the actual prerequisites and needs these organisations have related to digitalisation through BIM adoption. These organisations often have large portfolios centralised on one or several campuses containing buildings with a variety of complexity.

On the basisof the dimensions identified in this paper, the aim is that futureresearch will contribute to identification of a narrow selection of relevant BPIs and enable future comparison between the approach taken in two countries, Sweden and Australia. University building management organisationsoften mange large portfolios centralised on one or several campuses containing a myriad of different buildings, ranging from standard office spaces to complex laboratories. Also, building management organisations connected to universities are likely to be willing to integrate innovative solutions in due to their propinquity to education and research making this segment suitable and attractive to investigate.

7. Conclusions

BIM has to be adapted to suit the needs of building management in a similar manner that building management organisations have to adapt to BIM methodologies. Bridging the gap between the often separate entities will inevitably require proactive change. A starting point is that non-propriety formats such as IFC enables development of technical solutions addressing BIM in building operations. This is an important cornerstone in the development of BIM practices that cover building management. A problem with IFC models created as design and construction support, is that they seldom are populated in accordance to meet building management requirements. Therefore, requirement specifications have to be clear, inclusive and developed by the building managing organisation in a project's early phases. In addition, further inclusion of building managers throughout the design and construction phase will incorporate valuable input from the end user ensuring the appropriatecontent in the BIM model to serve a building over its lifecycle.

The literature review showed that there are gaps in terms of how a common knowledge of BIM uptake in building management will create benefitsand what constitutes a level of performance specific for these organisations. Also, through correspondence with building management organisations it was found that there is a lack of insight as tohow the companies themselves perceive benefits in relation to critical success factors for BIM adoption.Performance literature and assessment tools related to BIM performance in building management organisations tend to focus largely on technology aspects which naturally is a major factor.

Aside from the technical aspects, there are several other factors affecting BIM implementation in building management that needs to be taken into consideration when developing strategies for implementation. Assessment of performance among building management organisations is essential to evaluate performance and develop strategies for implementation. A self-assessment approach to this

will enable user-friendly assessment that does not require potentially threatening external supervision and external knowledge. What should be assessed, however, has to be identified and defined. The first step in identifying what to assess is to identify and map what dimensions of the respective organisations are the most important in relation to BIM implementation, as well as the level of maturity for these dimensions.This will help specifying in which areas they are ready for implementation as well as areas in which they, and in the long run the whole sector, need to improve. The dimensions in which the importance of BPIswill be sought in planned future research are (1) Technology, (2) Knowledge, (3) Communication, (4) Processes and (5) Organisational culture and motivation.

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Boosting deep renovation in the Nordic Countries

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Abstract

Buildings are a strategic sector for energy policy. The Energy Performance of Buildings Directive together with the Energy Efficiency Directive and the Renewable Energy Sources Directive, define a framework that creates the conditions for long term improvements in the energy performance of Europe's building stock. The Article 4 of EED requires Member States "to establish a long-term strategy beyond 2020 for mobilising investment in the renovation of residential and commercial buildings". The Member States have developed their first renovation strategies in 2014 and will update them in 2017. These strategies have been assessed. Countries in the early stages of the energy efficient building construction get easily good estimates because they could present plenty of Kyoto pyramid theory style new openings. If the energy performance is poor, it is easy to get big energy savings by reducing consumption what is the foundation for energy efficient building stock according Kyoto Pyramid. In the Nordic Countries energy efficient building construction has been for decades "business as usual" so big savings are not achievable. This paper discusses whether the Kyoto pyramid of priorities could be seen as steps. The sensible energy efficiency improvement measures depend on the step where member state is. If energy performance of buildings is already good, the investments should be head to enhance energy efficiency and promotion of renewable energies.

Keywords: Building stock, deep renovation, energy, strategy, Kyoto pyramid

1. Introduction

1.1 Background

Energy efficiency has become a key priority of the Europe 2020 strategy for smart, sustainable and inclusive growth and resource efficiency (EU, 2010c). Through efficiency, security of energy supply will be improved, emissions will be reduced and energy reserves wasted due to inefficiency will be recovered.

The EU's updated strategy, which will extend up to 2030, has the aim of reducing greenhouse gases by 40 percent compared to the 1990 level. In addition, a binding target has been set for the use of renewable energy (EU, 2014). The Paris climate agreement signed in the autumn of 2015 will further tighten requirements set for the energy efficiency of buildings and the adoption of renewable energy (UN, 2015).

The first step in implementing the strategy with regard to the existing building stock was the requirement to improve energy efficiency during renovations (EU, 2010b). In addition, the public sector has been tasked with setting an example by entering into energy efficiency agreements, improving the energy efficiency of public buildings, making energy efficiency a criterion for awarding public contracts, and obliging energy companies to help consumers cut energy consumption.

The energy efficiency of buildings is regulated by a specific 'Energy Performance of Building Directive (EPBD)'. However, the generally applicable Energy Efficiency Directive (EED) requires measures that go further. It requires member States to incentivise investment in the deep renovation of buildings (EU, 2012). Construction is also subject to the Renewable Energy Directive (EU, 2009) on the use of renewable energy and the Eco Design Directive on the energy efficiency of products (EU, 2010a). Energy performance certificates (EPC) are a result of regulations such as these.

A Deep Renovation Strategy must be drawn up at three-year intervals. A 'deep renovation' in accordance with the Energy Efficiency Directive is a cost-effective renovation which leads to a refurbishment that reduces both the delivered and final energy consumption of a building by a significant percentage compared with the pre-renovation levels leading to a very high energy performance. Such deep renovations could also be carried out in stages. EU (2013) indicates that the significant efficiency improvements resulting from deep renovation are typically of more than 60 percent energy. The requirement for high savings per cent follows the priority presented in the Kyoto pyramid (Figure 1) The private sector is even more ambitious having at least 75 percent energy saving target within deep renovation (GBPN, 2013).

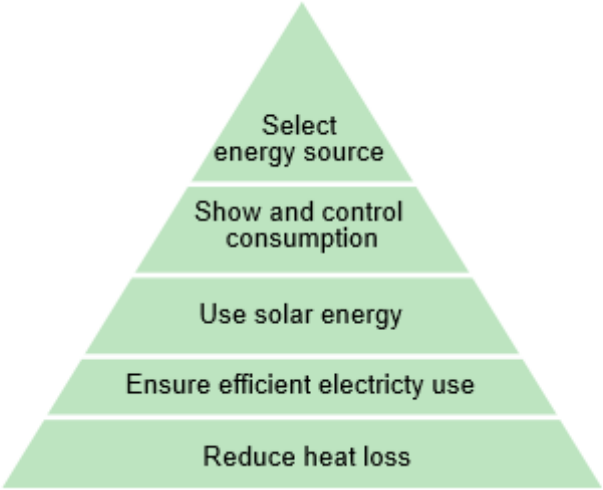

Figure 1. Kyoto pyramid principles in energy efficiency improvements.

The first Deep Renovation strategies were submitted for evaluation in the spring of 2014. It was assumed that the strategy would be a 'piece of cake' for the Nordic countries, where the energy efficiency of buildings is already high due to the cold climate and the energy crises of the 1970s. However, the evaluation of the Member States' strategies produced a surprise: the Nordic countries' strategies were rated below the average for the 27 countries assessed (JRC, 2016).

Estimated energy savings of the existing building stock are in the Nordic countries between 12..-35 percent to the year 2050 (Table 1). These figures are far from presented Deep Renovation target at least 60 percent.

	Denmark	*Finland*	*Sweden*
% change of total GWh	*-35 %*	*-20 %*	*-12 %..-25 %*

Table 1. Expected energy saving 2014-2050 in percent (heating energy and hot water)

1.2 Research question, method and material

The objective was to acquire understanding why top professionals of energy-efficient construction did not meet the criteria of Deep Renovation Strategy. The Kyoto Pyramid was used as framework for this case study.

A literature review forms the basis of the research method. The research material from Sweden, Denmark and Finland comprised material – produced by Nordic public authorities and research institutes – on the renovation of the building stock. It includes statistics of the building stock, legislation, regulations, and reports drawn up for the EU, on the implementation of the Energy Efficiency Directive (EED) and Energy Performance of Buildings Directive (EPBD).

2. Renovation strategies in Nordic Countries

2.1 Denmark

In Denmark, construction is regulated by the Building Act and building regulations (BR, 2015), the Act on Listed Buildings and Preservation of Buildings and Urban Environments (LBK, 2014), energy-

labelling legislation and regulations (LBK, 2016). When the Building Act was amended in 2010, the requirements set by building regulations were adjusted to apply to all renovation projects. Financing for improving the energy efficiency of old buildings must be sourced from the market. However, such improvements are also promoted via publicly funded advice, for example through information and education targeted at households. Also tool has been developed for construction sector projects. Financial support is provided in the form of tax deductions.

The energy requirements for new buildings have been steadily tightened since the 1970s energy crisis. Denmark sees that they have built up considerable expertise and, compared to other countries. Key components of Danish deep renovation strategy (Denmark, 2014) are 1) transparent market for renovations, 2) besides reduction of energy consumption also broader aspect of sustainability are taken account and 3) heating systems are converted to use renewable energy. The Danish strategy also includes cross-cutting initiatives relating to skills and innovation. These initiatives are intended to overcome barriers in promoting energy renovation by increased investment in training and skills development within energy renovation and a greater emphasis on research, innovation and demonstration.

2.2 Finland

In Finland, construction is guided by the Land Use and Building Act (YM, 1999) and the means of combating climate change set forth in the Climate Change Act (YM, 2014). More detailed regulations on the energy efficiency of buildings are issued separately for new construction (YM, 2012) and renovation (YM, 2013).

Finland's national strategy (Finland, 2014) emphasises innovation and technology dissemination, communications, skilled labour and education. Lessons learnt about the best ways to improve energy efficiency as well as successful projects need to be shared. Property owners are encouraged to introduce improvements in connection with normal structural repairs and system upgrades. The concept of energy efficiency as an integral part of all renovations should be emphasised by incorporating it into the curriculum at all levels of construction education. Courses have to be targeted for both young people and mature students and for both new recruits and professionals who have already established themselves in the industry.

2.3 Sweden

In Sweden, the Energy Efficiency Directive has been enacted via the Planning and Building Act (SFS, 2010), the Act on Energy Metering in Buildings (SFS, 2011) and supplementary decrees and building regulations, as well as general guidelines (BFS, 2016). The energy economy is evaluated on a holistic basis. Despite the fact that requirements have been set for energy consumption, the minimum level of building insulation, and electricity consumption and energy consumption metering, there is almost unlimited choice with respect to implementation methods. The energy efficiency of the old building stock is also promoted through other measures. The authorities maintain a range of guidelines, such as general guidelines on the alteration of buildings (BÄR, 2006). Briefing sessions have been organised by the Swedish Energy Agency, which has also drawn up recommendations for large-scale, nearly zero energy renovations. In addition, a range of provincial and municipal-level advice and technical assistance is available. Financial incentives include tax reductions and support for solar heating.

Previously Sweden had a target for improving the energy efficiency of the building stock. In 2010, a new structure of targets for the environmental target system was formulated. New target of a Well-Built Environment stresses a good, healthy living environment and contributes to a good regional and global environment. Sweden sees that they have an energy-efficient building stock compared with many other European countries. Deep renovation strategy (Sweden, 2014) bases on the assumption that there is an obvious opportunity to increase the energy efficiency of existing buildings in future 1) by well-working market, 2) by existing instruments (technology procurement and networks, subsidies to beyond the state of art projects, research, advice bodies, etc.) and 3) natural regeneration (renovation automatically improves energy efficiency, since components are replaced with more energy efficient ones).

2.4 Requirements from Nordic point of view

High scores tend to be given to countries which have reported their findings in minute detail (JRC, 2016). The Nordic countries would probably have produced similar reports in the 1970s, when renovation became a research topic in those countries. In the wake of the 1970s energy crises, a great deal of research was done on issues such as additional insulation, 3-glass windows and what to do about oil-based heating.

In its assessment, the EU placed an emphasis on changes in the number of renovated buildings (JRC, 2016). Raising the number of renovated buildings from zero to a thousand in just a few years would constitute a major change of this kind. A large decrease in consumption also earned a high score. If the performance of a building is poor, thermal insulation, better windows and central heating can easily reduce energy consumption by 60-80 percent. The situation is entirely different in the Nordic countries, where buildings that were insulated and connected to district heating networks during the building stage, are now starting to be renovated. Such buildings have less energy-saving potential than those with less insulation.

New financial instruments were another highly valued factor in the EU's strategy assessment report (JRC, 2016). In some European countries, it is possible to bring the instruments of international financial institutions onto the markets. This is not an option for rich countries. An unspoken rule of the market economy is raising prices by public support. R&D should be the means of ensuring that product prices and features are attractive to customers and products are affordable without public subsidies.

2.5 Key indicators of building energy performance against Kyoto pyramid

The Kyoto pyramid principles are reduction of heat losses, reduction of energy usage, utilization of solar energy, showing and regulating the energy use and choosing local energy source. Emphasis on structural renovations (level 1 in pyramid) is due the fact that two third of the EU's buildings were built when energy efficiency requirements were limited or non – existent. Most of these buildings will still be standing in 2050. It is estimated that huge savings can be achieved through simple renovations such as insulating the attic, walls and foundations, and installing double or triple glazing. The most cost efficient way is carrying out those measures within ordinary renovations (EU, 2016). Table 2 presents key indicators of building's energy performance in Nordic Countries.

Table 2. Kyoto Pyramid objectives / Key indicators of building energy performances in Nordic countries.

	Finland	*Sweden*	*Denmark*
Select energy source renewable energy (RES) *Heating*	*Converting to renewable energy ~ 48%*	*Strong use of heat pumps ~ 58%*	*Converting to renewable energy* *~ 29%*
Electricity	*~ 65 %*	*~50 %*	*~ 55 %*
Show and control consumption *(DH=district heating)*	*Electricity: 100 % smart metering* *DH: building level smart metering*	*Electricity: 100 % smart metering* *DH: building level smart metering*	*Electricity: 100 % smart metering* *DH: individual smart metering*
Solar electricity & heat	*< 1%*	*< 1%*	*~ 3%*
Efficient electricity use	*3,9 MWH/capita/a*	*3,8 MWh/capita/a*	*1,8 MWh/capita/a*
Reduce heat loss, facade, roof, windows	*Energy requirements have tightened continuously after 1970s*	*Energy requirements have tightened continuously after 1970s*	*Energy requirements have tightened continuously after 1970s*

Reduction of heat losses: All Nordic countries have established regulation to decrease structural energy use (windows, facades, roofs) already since 1970´s. The starting point was energy crisis during 1970´s. After that has regulation become more and more tight and in the future there will be nearly zero energy buildings. Comparing Nordic countries to other European countries there is not much possibility to save energy in reasonable prices.

Efficient electricity use: The specific domestic electricity consumption is high in all Nordic countries. Reasons for this are electric space heating, saunas in Finland, lighting during the dark wintertime, etc. There is big potential to use energy more efficient.

Solar energy: Solar energy is not common in Nordic countries. The share of solar energy is in Denmark about 3 % and in Sweden and Finland below 1 %. Sunny countries like Malta, Cyprus, Portugal and Greece are using 2-15 % solar power in heating.

RES in heating: In Finland RES heating is produced by 2/3 wood and biomass and 1/3 waste RES and geothermal heat. IN Sweden RES heating power is produced by nearly all biomass and Denmark about half of biomass and half of waste RES. All countries are increasing RES in heating. Nordic countries has already quite good situation with use of RES compared to other European countries.

In Kyoto pyramid principles in the Nordic countries there are minor possibilities in level 1 reduce heat loss. There are some possibilities to reduce household electricity use. The biggest reduction possibilities are at levels 3.4 and 5. Instead Kyoto pyramid, Kyoto Cube describes what better the most feasible ways to cut energy use of old buildings. This also explains poor scores what Nordic countries got from assessment of Deep renovation strategies.

3. Conclusion

This paper has discussed the Nordic countries' strategies for the energy-efficient improvement of their old building stock. The Nordic countries have long traditions in improving energy efficiency, which stretch back to the energy crises of the 1970s. They also have a great deal of experience and expertise in the energy efficiency of buildings. Over the decades, this has become integral to construction in such countries. Instead, the foundations of Kyoto Pyramid (reduction of heat loss) the most cost effective investment target can be found in the Nordic countries from Kyoto pyramid levels 3) use of solar energy, 4) show and control consumption and 5) select of energy source. Not anymore in reasonable price from Kyoto pyramid level 1) to reduce of the heat loss.

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The role of objects in decision-making processes: The case of an energy renovation

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Abstract

Most studies on decision making in construction projects suggest theoretical models or conceptual methods for how decisions ought to be made or which concerns or issues to include, but the number of studies which examine 'actual' decision-making processes are relatively scarce. This study reports on field work done in an energy renovation of a social housing estate in Denmark. Based on interviews, observations, and a document study, a decision-making process is reconstructed in regards to the choice of either installing a centralised or decentralised mechanical ventilation system in the buildings. The study focus on how participants try to convince each other by mobilising different objects and therefore contributes to discussions on which role objects play in construction projects. Two types of objects were mobilised in the pursuit of convincing others, namely a note written by an engineer and two decentralised ventilation units presented by scientists from the Danish Technological Institute. The latter was presented as having most impact on the decision, which meant installing decentralised ventilation in the buildings.

Keywords: Decision making; energy renovation; objects; actor-network theory;

1. Introduction

Decision making in construction projects has gained a lot of attention in academia. A great number of studies are approaching decision making by trying to explain how the processes should be done or what kind of topics or issues to include when confronted with decisions. For example, Ho (2011) has conducted a review of theoretical models which relates to decision making in construction management literature. She points out that authors built on previous models in order to construct their own contributions. Another review made by Jato-Espino et al. (2014) find many different multi-criteria decision-making methods have been presented in scientific articles over the years. Approaching decision-making processes by developing theoretical models or methods for how they should be done is an important topic, but what the studies are missing is to account for what is actually happening during decision making on construction projects. This present study investigates how decision-making processes occur during an energy renovation of existing buildings.

In recent years, some researchers have guided readers' attention towards why (or why not) sustainable measures are taken during the process of renovating single-family houses. Singlefamily housing accounts for a large part of the existing building stock in many countries in the EU. Incorporating sustainable measures when the houses are getting renovated might lead to reductions in carbon emissions on a national scale. Vlasova and Gram-Hanssen (2014) questioned in their study to what extent ideas of the future everyday life of inhabitants are included in the planning and design of retrofits of detached, owner-occupied houses. They highlight that decisions about implementing technologies which can reduce the energy consumption of the houses have impact on the social practices of the householders. They therefore suggest focus on how the material layouts of retrofitted buildings and the sustainable everyday practices of inhabitants relate to each other. Whereas the study by Vlasova and GramHanssen is one example of an empirical study of renovation of single-family houses, only little attention has been paid on empirical studies of decision-making processes during energy renovation of multifamily buildings. Palm and Reindl (2016) on the other hand study how energy efficiency measures are taken during renovation of multifamily buildings. Their study investigates the renovation processes of one housing organization in Sweden where explicit goals of improved energy efficiency have been expressed, and their focus has been on how these goals have been made part of the planning and design phase. They highlight that only little attention has been paid to the planning and design of renovation projects in multi-unit dwellings, even though decisions taken in this phase has great impact on the building after renovation. Design processes during energy renovation of multilevel housing has been understudied, and especially negotiations leading up to the "final" renovation design.

In recent study by Buser and Carlsson (2017), decision-making processes during renovation of single-family houses are shown to be shaped by material features of the building presented in technical reports together with the social practices with which the house is associated. The material features and social practices might even limit the scope of the renovation projects in some situations. Their study shows how a sociomaterial approach can be important when studying decision-making processes, because householders' decision whether to renovate or not (or to what degree) can be influenced by legal documents and energy reports which display certain interests, positions or goals. The present paper extends this research interest and scrutinizes how decisions are negotiated during energy renovation of multifamily housing blocks from a sociomaterial approach. Similar to Yaneva (2008), I reconstruct decision-making processes from a 'renovation in the making' and how material features, as described by Buser and Carlsson, shifts interests, convince others of a statement and display certain interests and

positions. The present paper draw on empirical material from field work conducted in relation to the renovation of a social housing estate in Denmark.

2. The role of objects in decision-making processes

Studying design of buildings are important, because designers can easier change the building represented in their drawings than the construction worker when construction already has begun. Changing materials of the walls or erasing rooms as a result of budget cuts can happen by a single click on the computer during design activities. On the contrary, during construction the change has a higher cost; materials need to be cancelled, already made constructions might be torn down, new expertise might have to be enrolled, and so on. Practitioners are therefore interested in preparing the building prior to construction as good as possible. But building design is not only the planning of material things, it is also the resolution of sometimes competing social interests (Gieryn, 2002). Deciding on how the building becomes "as good as possible" is an act of negotiations among the designers on the project. Planning for the stability of the constructions, the fire safety of the building, and similar concerns are one part of building design. Another is the negotiations of space disposition, functions and aesthetics, where eventual owners or occupants might be involved in these discussions. As Gieryn (2002) puts it: *"The interests of powerful voices in the design process are etched into the artefact itself"* (page 42). The interest of the designers in what the building 'is' or how it 'should be' is translated into programs and sketches as these discussions are going on. Building design is far from being a neutral playground for exchange of political interests. Instead, designers have to take into account competing social interests and choose whether to include one set of interests or exclude another set of interests. In order to meet a diverse set of interests, designers have to negotiate requirements, make compromises and incorporate these into drawings, documents and other project material. The "final" design will therefore be a product of the choices made during design of the building. However, the "final" design conceal the many possible design decisions and why some were made and others not. The very interests, politics and power negotiations which permeate building design are hidden. In this paper, I take a glimpse into the "machine room" of building design in order to investigate how negotiations of interests progress on a renovation project.

The role objects has been observed to be crucial in interactions among designers within the architectural, engineering and construction industry. Henderson (1999) points out that sketches and drawings are the basic components of communication among engineers and designers. Designers' words are built around the drawings and sketches. The drawings and sketches are important means for organizing the design-to-production process and serve as "social glue" between individual and groups of designers (*ibid*.). One empirical example described by Bendixen and Koch (2007) demonstrates how drawings are used to negotiate briefs of a 'building-to-be'. In their case, drawings are developed and used to support political purposes. The negotiations about the brief for the building project illustrate how the number of storeys in a building quickly could move between four and six without any drastic outcomes. Later in the design processes, these kinds of manoeuvre would probably lead to losses of substantial amount of detailed design work. Tryggestad, Georg and Hernes (2010) argue that projects are not the product of rational decision making, but projects are more likely to be controversial, subject to different interpretations, and something which needs to be negotiated among the parties involved. Project goals and design ambitions therefore change through the course of a construction project in various "trials of strengths" (Latour, 1987). In the case of Tryggestad, Georg and Hernes, objects such as artistic sketches, drawings, photos and models are not just considered as visualizations of knowledge

(Whyte, 2003), but the objects actively mediate construction processes and transforming ambitions along the way. The work on these objects and the circulation of them is used to test the design's technical feasibility. Authors have for some time called for attention to the role of objects in construction projects (e.g. Bresnen and Harty, 2010). In this paper, I want to extend these studies of decision-making processes by highlighting the importance of how various objects are presented for the parties along the way and give an example from an energy renovation project.

My account of the decision-making processes from the case is based on actor-network theory and an interest in the mundane and material practices (Latour, 1986) of designing a renovation project. In this paper, I am interested in following how people presents arguments on paper, on prints and diagrams, as well as in physical objects that take up space in meetings. Similarly to how scientists are explaining the world from inscriptions (ibid.), I want to trace how engineers, architects and tenants are explaining their world through choices of which objects to work with and present for each other.

3. Empirical setting and research methods

Social housing estates are increasingly subject to renovation. In many places, the age of social housing estates has resulted in poor living conditions and poor energy performance, and the aim of the renovation projects is to modernise the buildings and improve their energy performance. This paper gives insights to a case study of one such renovation project in Denmark, namely the renovation of four multi-family apartment blocks which are rented out as social housing. The case study focusses on the design phase and how decisions on energy-efficient measures are made during this period. One of the overall goals with the renovation project is to reduce the energy consumption of the apartments from an estimated consumption of approximately 130 to 50 kWh per square meter per year. The case study explores how the involved stakeholders negotiate and decide on initiatives to reduce energy consumption. This paper focus on one particular issue how a mechanical ventilation system with heat recovery should be installed in the four buildings.

Mechanical ventilation with heat recovery is one mean to drastically reduce the heating demand of a building (Meijer et al., 2009). A ventilation system like this reuses the warmth from the indoor air to pre-heat the supply air from the outside. The idea is therefore that the heating system, in this case radiators, would not have to heat up the indoor air as much as if there were no heat recovery. Together with other initiatives for energy reduction (such as thicker insulation in the building envelope, as well as replacement of the existing windows, doors and heating systems with new and more efficient versions), the ventilation system can reduce energy consumption while also improving the indoor air quality. This paper describes the processes leading up to the decision regarding the type of ventilation system; paying particular attention to which role different objects play during the negotiations. The decision in focus is whether a centralized ventilation system or decentralized ventilation system should be installed in the buildings (both with heat recovery). The decision has implications on maintenance and use of the ventilation units, which I will elaborate on in the section 4.

Social housing estates are owned and managed by non-profit housing associations in Denmark. The rent in social housing is regulated by the Danish government in order to accommodate for tenants with low incomes. Each housing association has their estates organised into individual housing sections which are financially independent from each other. The housing association is responsible for the strategic management of the housing sections, while the housing sections are responsible for the

everyday management of their (respective) estates. The social housing sector builds on a principle of democratic tenants' participation and self-governance. The tenants living in a housing section elect representatives to a board of tenants for that particular housing section. The board of tenants is responsible for the daily management and financial governance of the housing section. Tenants are entitled to exert influence on the agenda at the meetings in the board of tenants if they have any concerns or issues that they would like to raise. Once or twice a year, a general assembly is held in which all tenants in the housing section are welcome to participate. The board of tenants is in this case asked to decide which kind of mechanical ventilation they want in the apartments after renovation, and therefore play an important role in the discussions.

The case study revolves around a renovation project initiated by a housing association and supported by the particular housing section in which the buildings are located. The housing section, and in particular the board of tenants in this section, have been interested in renovating the estate since 2009-2010. Their interest stems mainly from a draughty building envelope, old water and heating systems, as well as problems with mould in some apartments. The renovation project went through different design proposal before it started officially in 2015. Most of the renovation costs are financed by the housing section themselves (by increasing the rent), but the project has also received economic support from the Danish National Building Fond. The role of the construction client is shared between the housing association and the housing section. The housing association manages the strategic decisions regarding estate operation in line with their overarching goals pertaining to all the housing sections, while the housing section, and especially the board of tenants, manages practical decisions about how building components and systems should be constructed to meet the wishes of the tenants. The housing association appoints a renovation committee which includes representatives from the housing association, the housing section and the consultancy companies allocated on the renovation project. The main purpose of the committee is to present details about the renovation project for the board of tenants, i.e. explain the technical, organizational and financial issues, so that the board can decide on specific issues. In this paper, I describe the process of one of these decisions.

The study is a qualitative field research based on interviews, observations, and a document study. The field work was conducted from August 2015 to January 2017 in which the renovation project moved from schematic design over detailed design to bidding procedure and tender. 22 meetings were observed, 12 interviews conducted and project material gathered along the way. Additionally, I visited the consultancy company which was responsible for detailed design of the project for 16 days over a two months period in order to follow discussions between project meetings. For the purpose of the study presented here, three interviews were conducted by the author; one interview with a ventilation engineer from the mentioned consultancy company which also is responsible for the design of the mechanical ventilation system, one interview with the project leader from the housing association, and one interview with three members from the board of tenants, one of them being the chairwoman of the board. The informants were asked about how they relate to the initiatives to reduce energy consumption taken in the renovation project and how decisions about the mechanical ventilation system were made. Sound was recorded during the interviews and the recordings were transcribed in order to get a sense of the informants' arguments. After transcription, the data was correlated with meeting minutes from the renovation committee meetings and field notes from observations at project meetings. The reconstruction of the decision processes presented in section 4 is made on basis of a triangulation between the interviews, the documents and my own observations. At observations of project meetings, I recorded sound and took notes. During the meetings, I focused on how the participants referred to

entities either present in the room or of which had been circulated among them by for example email. During the field work, a conflict seemed to arise amongst the participants. An issue which led to discussions for four months. The discussions are what led me to write this paper.

4. Decision on mechanical ventilation

The case revolves around a decision whether to install decentralised or centralised mechanical ventilation system in four multilevel apartment buildings. The decision has implication on how the ventilation system will be used and maintained. If the decentralised system is selected, then the tenants can operate it from their apartments. If the centralised system is selected, then only the maintenance employees would be able to operate it. Because the decision affects the tenants, the housing association wanted the board of tenants to decide what they would prefer. The decentralised ventilation units are placed in the apartments and the tenants can adjust the temperature of supply air and the airflow in each apartment separately. The centralised system has ventilation units standing on the roof or in the basement, and when the maintenance employees change the temperature of the supply air, they change it for all apartments that share the same staircase. If the board of tenants decide on a decentralised ventilation system then they themselves need to take care of some maintenance, namely changing filters in the ventilation units once or twice a year. The rest of the maintenance will professionals take care of, such as if the units break down. If the board of tenants decide on a centralised system, then the maintenance employees are responsible for changing the filters of the ventilation units. The board of tenants therefore encounter this decision and in this section I will describe how the decision process unfolded during the course of the project.

4.1 Experiences before the renovation project

First, I will introduce three experiences which, as I will show later, have had impact on which system the board of tenants choose in the end. The experiences have been told by the informants after the decision was made and they had to reflect on the process. The first experience is one that is prevailing in the housing association. The experience was told by the project manager from the association and she related the experience to some previous renovation projects made by them. In other estates, the housing association had installed centralised ventilation, where tenants had blocked the ventilation outlets in the apartments, because they felt draught from the outlets. Since the system is measured to be balanced across all apartments in, for example, one staircase or one building, blocking will lead to higher airflows in the remaining apartments. The action taken by the tenants gave the association some extra work in order to ‘correct’ the ‘wrong’ behaviour. First, the association needed to gain access to the all the apartments by notifying the tenants weeks in advance. Then inspecting the apartments, telling the tenants not to block the outlets, and re-adjusting the ventilation units.

Another experience about ventilation systems for social housing was expressed by the ventilation engineer from one of the consultancy companies designing the renovation project. His responsibility is to plan and design the ventilation system on the renovation project. When reflecting on typical ventilation systems for social housing during an interview, he stated that he usually did not plan decentralised for multilevel apartment buildings. His experience is that manufacturers usually recommend centralised systems for multilevel apartment buildings and decentralised systems for detached, single-family houses.

A third experience about ventilation units in multilevel apartment buildings is expressed by the board of tenants. Their experience revolves around a centralised unit standing on the roof of a newly built multilevel apartment building next to their apartments. The building next to their apartments was constructed in 2012, and since then, tenants have heard noise from time to time coming from the unit. The unit *"wails over there",* as one member of the board states. The board assumes that the noise is due to lack of maintenance and changing the filters would help. The noise is reaching one tenant who live in the apartment block furthest away from the neighbouring apartment building. Additionally, the board do not like the appearance of the large metal boxes which comprise the units. This experience, together with the other two, has been expressed after the decision of ventilation system had been chosen.

In August 2015, a discussion on the renovation project starts about which kind of ventilation system to install in the buildings. The backdrop of the discussion is the three experiences described above. The discussion goes on for three months and involves three important events: 1) A presentation by the ventilation engineer about pros and cons for the two types of systems, 2) A visit to the Danish Technological Institute arranged by the housing association, and 3) the "final" decision made by the board of tenants.

4.2 Presentation by the ventilation engineer

At a meeting in September 2015, the ventilation engineer presented the two possible ventilation setups for the board of tenants and the rest of the renovation committee. His presentation consisted of the following themes: The two different ventilation principles, maintenance of the two systems, service life of the different units, variations in occupant influence, as well as estimated prices of instalment and replacement. Prior to the meeting, the engineer had send a written note about the ventilation options to the meeting participants. In the note, the engineer describes centralised ventilation as the "traditional" type of ventilation for these types of buildings and generally the note seems to favour the centralised version. The following section is taken from the introduction.

"Given that decentralised solution is an alternative to centralised ventilation solution – which not until recent years has become popular in the Danish housing stock – is the structure of the note built up by the differences between the decentralised solution in relation to the traditional centralised unit structure" (note written by the ventilation engineer, October 2015, translated by the author).

The cost calculations stated in the document also favour the centralised version. The decentralised version is estimated to be almost six times more expensive if the tenants change the filters and almost ten times more expensive if the maintenance staff change the filters. Both compared to the centralised version. Additionally, the costs for replacing broken units in centralised version is estimated to be almost 33 percent lower than the costs for replacing decentralised units. The document ends by recommending the building client to choose a centralised system, because service of decentralised units would be a challenge. The engineer stated during an interview that he tried to convince the board of tenants to go with centralised system, but would plan and design which ever system they wanted. He distributed the note among the participants as an inscription device arguing for his interests and in hope of convincing the others. In the top of the note, it says that the purpose of the document is to be a "basis for decision", and based on my interviews, the document has been part of considerations in the board of tenants and the housing association.

The board of tenants did not get convinced about any of the two types of systems after reading the note and hearing the presentation from the engineer. Their reaction to the arguments was that it would not matter which system they choose.

"[The engineer] did not recommend any of the two systems. He told us it did not matter which one we chose. There would be practical and impractical things with both units" (member of the board of tenants, November 2016, translated by the author).

Even though the engineer tried to convince the board of tenants, the tenants were not convinced and for them the decision was still open. They wanted more information about decentralised units, because they were displeased with the centralised units nearby their apartments, but they were not completely sure on the decentralised either. The next event is their effort to learn more about both ventilation principles, but especially the decentralised version.

4.3 Visit to the Danish Technological Institute

The members of the renovation committee took a field trip to the facilities of the Danish Technological Institute1 (TI). Among them were the board of tenants, representatives from the housing association (e.g. the project manager), and representatives from the consultancy companies (e.g. the ventilation engineer). The visit consisted of two parts; first, a presentation by two of their scientists which both are trained engineers, and second, a visit to their laboratory to see examples of decentralised ventilation units. The project manager from the housing association recall the main points of the visit in the following way.

"A researcher told us about the two types of ventilation – benefits, disadvantages, experiences, what people do today, and so on. There was brought a couple of decentralised units in, so you could see them physically. You could see how it was to take such a filter in and out of the unit." (project manager from the housing association, November 2015, translated by the author).

The way the participants remember the presentation by the scientists was similar to the one that the ventilation engineer had given earlier. Again they understood that they could choose both kinds of systems, but the information about prices was different this time.

"We were not recommended the one over the other. Price-wise it was the same." (another member of the board of tenants, November 2016, translated by the author).

The presentation by the scientists act as an anti-program (Latour, 1990) against the interests of the ventilation engineer. The argument put forth by the ventilation engineer was that there would be a price difference, but the scientists stated no difference in price.

After the presentation held by the scientists, all the participants went into the laboratory of the Technological Institute. In the laboratory, two decentralised units were placed so the participants would be able to see them "physically", as the project manager called it. The ventilation engineer said that the display was to show "how the box looks like and how you open and close it."

The reaction from the members in the board of tenants was that the visit was quite satisfying for them. Seeing the physical ventilation units seemed to make quite a difference. The chairwoman in the board describes it in the following way.

"We got the experts from [TI], who have studied many things, to present a review of ventilation systems we could have in the apartments. That is, like a fridge. Mechanical ventilation. We saw different things. How much space it took up, what it was able to do, and so on. It was a real eyeopener" (chairwoman of the board of tenants, November 2016, translated by the author).

1 The Danish Technological Institute is a consultancy company specialised in developing and testing technologies, e.g. energy and climate, food, biotechnology, materials, production and construction technologies. For more information, see http://www.dti.dk/about.

The board of tenants was told how to change the filters in the units, they heard them run silently (like "a fridge"), and saw how much room they took up. The chairwoman of the board calls it "a real eye-opener", because until the laboratory visit, they had only been talking about the ventilation system as technical values, economic values, as well as lines on plan drawings and photos of similar units. After the visit, the board of tenants had a better sense of how the ventilation units could be able to fit in their future apartments.

4.4 Decision on which type of ventilation system it should be

The two types of ventilation systems both have benefits and shortcomings. The ventilation engineer presented his point of view and recommended centralised units. The scientists from the Technological Institute presented their point of view, plus physical examples of decentralised units. The board of tenants ended up choosing decentralised ventilation units for the project. The adjustable airflow and temperature on supply air into the apartments were important issues for the board of tenants. As a member of the board of tenants explains it:

"We decided on the decentralised units, because then people can choose their temperatures themselves. You can adjust the supply air from 19 to 22 degrees, if I remember correctly" (member of the board of tenants, January 2017, translated by the author).

As an earlier quote from a member of the board of tenants stated, the scientists from the Technological Institute presented the two types of ventilation systems without a price difference. Next to this, the board of tenants were displeased with the centralised unit on the neighbouring building. Also the minor sound the decentralised units were making pleased the board. The board of tenants had these issues in mind, but their certainty became first apparent after the visit at the TI. As one tenant describes it:

"We should figure out how it could be placed in the apartment, where it should be placed, because there were different kinds [of decentralised units]" (member of the board of tenants, January 2017, translated by the author).

By the quote above, it seems that seeing the physical units had an impact on th board of tenants' decision.

5. Discussion

The present study reports on a renovation project "in the making" (Yaneva, 2008) when design decisions are open to interpretation, fluid and valuated in many different ways. The complexity of renovation projects are extensive, and this study is only a fracture or a small peep into the "machine room" of designing. Following decision-making processes, the difficulties the participants meet, the unpredictable obstacles turning up, the opposition the participants are meeting, is a very difficult task. I have tried to reconstruct how a particular decision unfolded over the course of four months, but by taking the complexity of renovation projects into mind, then this particular decision process could have turned out in several other ways. The interesting part is how social structures are "becoming" through design (Gieryn, 2002). The way this decision process has been, the future tenants of the estate need to change filters in their ventilation units. They are handed over maintenance tasks. The question then becomes if they "subscribe" to this idea of themselves which originated from the deisgners' intentions (Akrich and Latour, 1992).

A lot of work has been done on drawings (e.g. Henderson, 1999; Bendixen and Koch, 2007; Whyte, 2007), but less attention has been paid to all the other types of objects that constitutes construction processes. In this case, a document, presentations by professionals and two ventilation units were also part of decision-making processes. Since there is not many other studies to compare these observations with, the role of these objects are still up for question. It seems from this case that the physical ventilation units had an impact on the decisions made by the board of tenants, but if this will be the case in other similar projects must be an empirical question.

The advices made by experts such as the ventilation engineer and the two scientists at the Technological Institute also seemed to play a part in the decision. However, as pointed out by Buser and Carlsson (2017), different sources of expertise might provide contradictory advices. In this case, the presentation from the ventilation engineer was slightly out of sync with the presentation by the scientist, while the latter disagreed with the price difference presented by the first. Expert knowledge, like the decision processes, is therefore not to be regarded as "black boxes" (Latour, 1987), but can play out many different ways.

6. Conclusions

The present study highlights the importance of studying energy renovations 'in the making' and reports on a particular decision-making process by focussing on which role objects play in the negotiations among the participants. Based on a qualitative field study consisting of interviews, observations, and document study, the study reconstruct three main events in which participants discussed whether to install centralised or decentralised ventilation in the renovated buildings and where objects played an important role. The three events were a presentation by a ventilation engineer which favoured centralised ventilation, a visit to the Danish Technological Institute which seemed to favour decentralised ventilation, and the choice made by the board of tenants which landed on decentralised ventilation. Two types of objects were observed to have an impact on the discussions, which were a note written by the ventilation engineer and physical decentralised ventilation units presented by the Technological Institute. Studies of objects' role in decision-making processes during construction projects is scarce, however this approach to decision making in construction could lead to a reassessment of how we understand 'actual' decision-making processes.

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Architectural qualities in protected buildings

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Abstract

This article provides a theoretical basis for the management of architectural qualities in protected buildings. A lack of focus and structural emphasis on architectural qualities within the management of protected buildings is an obstacle for suitable protection and development of such buildings. Architectural qualities are among the formal reasons for the protection of buildings. Still, such qualities are not stressed in their management, which instead prioritize provable historic qualities and juridical framework. The article poses four questions: (1) Is architectural quality of universal validity or is it subjective? (2) Is there a final definition for architectural quality in a building, e.g. the original architects intentions? (3) Is architectural quality unaffected by whether the building is in use? (4) Are protected buildings living architecture, or do they belong to the past as museum objects? Answers are sought in a theory of knowledge and understanding, Gadamer's hermeneutics, due to its gravity and its emphasis on the cognition of architecture. Despite its recognition, it is not generally applied to the management of protected buildings. Gadamer's hermeneutics deals with human existence, of which the art experience in architecture is merely one aspect. Gadamer dismisses a subjective understanding of architecture, declaring that experiencing architecture is participation in a fellowship of meaning. Gadamer's writings have provided added theoretical perspectives on architectural qualities in protected buildings, and incentives to protect, use and reinterpret protected buildings: the legal protection of a building is a formalization of the buildings existing significance. This forms a premise for the use of a protected building, with a continued focus on and reinterpretation of its significance. Gadamer focuses on the work of art, rather than the creator: to understand is not to enter the artists mind but to enter the space of meaning that the work offers. The article offers a theoretical foundation for the management of architectural qualities in protected buildings. Applying hermeneutics to the management of protected buildings implies that one should place emphasis on architectural quality, continued use and reinterpretation of significance. The aim is to enable dialog on and management of architectural qualities, in addition to historical qualities, in protected buildings and generally.

Keywords: cultural heritage, protected buildings, architecture, Gadamer, hermeneutics

1. Introduction

This article aims at providing a theoretical basis for the management of architectural qualities in protected buildings. The term management of architectural qualities addresses the structural emphasis on, valuation and continuous safeguarding of qualities that can be said to be architectural. For this to happen, one must be able to describe architectural quality. This paper discusses such quality, in relation to the management of protected buildings. In the management of protected buildings, there is a continuous balancing of use versus preservation. There is also a continuous ponderation of architectural and historical qualities. Whilst both architectural and historical qualities can form a premise for the legal protection of a given building (Lovdata, 2016), the continuous safeguarding of such qualities does not necessarily benefit from the same moves: the perception of protected buildings as historic document fabrics, contrasts the continuous reinterpretation and transformation that is often needed for a building to keep in pace with a changing society.

The term 'protected buildings' refers to cultural heritage buildings that are protected by law. Such legal protection affects the management of such buildings, as they are associated with more limitations than buildings that are not protected, in terms of changes that can be made to them, and they are also associated with and partly managed by the cultural heritage field, which differs from general building management. When the term 'cultural heritage' is used, it refers to the professional field of cultural heritage.

Both history and architecture are established fields within our societies and academic institutions. However, history has a larger basis of widely accessible knowledge, whilst architecture to a larger degree can be seen as a proficiency, less accessible to the nonprofessional. There is a range of qualities that work together to create architecture. Architecture covers different skills needed in a building, such as calculable constructions, logistics and historic style. At the core of the architect's profession, there is the phenomenology of architecture (Norberg-Schulz, 1980). This relates to the space of meaning that the architecture offers; how we experience the architecture and how this affects us. This is a profound tailoring of a building to its use, where the building assists your state of mind, such as a library accommodating concentration, a place of worship accommodating spirituality and a prison posing a space for repentance. This part of the profession distinguishes architecture from engineering and history, and connects it to art. In resemblance to other works of art, these qualities can be difficult to communicate. Even architects have inadequate language for it. This affects the public debate on architecture, and it affects the management of architectural qualities in protected buildings. As these qualities are deeply connected to a building's intended use, and will affect any use, they are an important aspect to consider in the management of protected buildings.

Cultural heritage was established as a professional field at the end of the 18th and during the 19th and early 20th century. The field went from being dependent on private initiatives to having juridical framework and a significant level of international cooperation. Leading theorists from the institutionalisation of the field are still frequently referred to today, such as Eugène Emmanuel Viollet-le-Duc (1814-1879) and John Ruskin (1819-1900). While Viollet-le-Duc was occupied with scientifically based restoration (Viollet-le-Duc, 1877), Ruskin underlined the irreplaceable and weighty value of age, and described restoration as *'The most total destruction a building can suffer'* (Ruskin, 1880, p. 194). Alois Riegl (1858-1905) focuses on historic and age value, and dismisses artistic value as subjective and relative (Stanley-Price, Talley and Melucco Vaccaro, 2010). His writings have had a

considerable impact on art history, and on management of protected buildings in the Nordic countries. Viollet-le-Duc, also a practicing architect, can be claimed to emphasize architectural qualities. Whilst Ruskin said '*We have no right whatever to touch them' (Ruskin, 1880, p 197), and Riegl stated 'one may no longer speak in the future of "artistic and historical monuments, " but only of historical monuments. '* (Stanley-Price, Talley and Melucco Vaccaro, 2010, p 72), Viollet-le-Duc allowed for reinterpretation and restoration based on an understanding of the architect's original vision. He was inspired by science and anatomical studies (Vinegar 1998), and aimed to develop a scientifically founded management of older buildings, based in an understanding of construction, use and historic style (Viollet-le-Duc, 1860). It is relevant to also consider protected buildings and their significance from a philosophical viewpoint.

Hermes, Greek god and messenger, is credited with the ancient Greek hermēneuein, to interpret, which combined with technē gave hermēneutike, the 'art of interpretation' (Honderich, 2005). Hermeneutics originated as a tool for the interpretation of text, and has evolved to include numerous fields where interpretation of embedded meaning is of relevance, such as law and art, amongst others (Krogh, 2014). Snodgrass and Coine (1996) argue that the design process (of buildings) is hermeneutical, as opposed to formal logic: *'(...)the design process belongs to the domain of social actions and interactions, is firmly embedded in a human situation, and is a focal nexus within a network of intersubjective relationships'* (Snodgrass and Coine, 1996, pg. 92). Snodgrass and Coine emphasised Gadamer's writings. Gadamer has also been used in the education of architects (Leach, 1997). Tatla (2011) states that modern architecture is indebted to Gadamer and Philosophy in general, specifically for the methods for communication it has provided. Gadamer's hermeneutics has inspired architects and others for decades (Kidder, 2013).

Hans-Georg Gadamer was a German philosopher occupied with and influential in hermeneutics. The hermeneutics of Hans-Georg Gadamer will be a main focus in this article. The hermeneutics of Gadamer emphasizes the experience of art, including the experience of architecture (Gadamer, 2013). Gadamer is also interesting for his emphasis on the cognition of architecture. Gadamer believed that it is vital to understand architecture hermeneutically, and that architecture is suited to the understanding of hermeneutics: architecture carries meaning that takes part in, contributes to and is intertwined with a superior reality. Gadamer was occupied with premises for interpretation of architecture, and directly discusses the research questions for this paper. It should be noted that Gadamer, although interested in the cognition of architecture, is primarily chosen for his interpretation of art in general. He is not primarily considered a thinker of architecture, as his works cover a much wider field. Despite its general recognition within philosophy, Gadamer's hermeneutics is not generally applied to the management of protected buildings. The management of protected buildings has, as our community as a whole, been affected by the subjectification of the art experience, referring, amongst others, to Alois Riegl (Riegl, 1996). The subjectification of the art experience dismisses the capability of assessment of architectural quality, instead focusing on historic qualities. We argue that this attitude is ignoring fundamental qualities in protected buildings.

Our reason to dive into this philosophic field is a wish to clarify architectural quality, our relation to and experience of such quality. We desire to understand what architectural quality in protected buildings entails and how it can be accessed and grasped. The aim for this article is to provide a clarifying, theoretical perspective on how one can perceive architectural quality, as distinct from other qualities in protected buildings. The purpose is to enable awareness of architectural quality in protected

buildings, so that this can be observed, documented, discussed and managed in an expedient manner. The article poses four questions:

• Is architectural quality of universal validity or subjective?
• Is there a final definition of architectural quality in a building, e.g. the original architects intentions?
• Is architectural quality unaffected by whether the building is in use?
• Are protected buildings living architecture, or do they belong to the past, as museum objects?

We aim to discuss these questions, with a basis in Gadamer's hermeneutics. The results from this study will be a reflection on architectural quality in protected buildings in relation to key hermeneutic theory. A brief introduction to hermeneutics will be given, including origin, meaning and application. The main focus will be on Gadamer, his writings in his main work 'Truth and Method' and its relevance to our research questions.

2. Architecture in protected buildings

Architecture is an ancient profession. Our oldest preserved book on architecture is Vitruvius' 'De architectura' from between the years 30 and 15 BC. Architecture is also a professional field in continuous change. Such continuous change works against an institutionalization of a professional field.

Architecture is a field depending on science and calculations. This is critical for the construction and durability of our buildings. Coincidentally, architecture is a field connected to the arts, through its teaching and our experience of architecture as an art form, exhibited in galleries and elaborated on in books. Architecture is also an important culture bearer; architecture is a historic document fabric. Protected buildings are the historic documents that are the most accessible to the general public (Young, 1991). Architecture includes numerous fields and qualities. This is relevant for the management of protected buildings. Such buildings are typically adapted to new uses or technologies and in the adaption process, something in the protected building needs to change. Even if it is an empty space that is sacrificed, this affects the building. To make qualified decisions on what one should keep and what to waive, an understanding of the different aspects embedded in protected buildings is vital. Architecture is shaped around humans and their needs (Vidler, 1990). Thus, a strengthened focus on architectural quality in the management of protected buildings could ease such management, choice of uses and adaption to those choices. This study´s ontological standpoint implies that protected building use and legal protection are dependent on the existence of the building itself: it looks at what exists and the hierarchy of these existences. The study looks to the theory of cognition, and especially Gadamer's hermeneutics, as Gadamer emphasized the cognition of architecture.

3. Method

It can be difficult to distinguish the art experience architecture offers from other aspects of a building. This is relevant for all existing buildings, and is a challenge when working with protected buildings. This paper discusses the four research questions, based on a literature study of hermeneutics in general and Gadamer's hermeneutics in particular. The aim is to provide a reflection on the interpretation of architectural qualities and an understanding of their existence.

4. The hermeneutic circle

Hermeneutics is a collection of theories related to interpretation. In connection to the Reformation, there was a need for reinterpretation of the Sacred Scriptures. Matthias Flacius Illyricus (1520-1575) was Martin Luther's successor. In 1567, Flacius issued 'Clavis Scripturae Sacrae seu de Sermone Sacrarum literarum' (directly translated 'The key to holy scripture or a discourse concerning the language of the sacred writings') (Flacius, Johnston and Kilcrease, 2011). Flacius claimed that, in the Sacred Scriptures and in other matters, the different parts that constitute a whole obtains its comprehensibility from its relation to the whole and the other parts this whole consists of (Krogh, 2014).

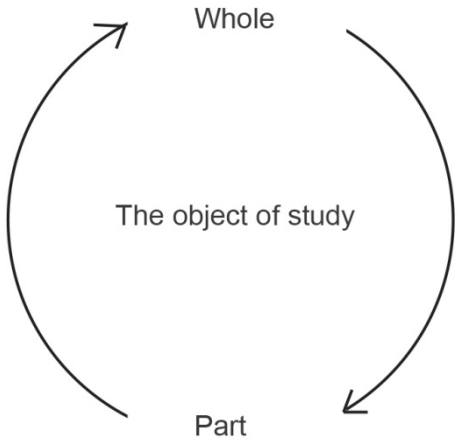

Figure 1: The Hermeneutic circle

This is an important principle in hermeneutics and is illustrated in the hermeneutic circle in figure 1. The hermeneutic circle was invented by Friedrich Ast (1778-1841) (Krogh, 2014), but the principle is seen already with Flacius. It is vital that the part and the whole are not equally important; the whole is more important than the individual parts. Hermeneutics started as a tool to interpret text, where the connection to the texts' meaning was uncertain, or the connection to the author, the time period or other key frameworks were broken. Over time, hermeneutics has been applied to a wide range of objects where interpretation is of interest: amongst these are religious texts, juridical texts, literature, expressions of the arts and politics (Krogh, 2014).

Martin Heidegger (1889-1976) developed the hermeneutic circle. He showed how it is not only the whole that affects our understanding of the parts, but our understanding of the whole (Lægreid, 2006), as shown in figure 2. For Heidegger, history was important to our society due to the insights it can render to the future. Gadamer was Heidegger's student. Gadamer's hermeneutics concerns the interpretation of text or other expressions for man's creativeness, as the object presents itself to us and with the insights it has potential to give us.

The singularly most important text for this research is Gadamer's main work, 'Truth and Method', and it's writings on the art experience. It has also been necessary to look at other researcher's notions of Gadamer as a thinker within the professional field of architecture. These writings are discussed in relation to the four research questions, which are based on experience from working in the cultural

heritage field. They are articulated to discuss topics that the authors perceive to be inadequately both discussed and answered in the management of protected buildings today.

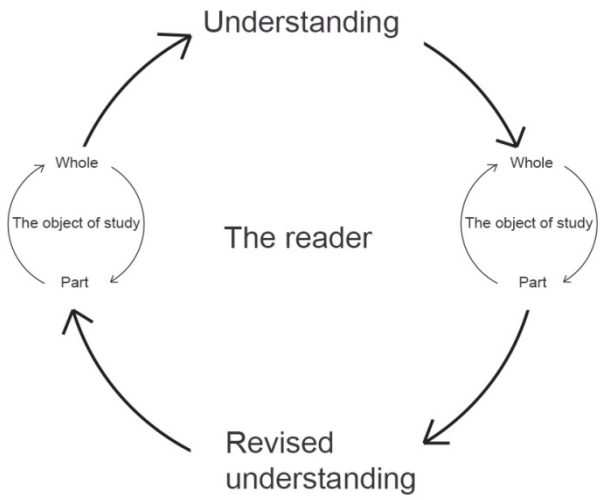

Figure 2: Heidegger's developed hermeneutic circle

5. Gadamer

As a young man, Gadamer had an interest in numerous fields; music, art, language, philosophy and history. He describes meeting Heidegger as epoch-making, and how this meeting released Gadamer from a sense of self-confidence as a young student. He delivered his doctorate dissertation, on Plato, at the age of 22. He first became a professor in Marburg in 1937 and later obtained a professorship in Heidelberg, where he was active until his death in 2002. His major work is the extensive book 'Warheit und Methode' (1960), 'Truth and Method', a principal work in twentieth century hermeneutics (Krogh, 2014).

Gadamer's hermeneutics is not science and is not based on a hypothetico-deductive model (Connolly and Keutner, 1988): it is not easily verifiable, reconstructed or value neutral. Text and other expressions of human creativity are still communicated. It is possible to follow, as in verifying, another's communicated chain of thought in a search of truth and accuracy. Gadamer refers to the hermeneutic circle, and how we should understand the part through our understanding of the whole and vice versa (Gadamer, 1988). He describes how this principle has shifted from antiquity's rhetoric to modern hermeneutics, from being applied to the art of speaking and to the art of understanding.

Gadamer describes our ability to read text, abstracted reality, written down with abstracted symbols, and to understand this text. Gadamer claims that it is a task of hermeneutics to clarify that this is not mystic communication between spirits but participation in a mutual meaning and perception of reality. Gadamer did not see our historic standpoint as an obstacle, but as a key to insights: the object carries eternal insights that are continually understood within a continuously changing framework. We are not capable of understanding a work of art detached from our value sets; instead, we should reflect on these value sets and, if needed, replace them. Gadamer's hermeneutics is ontological; dealing with human existence, and the hierarchy within existence. It is also philosophical; it aspires to answer the unanswered. When an unanswered question finds an obvious answer, it is no longer part of philosophy.

5.1. Truth and Method

'Truth and Method' is Gadamer's main work. One third of this book is dedicated to the understanding of art, including and focusing on understanding architecture as a work of art. The title goes directly into the core of Gadamer's hermeneutics, 'Truth', and the era's expectations to research according to scientific principles, also within philosophy; 'Method'. Gadamer points out that the theory of cognition was created before, and thereby independent of, the limitations of modern methodology in science. Gadamer focuses on the work of art, rather than the creator: to understand is not to enter the artists mind but to enter the space of meaning that the work offers. Gadamer claims that a prerequisite to understanding, in a new time and under new conditions, is to understand differently. Understanding is part of a continuous remodelling process of the work itself. This is possible because the meaning of the work is intangible: a painting is tangible, but the idea that inspired its creator is intangible, and can barely be understood through is tangible manifestation. The conclusion is that the work of art has the higher level of existence, and that the person experiencing the work of art, being they the artist or the spectator, is subordinate. The subordinate enters the work of art. By experiencing the work of art, the spectator does not create the experience; he fulfils it.

5.2. Das Spiel: the play

Gadamer uses play to illustrate our experience of art. This might seem unfitting at first; however, the choice of explanatory model is elaborated on. Ontologically, the play has a higher level of existence than the player. A chess set, tucked away in a drawer, still exists without being played, but it must exist for us to play it. Although chess exists without being played, a value is lost; by being played, chess is fulfilled. By playing, the player enters a form of existence that is more fundamental than that of the player. This is shown in how the player becomes absorbed by the game of chess. Gadamer transfers this insight to all 'Spiel', plays, and to our experience of the arts; the work of art exists without our experience of it, but its existence is then unfulfilled. When the viewer enters the art experience, he fulfils the work of art and enter a higher form of existence, allowing the viewer to forget their surroundings and be absorbed by the art experience.

5.3 Prejudice

Humans have subjective references; however, great art speaks to the majority, and has spaces of perception we can enter due to common cultural preferences, our prejudices, according to Gadamer. Gadamer dismisses the Enlightenment's idea, of liberating the text from historic framework by seeing through this, as naïve. Understanding cannot be value neutral or objective, as understanding begins with a preliminary understanding that the reader uses to relate to the text. This preliminary understanding is then altered by the experience of reading the text. The preliminary understanding is based on our prejudices. To Gadamer, prejudice is a positive feature, a tool we need to understand. At the same time, we should be prepared to alter our prejudices, to open up to new insights. Gadamer criticises Kant's subjectification of aesthetics, and claims that it led to a hundred yearlong ontological embarrassment. According to Gadamer, it is vital to overcome a subjective definition of art. To Gadamer, art is a common bearer of culture and meaning, of importance to our society.

5.4 Horizon of understanding

Gadamer believed that we should start a dialogue with the text, be open to change our prejudices and thereby gain new insight; this is referred to as the fusion of horizons. The horizon of understanding is vital in Gadamer's hermeneutics. We are restricted by the limitations of our mental horizons. Gadamer does not focus on this as a positive or negative premise for our understanding; his description is factual. The horizon of understanding is not meant as a psychological term, referring only to a person's inner thoughts; it can be the horizon of a profession or a society.

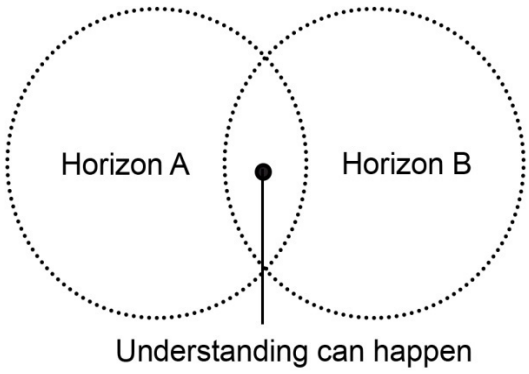

Figure 3: The horizon of understanding

If two such horizons, ours and the object we seek to understand, have no overlap, there is also no understanding. To gain understanding, our horizon needs to change, so that the horizons reposition in a way that overlap. This meeting of horizons is referred to as the fusion of horizons.

5.5 Reception history

A works reception history is, to Gadamer, its capability to communicate with us, and let its initial horizon continue to exist in our time and within our horizon. The link that makes such continued understanding possible is tradition. Antiquity, our civilisations cradle, is still capable of affecting us, through its works of human creativity. Gadamer claims that Romanticism and Schleiermacher fail to recognize our connections to the traditions we come from, as the basis of our interpretations and thus for all hermeneutic effort. He believes that Schleiermacher's hermeneutics faded into methodology and missed a crucial point in hermeneutics by looking to the past rather than the present in the interpretation of older works. Gadamer writes, in 'On the Circle of Understanding', that understanding is mainly about understanding ourselves. Understanding others comes second. The most important insight we can gain from striving to understand, for example antiquity's texts, is understanding for our time, not the epoch these texts stem from.

5.6 Bildung

Bildung (culture) is a term used in 'Truth and Method', and is seen apart from taste. Whilst taste is individual, bildung is a community, a common level that is defining of a culture. According to Gadamer, the original purpose of bildung was the development of culture, but it has deteriorated into a self-conscious system where the bildung and its demonstration have become goals in themselves.

6. Concluding discussion

The research questions are based on pressing issues that are inadequately discussed today. A continuous challenge when working with protected buildings is the subjectification of art and architecture. Most people are capable of using a building adequately, and to decide whether an artwork is to their taste. However, whilst everyone has the right to personal taste, this is not automatically the same as having the ability to be a professional and legitimate judge of a given buildings universal value. Thus, we ask the first research question: according to Gadamer's hermeneutics, is architectural quality of universal validity or subjective? Gadamer thought that the subjectification of art led to untenable, aesthetic nihilism. He claimed that great art speaks to many, due to tradition, with common references. Architecture and its qualities are, according to Gadamer, general. The architect works within a tradition and stands on the shoulders of giants.

Another challenge in working with protected buildings is the demand to return a protected building to its former state, perceived to be a buildings true state. However, buildings, their surroundings and the way we perceive their value change continuously, and such a hunt for a buildings true state can be unworkable. This led us to the second research question:

In our second research question, we asked if there is an upshot for architectural quality in a building, e.g. the original architect's intentions? Gadamer differentiates different arts, such as the reproducing arts; music and theatre, and sculptural arts; architecture. This does not mean that architecture does not change. Within a changing world, the work of art will also change. Not only do we perceive the work of art differently, sculptural art appears differently with altered conditions. Gadamer points to our connections today, and how recreating the past is not possible. Any attempt to recreate the past can only produce a copy. Such a copy, according to Gadamer, will not be a return to the work of arts inner meaning, but instead a reproduction of dead meaning. It should also be noted that not even the original artist knows the full, inner meaning of a work of art, as there is also unconsciously added meaning.

Architecture is designed to facilitate human life and activities. Still, one possible consequence of the legal protection of buildings is that they are used less, or not at all. This is sometimes due to the vulnerability of specific cultural heritage values, but it can also be due to simple inconvenience associated with the protection, related to administrative procedures and cost increase. The loss of the use of a protected building introduces new, severe challenges for the building, and it represents a loss of potential gain. It is our experience that the loss that the value of use represents is underrated by a number of decision-makers in the cultural heritage field.

Thirdly, we asked if architectural quality is unaffected by whether the building is in use? Gadamer actually points out that the legal protection of a building is not built; it is declared and passed. This is a formalization of existing values, meaning and importance, forming a premise for the further use of the building. The legal status is subordinate to the work of art. Gadamer writes that a building cannot be deprived of its purpose without losing part of its reality. If reduced to an item of aesthetic awareness, it is reduced to a shadow existence, not really living, but merely existing, as a landmark for tourists or a picturesque image of a deformed, former life. Gadamer describes the museum treatment of works of art as well meant desecration; it is treated as a museum object for protection, but in this act of consideration lies the loss of its original situation. Buildings that are protected should be preserved for future generations. Gradually falling out of time, protected buildings can require both change and

update. When this proves difficult within the borders of the legal protection, due to a lack of ability to join the forces of protection and development, the building could typically be left to decay, or even demolished. Such decaying, empty buildings in an otherwise thriving area give life to the expression 'belonging to the past'. But do these buildings, to be preserved for future generations, truly belong to the past?

Finally, we asked if protected buildings are living architecture, or do they belong to the past as museum objects? It is a paradox that existing buildings are said to belong to the past. Here today, these buildings also belong to the present. The present should manage them with reference to the buildings meaning, their architectural quality. Otherwise, one risks what Gadamer refers to as a copy of the copy, a copy of another epoch's interpretation of inner meaning. To illustrate this, Gadamer refers to Plato; and his picture of humans being three steps distance from the truth. However, the present is not free to alter or move the work of art; on the contrary, this will go against the work of arts inner meaning. Gadamer claims that the cutting of a work of arts connections to its situation is comparable to framing it and hanging it on the wall. Historic document value should not be superior to the inner meaning of the work of art. Gadamer claims that it is vital, and of principal character, whether one perceives the work of art as a historic document to be interrogated, or submits to the work of arts inner meaning. Gadamer believes that philosophy changes our understanding of history from dissecting to thinking, and recommends to start a living conversation between our historic works of art and today.

Gadamer provides tools for interpretation of meaning in architecture. These are focused on architecture's, within the building industry, discipline-exclusive artistic aspects. However, Gadamer does not to the same degree provide a tool for evaluating (artistic) quality in architecture. Gadamer's hermeneutics has thus been criticized. It should be noted that Gadamer offers a mental tool to experience architecture as its subordinate. If one is willing to enter the space of meaning a given building offers, Gadamer's hermeneutics could be a useful mental tool, to see architectures artistic qualities apart from its other aspects, accommodating a continued reinterpretation of the building at hand.

To conclude, Gadamer's hermeneutics and its perspectives on the art experience in architecture has provided interesting perspectives regarding protected buildings. The meaning of a given work of art has been clarified, and it has been argued to be superior to other aspects of the work of art. This is clarifying for all of the research questions. The hermeneutic process of understanding the parts with a basis in the whole and vice versa, as illustrated in the hermeneutic circle, is relevant when working with protected buildings. Building details and surfaces are studied intensely, so that the immersed viewer might miss the unity that gathers it all. This unity risks going amiss if only detailed specialists are involved in management and not also holistically oriented professionals. Hermeneutics' quest for inner meaning and Gadamer's notion of truth answer a need to grasp the intangible, a vital aspect of a building; the tone that sounds in the chest whilst passing through the space.

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Contract Strategies in Hospital Projects

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Abstract

By taking advantage of experience gained through completed projects, new hospital projects can achieve both project success and project management success. In the coming years, the Norwegian Government is significantly increasing investments in hospitals. This has raised the awareness in choice of contract strategy. The purpose of this paper is to identify what different contract strategies that are used in hospital projects, when the different strategies are used and what are the experiences with these different strategies.

An initial literature study was carried out up front of the case specific studies. Nine cases – with a total of 33 contracts – were studied, with data collected through a document study and a selfadministrated questionnaire.

The findings show that mainly four different contract strategies have been used, with variations of design-build and design-bid-build. When these strategies are used seems mainly do be dependent on if the projects are characterised by high or low complexity and on the respective market situations. All projects have been assessed on if they have achieved project success and project management success. Findings reveal that different contract strategies have resulted in highly successful projects (project success), though not all projects were delivered within time, cost and quality (project management success).

This paper identifies previously used contract strategies in hospital projects. The paper should be of interest for researchers who seek to find the prevalence of the different contract strategies within hospital projects, when to use them and what strategies that contribute to success.

Keywords: Hospital, complexity, market situation, contract strategy, standardisation

1. Introduction

In 2014, the four regional health authorities in Norway founded a new division in order to manage the construction of new hospital projects – Sykehusbygg HF (SBHF). Up till the present, hospital development projects in Norway have been carried out by the four respective regional health authorities, hence with four different client organizations. The investments, however, came from the same state budget. A lack of knowledge sharing between the client organizations has been identified as a major challenge to this manner of organizing the sector. As a response to this challenge, the four regional health authorities established a joint division in 2014, Sykehusbygg HF (SBHF). The purpose of this division is to serve as consultants to its owners and to co-locate the knowledge related to development, planning and execution of hospital projects. In the coming years, SBHF will invest approximately 10 billion Norwegian kroner per year on construction projects in the hospital sector. The purpose of this study is to identify the most relevant contract strategies for future hospital projects.

The common practice in choice of project delivery method in public sector has so far been DesignBid-Build (DBB). The research leading up to this paper, however, indicate that this has changed into an increase of Design/Build (D/B) recently. Gordon (1994) argues that it is preferable for a client organization to have various alternative delivery methods when deciding on a contract strategy. According to Miller et al. (2000), there are several project delivery methods to be used with success in major public projects.

Organizations that are investing in this magnitude must continuously seek to improve the business processes, which in the construction industry essentially consist of the contract strategy (Heidemann and Gehbauer, 2011, Wang et al., 1996). Contrary to this, an organisation cannot optimize their process and reduce waste if it does not have knowledge of what has been done in previous projects. Therefore, it is vital for the organisation to document the current situation and extract learnings from it. This can be accomplished if experience is translated into a knowledge base (Lichtig, 2005, Wang et al., 1996). Therefore, it should be considered at essential for a client organisation, like SBHF, to document experiences regarding contract strategy from completed projects. This constitutes, in fact, a base factor for implementing projects in a best possible and effective manner. Hence, to uncover and document experiences for the future hospital projects, the following research questions are addressed in this paper:

1. What contract strategies are used in hospital projects?
2. When are the different strategies used? and
3. What are the experiences with these different strategies?

The study is limited to looking at contract strategies used in Norwegian hospital projects. It could have looked at what contract strategies the client organisation was able to handle, but in the case of SHBF the client organisation is considered as professional enough to handle the contract strategies in question. This paper does neither consider how to further develop a well-functioning contractor market, which could be a natural thing to do when planning investments of this magnitude.

2. Research Method

The main methodological approach chosen for this study comprised of a comprehensive literature review, a document study, two expert workshops and the use of a self-administered questionnaire.

At first, a literature review with emphasis on contract strategies carried out. The focus was to understand what characteristics might impact the selection of procurement strategy and project success. Secondly, a document study was carried out in order to get a perspective on the extent of development of contemporary hospital projects. Sources were essentially publications and reports from the Norwegian government and the regional hospitals, including tendering and contract documents. Then, two workshops with six experts from SBHF were arranged. The first workshop aimed to verify the list of hospital projects. After this workshop, the list included 53 projects executed within the last ten years. In order to answer the research questions it was desired to limit the number of cases, as recommended by Flyvbjerg (2013). In the second workshop with the same experts, minor projects not regulated by the public procurement law were eliminated, thus 17 projects were suggested for the in-depth study presented in this paper.

Finally, the contract strategies from the projects were documented through a self-administrated questionnaire. The respondents were essentially project managers, as they were involved in the selection of contract strategy and later project execution. The questionnaire was designed to be self-explanatory and mostly restricted to closed answers, i.e. using checkboxes. In addition to facts about the contract strategies, the respondents answered questions about market situation and complexity. The respondents were also asked to – more or less subjectively – evaluate whether the projects experienced project management success and/or project success. The data presented later in this paper mainly stems from the responses to the self-administrated questionnaire. The answers about contract strategy are considered objective. The answers to the questions about market situation and project complexity are also considered as objective, even though the respondents may experience a need for rough simplification when forced to select between for example high/low complexity. When asking project managers about whether their projects experienced project management success and/or project success, the answer can be subjective and somewhat biased. The authors realise that this may limits the value of the results. Before the questionnaire was sent out, it was pre-tested on one of the actual respondents, in line with recommendations from Fowler Jr. (2009). According to Biemer and Lyberg (2003), the Pareto principle is valid for this method of data collection. Hence, 20 per cent of the efforts spent in data collection should provide 80 per cent of the results. This led to the acceptance of a reduced number of responses i.e. data was received from 14 of 17 cases. However, of the 14 cases, five of them gave no value to the research due to incomplete answers, hence five responses were rejected. Consequently, this research is based on 9 projects with 33 corresponding contracts.

3. Theoretical Background

3.1 Contract Strategy

Contract strategy as a term, according to Wang et al. (1996), describes organizational and contractual policies regarding the delivery of a specific project. Using different delivery method might greatly effect on project outcome and success (Al Khalil, 2002, Kumaraswamy and Dissanayaka, 2001). In many cases delivery methods are chosen based on in house knowledge or external assistance (Masterman and Duff, 1994), however according to Hosseini et al. (2016) decision makers should consider three main area, namely; client's objectives, project characteristics and market situation, before selecting a contract strategy.

Contract strategy includes several elements that need consideration, without any consensus of what are the most crucial elements. Gordon (1994) defines contract strategy as "construction contracting method", including four parts, namely; scope, organization, contract and award. Furthermore, Kumaraswamy and Dissanayaka (1998) identified construction project procurement system (contract strategy) as having four sub-systems – work packaging, type of contract, form of contract and selection methodologies. Both of them are basically referring to the same four elements - award, organization, contract and scope/work package. Lædre (2006), however, divides contract strategy into eight elements - prequalification, award criteria, contracting method, work descriptions, delivery method, contract type, incentives and contract regulations. This latter definition covers the definitions described by Gordon, Kumaraswamy and Dissanayaka. Due to investigation of Norwegian cases, the elements defined by Lædre were found to be the most applicable, and form the basis of the discussion.

The three main applied delivery methods in Norwegian hospital construction are:

- Design/Build. The client has one contract with a D/B contractor. Plans and specification is not a part of the contract, they are in fact a deliverable which must be produced from the contract (Gransberg and Molenaar, 2004).
- Multiple Design/Build. Similar to D/B, but the client has contracts with several design/build contractors from different disciplines, e.g. technical trades (Lædre, 2006)
- Design-Bid-Build. Where the client has separate contracts for design and construction (Shrestha et al., 2012).

Important parts of the contract strategy worth describing here – in addition to the delivery method – are contracting method, work description, contract type, incentives and contract regulations. The Norwegian public procurement law regulates all public procurements above the total cost of approximately 40 million Norwegian kroner. Consequently, this makes tender competition to be one of the few applicable contracting method for public owners without violating public procurement legislations. However, it is an option to bond by negotiated tendering in smaller contracts or in special situations such as lack of respondents. There are also examples from use of another contracting method, called competitive dialogue. The scope of the contract can either be described with performance or quantity based descriptions. The risk accrues the contractor if scope is defined by performance based descriptions, while quantity based descriptions leaves more of the risk with the client. Essentially contract type describes how the client compensates the contractor. Contract types can be divided into two major groups, namely fixed price and reimbursable contracts (Gordon, 1994). Similar diversion of compensation terms is made – however by different terms – is cost contracts and price contracts. The cost contracts refer to unit pricing and cost plus, while price contracts essentially are lump-sum contracts. Incentives refer to stimulus, and more specifically to stimulus in monetary terms. If used formally, incentives in contracts are mostly considered to be bonuses paid at pre-defined milestones. As contract regulations, the most used are the Norwegian standard contract regulations, with or without changes and additions. Such changes and additions can be made in order to encourage project cooperation. The alternative is to customize contract regulations for each project, but that seldom happens.

3.2 Characteristics that Impact Selection of Contract Strategy

Gordon (1994) identifies three market drivers to be assessed before deciding the contract strategy. The first is the availability of appropriate contractors to work in the location of the project. For example, design/build will not work very well in an area where few contractors practice design/build. The second is the state of the market, that is, whether there are enough suppliers to achieve sufficient bidding competition at the specific time. The last driver is the package size of the project, where the client must determine contract size to gain adequate competition. If the market capacity is insufficient to absorb larger contracts, this implies splitting large projects into smaller packages. Much alike, Molenaar and Songer (1998) describes market situation as how the industry is responding to the project, and this is the description of market situation that will be used onwards.

Projects can further be characterised per size, geographic location and complexity in general. These are – in addition to market situation – all vital factors when deciding on a strategy (Baccarini, 1996, Molenaar and Songer, 1998, Toolanen, 2008). In this paper, the project complexity is a function of total project cost and type of hospital functions. Later on, aligned with all aforementioned factors, Hosseini et al. (2016) identified 22 selection criteria clustered in three main categories- project characteristics, owner characteristics and external environment(market situation) to assist decision makers in the selection process.

3.3 Project Success

The success in projects can be described from a variety of perspectives. Samset (2008) describes success using five criteria; efficiency, effectiveness, relevancy, impact and sustainability. On the other hand, de Wit (1988) and Hjelmbrekke et al. (2013) divide success into project management success (PMS) and project success (PS). PMS is a measure of the process, i.e. the project is delivered within time, cost and quality. Productivity and efficiency are other terms with adjacent meaning. Project success is a measure of the product from the project. Effectiveness is an adjacent term. Both de Wit (1988) and Samset (2008) argue that there is no necessary correlation between achievement of the one to fulfil the other. PMS does not automatically result in PS, and visaversa. In this paper, each examined contract have been evaluated in PMS measures – within planned schedule and budget in addition to the number of defects after takeover. PS, inspired by Samset (2008), are (subjectively) measured against relevancy, whether the project covers its intended needs, effectiveness, to the extent the project serves its societal objectives and impact, of which users and employees are satisfied.

4. Findings and Discussion

4.1 The Used Strategies

Table 1 presents a summary of case projects, including size and delivery method. One of the findings, that is not illustrated in table 1, is that all the projects used cost based contracts.

Table 1 Key figures from the investigated cases

Project	*Size (m^2)*	*Cost (Million USD)*	*Project delivery method*	*Contracts*
Marie Joys' house	11 000	51	D/B	1
UNN Patient hotel	11 855	46	D/B	1
Knausen-center	8 100	22	D/B	1
DPS Sola	4 062	12	D/B	1
New Østfold hospital	85 500	748	D/B and DBB	5
Radium hospital research center	17 571	158	Multiple D/B and DBB	2
Knowledge center	17 900	111	Multiple D/B and DBB	2
Vesterålen hospital	15 062	128	DBB	17
Psychiatry Rønvik	5 500	25	DBB	3

Selection of projects and the data collection resulted in nine cases with 33 corresponding contracts. Findings from the document study and the workshops reveal the scope of projects in the contemporary hospital development industry in Norway. The projects have a relatively wide span in complexity, scope, general market situation and geographical location. Total project cost is spanning from approximately 12 million USD in the smallest projects to about 750 million USD in the largest complete hospitals.

Results indicate that a broad spectrum of contracts strategies has been applied in hospital projects. Keynotes from all the analysed contracts are:

- The clear majority of contracts contracted through tender competition.
- Direct contracting has not occurred.
- All D/B contracts are defined with performance based descriptions.
- All contracts within the same project have used the same contract regulations.
- All contracts have been awarded to the most economically advantageous tender.
- It has been applied one or more D/B contracts in seven out of nine projects.

Real world conditions, in fact, impose several limitations to what contract strategy a client should apply in a project. In addition, there are both organisational regulations and project specific characteristics that must be considered when deciding on a strategy.

4.2 When the Strategies are used

Figure 1 illustrates the contract strategies applied in the different market situations by considering the level of complexity of the projects. The categorisation of market situation is representing the total number of tenders. If there were many tenderers, the market situation was considered good. On the contrary, with few tenderers the market situation was considered poor. Four contracts – all D/B – experienced a *good market situation and low complexity.* Four contracts – three Multiple Design/Build and one Design-Bid-Build – experienced a *good market situation and high complexity*. Three projects – all Design-Bid-Build – experienced a poor market situation and low complexity. The last 22 projects – 20 Design-Bid-Build and two Multiple Design/Build – experienced a *poor market situation and a high complexity*.

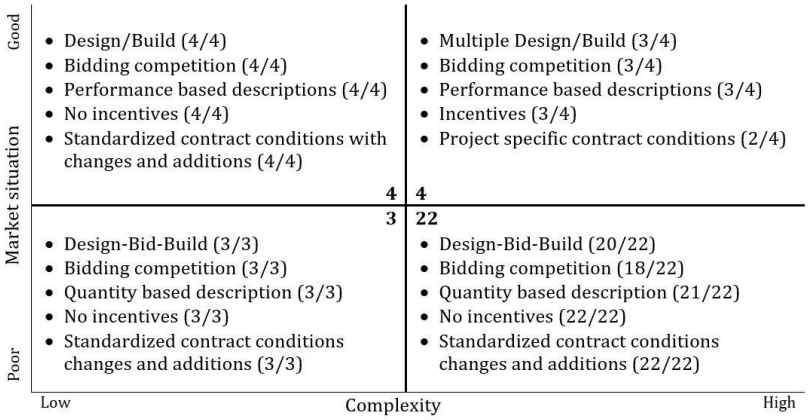

Figure 1: Applied contract strategy, sorted after complexity and market situation

According to figure 1, the clients have chosen DBB contracts when the general market situation has been assumed to be poor. On the contrary, the clients have opted to apply either a single D/B contract or a combination of multiple D/B in projects with a good market situation. When it comes to complexity, it appears that Sykehusbygg HF applied Design-Build and Design-Bid-Build in both high and low complexity projects. However, Design-Bid-Build seems to be the preferred contract strategy for high complexity projects experiencing a poor market situation.

4.3 The Experiences from the different Contract Strategies

4.3.1 DESIGN/BUILD (D/B)

Findings reveal that all of the low complexity projects, in a good competitive market, tend to use D/B as the delivery method. All the investigated D/B projects were evaluated to be highly successful in the means of PS.

Three out of four projects had a contract size well fitted for the market. This is also confirmed by the number of tenders that were above average for all projects studied in this paper. In the D/B the award criterion price was ranked rather low compared to the ranking in the DBB contracts. Other award criteria that have been used are understanding of the task and organizational criteria. Respondents are unanimous that the chosen award criteria led to selecting the best tender.

For Marie Joys' house, the largest of these four projects, D/B is evaluated by the respondents to not be the best-suited delivery method. Collaboration between design and construction was not satisfactory. Consequently, the client had to spent significant resources on following up, both in the design and in the execution phase. The solutions did not turn out as expected, and consequently, the project was delivered two months late.

In evaluation of the process, half of the D/B contracts achieved PMS. In fact, none of the contractors exceeded the budget. Three were below. One contractor was slightly delayed, resulting in schedule overrun for the project. Regarding quality, only one contract observed defects and deficiencies at takeover. Collaboration between design and construction were excellent in two of the projects, but for the other two it was not satisfactory.

4.3.2 MULTIPLE DESIGN/BUILD (MULTIPLE D/B)

In three projects applying multiple D/B, five contracts are studied, which four were technical, i.e. electrical, piping and ventilation. These contracts are within projects of high complexity and all projects were evaluated to be highly successful with respect to PS.

Findings reveal that only one of the contracts had a size well fitted to the market, which can be explained by the low number of tenders. However, the respondents believe that the award criteria led to selecting the best tender. Similar to D/B contracts, the multiple D/B contracts also ranked the price criteria low, around 50 - 60%. One of the projects stands out, being the only one using project specific contract regulations in two of the contracts. The project specific contract regulations turned out to be similar to Integrated Form of Agreement (IFOA), emphasizing instruments of collaboration between the different trades. In design, collocation in a so-called "Big Room" was applied; however, collaboration between design and construction did not work at all for one of the contracts. The reason was that some of the participants did not show up at the sessions, resulting in the more traditional way of design. This might be the cause for delays in the project. For the other contract in the same project, the collaboration was excellent.

The only occurrences where incentives have been used are in combination with multiple D/B contracts. However, the effect of the incentives was not as planned, i.e. it did not motivate the contractor to do a better job.

Regarding the process, only one contract was delivered within time, cost and quality and thereby experiencing PMS. Three contractors did not comply with planned schedule and one exceeded the budget. In the latter, defects at takeover was observed. However, in the warranty period, no defects or deficiencies has been observed in any of the contracts.

4.3.3 DESIGN-BID-BUILD (DBB)

Five of the examined projects applied DBB contracts. In total, 24 DBB contracts have been studied. For all projects applying DBB, poor market situation has been a common denominator. The contract strategy applied for DBB contracts are almost exclusively equal; however, three of the four projects experienced PS. The only unsuccessful project was DPS Sola, a low complexity psychiatry building.

According to the answers to the questionnaires, only 16 contracts had a size well fitted to the market. The remaining eight contracts had the low number of tenders in common (in average two). In contrast to what happened in the D/B and multiple D/B contracts, the award criterion price were ranked rather high, on average above 80 %.

Generally, findings reveal that DBB does not require that the client spend much resources in follow-up, in fact the client used medium or less in 19 contracts. When the contractor did not comply with the planned schedule or budget, the client had to spend extensive resources on following up the contract. When considering PMS for the DBB contracts, the results vary a lot. Six contracts were considered to achieve no or little PMS. On the other hand, nine contracts were considered highly successful when considering PMS. This shows that the contract strategy alone does not determine high or low PMS.

5. Conclusions

This study investigates a broad range of hospital project in Norway in order to answer the following research questions; 1) What contract strategies are used in hospital projects?, 2) When are the different strategies used? And 3) What are the experiences with these different strategies?

A spectrum of contract strategies has been used within the hospital development industry in Norway. A clear, and somewhat unexpected finding, was the close to equal contract strategies selected for projects with comparable complexity and estimated market situation. One main observation is that clients have opted DBB contracts in poor market situations, while better market situations have led to selection of D/B contracts. While low complexity projects have selected single D/B contracts, the more complex ones have included multiple D/B contracts. This happens especially in the case of the technical trades, where the client can benefit from the contractor's competence.

It seems possible to standardize four distinct general contract strategies in the context of market situation and complexity of the project. There are many similarities between applied contract strategy elements within this context. Whether the choice of elements in a contract strategy is affected by personal preferences and cultural behaviour in the organisation or project characteristics is not investigated here. What is clear is that the selection of delivery method seems to have major implications on the selection of the other contract strategy elements, confirming the theory on constraints for example between delivery method and work description. Hence, we recommend the client organisation to be aware of these implications, and thus consciously consider the selection of contract strategy elements as part of a comprehensive scope.

It is worth noticing that all the four main contract strategies found in the case projects contributed to both project management success and project success. However, we also found examples, where, the projects had different outcomes although the market situation and project complexity were quite similar. Therefore, it can be said that the contract strategy is not the only factor that influence the chances for achieving PMS and PS as well. As long as the client consider the market situation and project complexity on the selection process, the applied contract strategies can apparently be good enough. It is important for the client to strive to make the strategy flexible for customisation adapted to the specific project characteristics. However, the SBHF should be transparent and foreseeable in selecting contract strategies. Future works could assess if this transparency contribute to a better supplier market.

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Positioning Organizational Culture Studies Between the Construction Industry and Other Industries

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Abstract

(Purpose) The main aim of this paper is to portray the overall position of construction related organizational culture (OC) studies amongst other OC related studies found. The amount, the extent, and the scope of the construction OC studies are investigated and their relationships and positions to other OC studies in other industries are described.

(Methodology) This study follows a bibliometric research approach integrated with an unsupervised learning based analysis of selected core studies. The study uses both well-established bibliometric methods and novel unsupervised learning approach to uncover theoretical themes of OC studies based on citation patterns and semantic text. Accordingly, the construction related OC studies are to be identified.

(Findings) Related to vast field of OC studies, the research of OC focused in the construction sector tend to be rare. The construction related OC studies have focused on topics, such as knowledge management, leadership, innovation, firm performance, and characterization of OC. The semi-qualitative machine aided methodology was found to support coarse qualitative analysis of the extensive dataset. Together with human interpretation the results seem to be credible.

(Limitations) The semi-automatic methodology of the Bibliographic coupling (BC) and the Latent Dirichlet Allocation (LDA) creates the results without human effort. This may lead to the wrong interpretations without proper analysis of the results. Also the use of limited phrase search may exclude some relevant studies outside the research data. Although the impact is insignificant compared to the found data amount.

(Originality) The research is based on vast dataset with somewhat new methodologies compared with the traditional literature studies. First, it was possible locate the construction OC studies in the broad scientific field of OC and to identify some interesting research clusters. Secondly, the methodology itself represents an interesting and modern way to do mixed-method interpretation of the dataset in the construction sector.

(Keywords) Organizational culture, construction, data mining, unsupervised learning, bibliographic coupling

1. Introduction

The influence of organizational culture on corporate performance, quality and productivity (i.e. overall quality) has long been recognised in the academic literature (Denison 1984; Gordon & DiTomaso 1992; Gregory et al. 2009; Hofstede et al. 2010; Siehl & Martin 1990). This linkage between organizational culture and overall quality is evident based on the research in manufacturing (Patterson et al. 2004), healthcare (Carney 2011) and knowledge-intensive like software (Mathew 2007) contexts. Compared to aforesaid, there seems to be only limited number of organizational culture studies published in project-based industries such as construction (Low & Shi 2001; Zhang & Liu 2006; Coffey et al. 2011). Thus, the study of organizational culture in the construction is still in the stage of debate (Oney-Yazici et al. 2007) and construction sector ought to study organizational culture more in project level.

The construction organisations can be comprehended as people centric bodies. The people centricity can further be understood via the existing on-site practices in these organisations. Culture is considered to be governing complex human behaviours while construction involves many and complex human activities throughout its design, production, occupation and disposal processes (Fellows & Liu 2010). Siehl and Martin (1990) suggested that culture influences employee attitudes and that those attitudes, in turn, impact organizational effectiveness. In these contexts, organisational and project culture plays a critical role in enhancing project performance. It seems somehow strange that project based industries such construction has awakened to study organizational culture properly not until the late 1990s and 2000s (Teräväinen et al. 2017).

The overall picture of the influence of organizational culture on the construction sector research appears to be still shallow. Thus, the main objective of this paper is to portray the overall picture regarding the state of art of organizational culture studies in the construction sector. The study focus on positioning construction related organizational culture studies among other organizational culture studies in the academic research.

The paper uses established bibliometric methods and unsupervised learning to structure, in a semi-automated fashion, a large sample of over 6000 organizational culture articles, highlighting construction related publications position within the overall science discourse on organizational culture. The remaining part of the paper is structured as follows. First, a brief review of the literature is presented. Second, the context of the study and the methodology adopted are described in more details. This is followed by a presentation of the findings, limitations and conclusions.

2. Organizational culture

Culture is an all-pervading construct of human existence but its conceptualization is still contested (Fellows & Liu 2013). Culture itself has almost 200 different definitions (e.g. Allaire & Firsirotu 1984; Kroeber & Kluckhohn 1952) reflecting very divergent views. Allen (1992) described seven ways to use word culture that include generic and expressive uses, as well as holistic and pluralistic. However, two main disciplinary foundations of organization culture can be identified to be sociological (organizations have culture) and anthropological (organizations are cultures). The sociological perspective has come to predominate. (Cameron & Quinn 2011). This perspective represents the objective entity school of thought by Brown (1995). Barthorpe (2002) has listed generally agreed features of culture for the objectivist perspective:

- any culture has three fundamental aspects: i) technological aspects, which include tangible materials and techniques (artefacts); ii) sociological aspects, which describe human relationships, (behavioural norms); iii) ideological aspects of culture, comprising of both tangible and intangible manifestations (beliefs, ideas, rituals, values etc.) (Lewis 1982);
- culture exist at different levels, which Schein (1985) simplifies into three main levels: i) artefact (the most superficial manifestation of culture); ii) beliefs, values and attitudes; iii) basic assumptions (the deepest level of culture);
- culture is both learned and shared.

It was not until early 1980s that the concept of culture was given serious attention by organizational scholars (e.g. Ouchi 1981; Deal & Kennedy 1982; Cameron & Quinn 2006). Since then culture studies have acquired prominent status in the management field (Liu & Zhang 2003). The organizational culture and effectiveness studies can be divided into three chronological stages the *Budding Stage* (1920s to 1970s), *the Promulgation Stage* (1980s) and the Testing Stage (1980 to the present) (Vesson 1993; Wilderom et al. 2000; Liu & Zhang 2003).

The intense interest in the association of culture with the different facets of organizational effectiveness in the 1980s and 1990s generated a great deal of research in which culture is examined in a positivistic light. Such studies treat organizational culture as a variable. Those, who viewed organizational culture as what an organization is, adopted a qualitative methodology (e.g. Martin et al. 2006; Alvesson 2002; Schein 1996). In general scholars are agreeing that the *organizational culture* (Liu et al. 2006):

- is a multi-faceted construct (Pettigrew 1979);

- reflects customary thinking, feeling, and acting that is attributed to a particular group of people as they learn to cope with their environment (Trompenaars & Hampden-Turner 2000; Ott 1989; Ouchi 1981; Deal & Kennedy 1982);

- is both learned and transmitted (Schein 1985); and

- is an abstraction from behaviour as well as a product of behaviour (Davis 1985; Quinn 1988).

Patterson et al. (2004) found that aspects of organizational climate, such as concern for employee welfare, would lead to satisfaction, and higher levels of satisfaction would result in increased productivity. Fenton-O'Creevy (1998) argued that higher involvement leads to attachment with the organization, resulting in enhanced motivation and desire for responsibility, and this would lead to greater productivity. The differences between organizational climate and culture are evident in the academic literature; organizational culture is argued to represent the deeper and more fundamental aspects of organizational life, although overall they both denote the same phenomenon (Denison 1996).

Currently organizational culture is seen to have major effect on the performance and long-term effectiveness of an organization (Oney-Yazici et al. 2007). Even though the construction industry is human-centered working environment, the effect of human aspect on performance has been somewhat neglected. The first observations of organizational culture-performance linkage have been made already in the Budding Stage but the academic research relating construction sector has started to investigate this linkage properly not until the late 1990s and 2000s.

In addition to this, Liu & Zhang (2003) stress that although organizational culture affects organizational performance, the mechanism on how organizational culture operates on the final organizational outcomes is still unsure. The main reason for cultural studies in the construction sector "… is to find out *how* it effects the organizational performance with a view to improving the performance effectiveness" (Liu 2003).

3. Methodology

The study consists of four steps. The overall summary model is presented in figure 1. Our methodological process consists of four phases (figure 1 - 1, 2, 3 & 4) and each phase include different stages (e.g. figure 1 - 1.1.; 1.2; 1.3; & 1.4). The research objectives (stage 1.1) were defined in the introduction at the beginning of this study. The process protocol (stage 1.2) for conducting the review process was formed to fit our study criteria with the aid of panel of experts including both construction management and machine learning process experts.

This study follows a bibliometric research approach integrated with an unsupervised learning analysis of the content of selected publications. The study uses both well-established bibliometric methods and novel unsupervised learning approached to uncover theoretical themes based on citation patterns and semantic text. Thomson Reuters Web of Science (WoS) database was used as a source of data as, with Scopus, it is one of the largest science publication databases both by volume and coverage. The selection between Scopus and WoS is in many cases irrelevant as the results derived from either correlate highly (Archambault et al. 2009) (stage 1.3).

In stage 1.4 we retrieved data from articles containing the term "organization* culture" or "organisation* culture" being mentioned in the topic of WoS records (*-mark represents cut-off in the search strings). The topic field searched if the term is used in the title, abstract, author keywords or the WoS enhanced metadata Keywords Plus® field. Relevant studies for the research criteria were seen to contain this particular phrase organizational culture (with different spelling styles) in fore-mentioned search fields. This approach allows the download of a broad dataset of literature relating to organizations culture, not excluding any streams on literature or empirical domain.

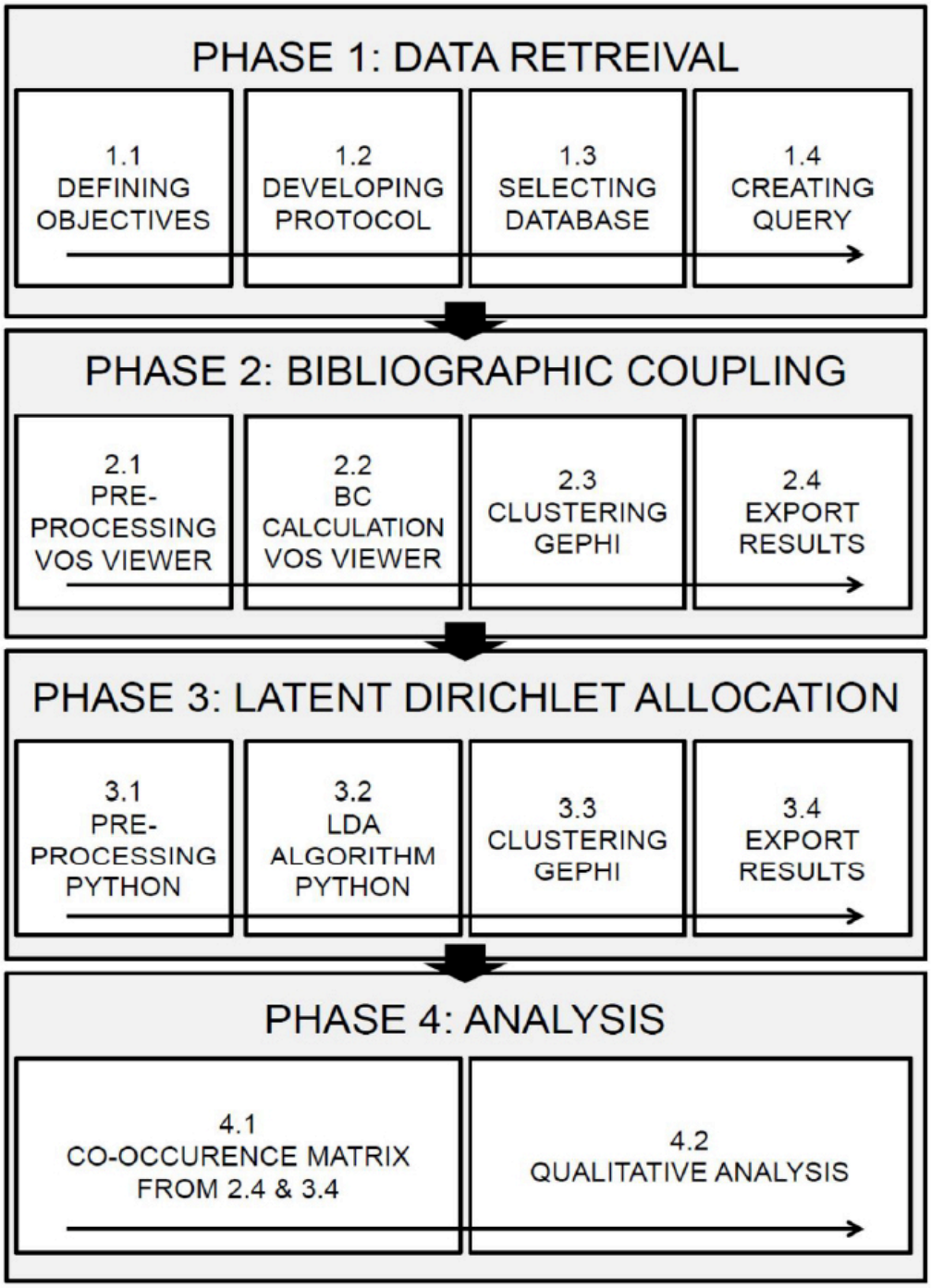

Figure 1: The process description of the methodology

At the second phase, the theoretical streams of literature within the dataset were uncovered using bibliographical coupling (BC). BC is an approach of quantifying the shared intellectual background of a set of documents. This approach calculates an association strength value between each document in the dataset based on the number of shared references. Kessler (1963) notes that "…a single item of reference shared by two documents is defined as a unit of coupling between them". If multiple items share the same reference it increases the weight of coupling. The theoretical assumption embedded to the BC method is that the more shared references, the stronger theoretical foundation the two documents share. The methods have been shown to highlight hot topics (Glanzel & Czerwon 1996) and linking documents with similar research focus (Jarneving 2007), creating the knowledge structure of a

field. By calculating the BC strength to all documents in our datasets, we were able to cluster and visualize networks of shared knowledge.

Calculations, including association strength and subsequent clustering between the documents, were done using VOSviewer software (stage 2.2) (van Eck & Waltman 2009). Results were imported to Gephi (Bastian et al. 2009) for further network statistics calculations and visualization (stage 2.3). OpenOrd layout algorithm (Martin et al. 2011) was used to visualize association strength based proximities of publications. Network metrics were extracted for each network cluster. Network measures calculated and used for qualitative evaluate are count of documents in each cluster, density, and degree. Density is a measure of interconnectedness of a network, it is the ratio of the number of connection in the network against the total possible number of connections. Degree is the count of direct connections an individual node has. Degree and density give a vantage point to the interconnections within the network. Eigenvector centrality measures the influence of a node in the network. Eigenvector centrality of a node measures is a relative score based on the connection to high-scoring nodes being more valuable. Central documents are identified, not only by their degree, by evaluating how valuable connections the node has.

In addition to the bibliographic coupling, at the second stage the data was cleaned and descriptive statistics such a yearly count, core authors and publications were identified (stage 2.1). At the second phase, the BC results were used to identify core cluster based on shared intellectual background (stage 2.4).

At the third phase, unsupervised learning, namely Latent Dirichlet Allocation (LDA) (refer to Blei & Lafferty 2009), was used to uncover latent thematic topics from abstract text of the articles. All abstracts, which were longer than 100 characters (pre-processing stage 3.1), were analysed using LDA (stage 3.2). The method is well-suited for analysing semantic text and discovering the underlying patterns within it. Blei and Lafferty (Blei & Lafferty 2009) have shown the usability of LDA finding that this method "…can extract surprisingly interpretable and useful structure without any explicit "understanding" of the language by computer". The idea of the approach is to that each document in a corpus is a random mixture over latent topics, and each latent topic is characterized by a distribution over words. In the model, each document is a mixture of a number of topics based on the words attributable to each of the topics. The algorithm analyses the latent probability distributions based on the semantic text used in the document, classifying the documents based on the patterns within them. For a detailed explanation on algorithms, refer to for example Blei and Lafferty (Blei & Lafferty 2009) and for an evaluation in analysing scientific publications, please see Yau et al. (2014) and Suominen and Toivanen (2015).

The LDA methods requires the researcher to set a value t, which is the number of topics created. This process is to some extent intuitive, and requires testing which number of topics create a classification interpretable by humans (refer to Chang et al. 2009; Suominen & Toivanen 2015). This limitation is however mitigated by how the results are further analysed. In practise, LDA analysis produces two results a word-based description of latent topics content and a probability distribution of each document belonging to each to the topics t. LDA is a soft classification method, where a document, rather than assigned to one cluster, is given a probability value of belonging to all of them. Using this probability distribution, the results are transformed to a bipartite network representation, where each document (document vertex) has an edge to each topic (topic vertex). Edge weight is assigned based on the

probability value of document n belonging to topic t. The network representation is uploaded to Gephi visualization software in stage 3.3, where the network data is clustered using the Modularity algorithm by (Blondel et al. 2008). This modularity created a hard partitioning, assigning documents and topics to only one classification based on the soft partitioning results produced by LDA.

At the final phase 4, we integrated the bibliographical coupling (stage 2.4) and unsupervised learning (stage 3.4) based results. Here a co-occurrence matrix was created (stage 4.1) to present the overlap between *semantic content* and *citation based content*. Finally, the articles related to construction are highlighted and their positions both in semantic and theoretical origins are discussed (stage 4.2).

4. Data Analysis

The Boolean search from the WoS database retrieved contains 6743 articles. Of the records 6739 have a publications year, resulting in the time series seen in Figure 1.

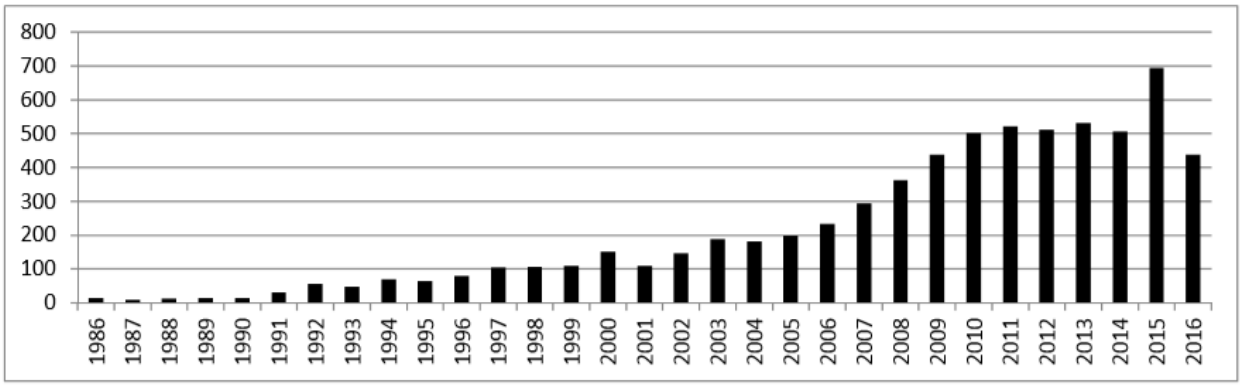

Figure 2: Annual histogram of the publications addressing organizational culture studies in WoS

In the 2015, there seems to be conspicuous growth in the OC studies generally. Presumably, the amount of the publications in the year 2016 will grow because the scientific databases are always complemented afterwards. Seemingly, the strongest increment in the numbers of the publications has been between the years 2006 and 2010. The amount of knowledge, and thus scientific publications, can be a self-reinforcing phenomenon particularly regarding topic having substantial research potential.

The largest publications outlets in the dataset are all core to organizational change and business ethics. The three by count largest being *Journal of Business Ethics* (N=96), *Human relations* (N=75) and *Journal of Organizational Change Management* (N=59). Largest industry specific journal relates to nursing, with theJournal of Nursing Administration having 32 publications. As a comparison, *Engineering Construction and Architectural Management* has four publications in the sample.

A number of publications in the sample are not connected to the overall sample, and are omitted as outliers. The largest set of connected publications consists of 6128 publications, thus the bibliographical coupling data consists of 6128 nodes (articles) and 1 395 280 edges between the documents. Although the amount of edges seems significant, the density of the network, defined as a ratio of the number of edges against the number of possible edges, is only 0,074. The low density value already suggests that there exist significant sub-networks within the whole sample. Using the Modularity algorithm, the bibliographical coupling network was reduced to 11 communities. Four of

which are clear outliers containing only under one percent of the documents in the dataset, thus clusters 2, 5, 6, and 7 were not included in table 1. Analyzing the seven communities with significant number of nodes, we identified thematically separate entities presented in the next table 1. Although it should be noted that the labelling is based on a qualitative evaluation of 10 the most central publications and that the resulting labels are aggressive simplifications of the content.

Table 1: Bibliographic coupling of the publications

Cluster	Nodes	Label	Milestone publications
0	660	Leadership	Hemmelgarn (2001); Gelfand (2008); Bavik (2016)
1	284	Managing cultural environment	Cropanzano (2005); Spataro (2003); Chatman (1998)
3	768	Knowledge management and culture	Janz (2003); Sanz-valle (2011); Al-adaileh (2011)
4	1400	Healthcare	Curry (2015); Firbank (2010); Banaszak-holl (2013)
8	1280	Theory of organization culture	Denison (1996); Hatch (1993); Ogbonna (2006)
9	1162	Firm performance	Wei (2014); Stock (2013); Jaw (2010)
10	568	Characteristics and evaluation	Patel (2012); Hofstede (2010); Guo (2009)

LDA was run with 10 topics. The total number of documents run through the analysis was 6430 documents as document with no or short abstract were excluded. Running the Modularity algorithm, the soft partition network produced 10 communities. Table 2 describes the number of nodes, documents, in each community, the three highest probability terms and the three highest probability publications.

Table 2: Latent Dirichlet Allocation of the publications

Community	Nodes	Top words	Highest probability publications
0	**724**	service, worker, innovation	Stump (2000); Clay-Williams et al. (2014); Malan et al. (2015); Das et al. (2014); Rappolt et al. (2005) Jafree et al. (2016)
1	**1020**	management, public, change	Dubra (2012); Girniene (2013); Block & Laurinkari (2012); Girdauskiene & Savaneviciene (2007); Abilia et al. (2011) Dubra (2013) Grumadaite (2013)
2	**748**	project, group, climate	Gounaris et al. (2010); Li et al. (2011); Benitez-Amado et al. (2010)
3	**531**	women, management, change	Clarke (2015); Lee et al. (2008); Villumsen & Kristensen (2016)
4	**529**	employee, social, technology	Suzuki (2013); Deshpande & Farley (2004); Gerhart (2009); Sarala (2010)
5	**612**	cultural, orientation, communication	Mellner (2016); Galea et al. (2014); Stamper & Van Dyne (2001)
6	**515**	social, system, management	Garnett et al. (2016); Rinfret & Lortie-Lussier (1997); Zhao et al. (2016); Teo & Dale (1997)
7	**726**	firm, relationships, TQM	Huang et al. (2007); Rozenbojm et al. (2015); Eres (2010); Sotirofski (2011); Howard et al. (2011)
8	**660**	Knowledge, innovation, leadership	Banutai et al. (2011); Summerill et al. (2011); Bercu & Grigoruta (2012)
9	**365**	Hospital, change, nurse	Adams et al. (2014); Seitlova (2015); Laing et al. (2012)

Table 3 shows the co-occurrence matrix of bibliographic coupling clustering and LDA analysis. The count of construction industry related articles is given in each cell in brackets. The overall count articles included into Table 3 is less than the total sample, as outliers were excluded from the bibliographical analysis, documents with short abstract where excluded from the LDA analysis and as not all articles could be matched between the analysis.

Table 3: Co-occurrence matrix of the BC and the LDA

	Cluster 0	Cluster 1	Cluster 3	Cluster 4	Cluster 8	Cluster 9	Cluster 10	Excluded	Grand Total	Construction
Community 0	43	11	32	**503 (1)**	59	32	11	33	724	**1**
Community 1	**92 (5)**	22	**395 (7)**	**89 (3)**	**113 (3)**	**165 (2)**	**73 (2)**	**71 (4)**	1020	**26**
Community 2	74	10	35	31	**102 (1)**	**362 (6)**	**106 (2)**	28	748	**9**
Community 3	**46 (1)**	20	**58 (1)**	79	**135 (2)**	**70 (4)**	**31 (3)**	82	531	**11**
Community 4	**57 (1)**	18	24	**58 (2)**	**113 (1)**	95	**140 (3)**	23	529	**7**
Community 5	63	65	43	99	**174 (1)**	**85 (1)**	**47 (1)**	34	612	**3**
Community 6	47	50	27	62	**153 (3)**	86	40	**48 (1)**	515	**4**
Community 7	**109 (2)**	40	50	249	**109 (1)**	80	37	**52 (2)**	726	**5**
Community 8	78	27	**69 (1)**	**77 (2)**	**157 (4)**	**120 (1)**	**57 (2)**	70	660	**10**
Community 9	39	18	30	**131 (1)**	69	**43 (1)**	**16 (1)**	19	365	**3**
Excluded	12	2	4	19	92	19	10	151	309	**(7)**
Grand total	660	283	767	1397	1276	1157	568	631	6739	**(79)**
Construction	**9**	**0**	**9**	**9**	**16**	**15**	**14**	**(7)**	**(79)**	**72**

Although these results are simplifications of the content of the publications, we are able to roughly analyze OC studies regarding construction context relatively to the OC studies of other scientific fields. In order of importance by total amount, the three most important communities (CO) related to the construction are CO1, CO3, and CO8. The three main clusters (CL) in order of importance, are CL8, CL9, and CL10. Totally we can recognize 72 construction related OC studies with cluster and community. 10 cells with CL and CO included more than 2 construction related publications from the BC and the LDA both, in total 41 papers. Such a low amount of the construction related publications conducts us to use as low saturation point as 3 publications when identifying significant nodes (underlined with grey in table 3).

This kind of two-dimensional review of the publication groups enables us to form rough focus areas of the construction OC studies conducted so far. The construction sector seems to lack academic publications in the research stream of OC. Although, the academic construction research has brought up social features and issues of the industry for some time. Also, the global construction sector is one of the biggest industries in the world measured by number of employees. In addition, the construction operations comprise typically a temporary network of organisations and labor. Thus, the amount of OC studies among the construction sector could have been expected to be more generous since the human interaction plays such a significant role in the global sector just by the volume itself.

Combining the theoretical background (BC) and semantic clustering over latent topics (LDA), there is patterns to see in table 3. Totally 25 papers out of 41 construction related papers falls under CO1 and CO3, which both have words management and change in their top words (see table 2). Further, totally 20 papers are clustered under CL8 and CL9, labelled *theory of organizational cultureandfirm performance*. Totally 7 of these above-mentioned papers can be found at the same in CL8 or CL9 and CO1 or CO3. Thus, there is strong pattern in themes *change management, organizational culture, and organizational performance*. CO8's top word *knowledge* and CL3's labelling *knowledge management* and culture can also be recognized as a pattern. In generally, the patterns can be structured according the focus point of the study. In this study, we stay only at the top-level analysis.

Although the analyses of studies by title or abstract have been questioned (Graham 2002), we considered this kind of top-level analysis accurate enough to form coarse qualitative analysis over the found studies in the nodes identified as significant concentrations of construction OC studies (papers 3 or more). The most concentrated construction OC studies' node is CL3-CO1 (see table 3). Based on the BC, the theoretical background of these 7 studies is shared with studies handling knowledge management (KM) and culture in other research fields. Review over the titles and abstracts of these 7 studies reveals our clustering to be quite right for main themes in the studies being organizational culture and knowledge management, and learning organizations. By reflecting this observation towards CO1, the semantic themes in the papers are *management, public and change*.

As this paper serves future in-depth organizational culture studies relating construction sector, the data-analysis is made for creating overall understanding over the topic. With the aid of BC, we are able to identify milestone studies for cluster under examination. These are presented in table 1. The LDA provides us to identify the most likely publications based on the semantic clustering. This kind of two-way selection of theoretical sources is rigorous and extensive, and an excellent way to start investigations over selected topic. Further, we are able to identify the most related studies to our topic, at least papers in the same nodes can be expected to investigate issues close to each other.

5. Discussion

The performed semi-automatic methodology consisting of the BC and the LDA created the results without human effort which allows the usage of much wider datasets in a research compared to literature review completed by a human. These results may look absurd without human interpretation or researchers' understanding of the non-human processes in the BC and in the LDA. Analyzing the data given by this approach, requires an understanding of the research limitations made in the process and the limitations of the BC and the LDA. Semi-qualitative analyze made by a machine is, at this point, narrower than made by a human. The more wider is dataset given, the more effective this kind of machine-aided analyze is.

This kind of interdisciplinary preliminary study enables us to identify our core core-themes and milestone publications over the topic organizational culture which makes premises of the study more rigorous. Moreover, with accuracy of current databases and metadata of papers in those, enables us to perform coarse qualitative analysis over abstracts of found papers. With more accurate metadata and entire article texts, it would be possible to execute in-depth qualitative analysis over the paper contents with the aid of BC and LDA.

Currently, machine learning and bibliometric methods provide a semi-automated approach to quantifying large datasets and even making literature review type analysis of metadata. Semi-automated methods have their inherent limitations. Analyzing the found data with two different and independent methods, reduce significantly inaccuracy in the results. Even with the use of two methods, human intervention is still needed to produce practical implications from the results. Focusing on the found intersection points (table 3) ensures that the conclusions are supported by both methods. The impact of the excluded publications on the results stays minor in this vast dataset.

As the primary aim of this study was not on the substance context of the found construction OC studies but on the coarse allocation of the papers by the BC and LDA. It would be useful to investigate the

actual context of the papers found in more-depth in the future studies. This kind of comparison would enlighten us of the real accuracy of our semi-qualitative machine aided analysis.

6. Conclusions

The study used established BC method and LDA analysis to structure, in a semi-automated fashion, a large sample of over 6000 OC articles, emphasizing construction related publications position within the overall science discourse on organizational culture. From the total amount of the found construction OC studies there were 72 one focusing on topics, such as, knowledge management, leadership, innovation, firm performance, and characterization of OC.

The OC studies in the construction sector seem to be rare with respect of the total volume although the construction sector is considered human-centered industry. Although, these few studies are of importance since the effect of OC on the construction performance has been recognized as a crucial one. As a future research topic, it is advocated to perform an in-depth study over the found construction OC papers in this study. This could be expanded to include analysis over data-gathering methodologies in the found papers. Moreover, it would be interesting to investigate which of the found papers use OC as a conceptual framework and which just refers to OC as given variable.

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The role of the project manager in a project space

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Abstract

The role of the project manager in construction projects has been studied extensively from different perspectives and the project manager plays an important role in coordinating the project and supporting communication and sharing of knowledge and information between project members. In recent years, more and more construction design projects adopt new working approaches in which project members work collocated and use structured methods as a way to enable face to face communication, which is known to facilitate knowledge sharing and create a better mutual understanding between multidisciplinary project members. Even though literature discusses these new settings, there are few studies on the role of the project manager while working in such a project space. A project space is defined as consisting of physicality, as well as materialization of power and social relations and experiences within the space. We study the role of the project manager within such a project space from an organizational spatial theoretical perspective. The research is based on three qualitative case studies in which data consisted of 26 semi-structured interviews and 60 hours of observations. From the empirical data, we contribute with a focus in understanding the role of the PM within a project space. The use and awareness of space and spatial configurations as well as facilitation to create a trusting environment are two findings that concern the PM role in relation to project space.

Keywords: project managers role, project space, construction design, spatial theory

1. Introduction

In project-based industries, it is often difficult to extract, distribute and share knowledge across both cultural and structural boundaries (Bosch-Sijtsema and Postma, 2009; Prencipe and Tell, 2001). Especially in construction design, multiple organizations and disciplines are involved in relatively complex projects. Within these projects, team members often work with situated and embedded knowledge, which is difficult to transfer both between project members within the individual project (Bosch-Sijtsema and Henriksson, 2014; Newell et. al, 2009), but also between projects and organizations (Engwall, 2003; Scarbrough et al., 2004), and between projects (Precipe and Tell, 2001). In this study, we primarily address the challenges of transferring and sharing knowledge and information within a single design project and we focus on the role of the project manager who is often considered to be a coordinator and boundary spanner who can influence knowledge and information sharing within a project (cf. Brion et al., 2012). The influence of the project manager is often discussed in terms of their task or contextual qualifications (Ahadzie et al., 2014; Loufrani-Fedida and Missionier, 2015). However, few studies focus on the context or project environment in which a project manager is working and how this influences the role of the project manager.

Increasingly, new work approaches are developed in order to facilitate knowledge and information sharing within the individual projects to increase the quality of the final end result. Some of these approaches applied in construction design are concepts using varies forms of structured work methods in which project members are working collocated for one or more days a week. Some examples currently used in the construction industry are the BIG Room concept inspired by the lean philosophy (Liker, 2004), extreme collaboration (Garcia et al., 2004) or integrated concurrent engineering (Evbuomwan and Anumba, 1998). These new design approaches enable project members to spend more time together and there through have the possibility for face to face communication which is acknowledged to improve and facilitate sharing of knowledge (cf. Newell et al., 2009). These project design approaches are relatively similar but we use the term Big Room in our paper.

Even though these concepts, are gaining more and more popularity particularly within the construction industry, few studies have looked at how these types of work environments influence the role of the project manager. We are particularly interested in how such a work environment, consisting not only of a physical collocation, but also of facilitating social interaction, influences the role of the project manager. For this we apply an organizational spatial perspective which provides a holistic view on a space including the physical and social space in combination with how a space is experienced by those occupying the space (Dale & Burrell, 2008; Kornberger and Clegg, 2004; Lefebvre, 1991; Taylor & Spicer, 2007). We study the project space consisting of the interrelated facets of a socially constructed space in terms of physicality, materialization of power and social relations and how project members experience such a space.

We study the role of the project manager within a project space from an organizational spatial theoretical perspective. Below we discuss the theoretical framework, after this the method is presented (section 3). In section 4 we present our findings and they are discussed in relation to theory in section 5.

2. Theoretical framework

In our study we are particularly interested in the role of the project manager. Studying the impact of the project manager's role on project performance is relatively new (Tuner and Muller, 2005) and most of the research in this area has been directed towards: 1) Whether or not it is possible to create a standardized description of the role of the project manager and if it is of any value for projects to have such standards (Crawford, 2005), and 2) What type of skills are most important for a project manager in terms of task or contextual skills (Ahzdzie et al., 2014; Loufrani-Fedida and Missionier, 2015). However, the contextual project environment or project space, have not been taken into account in earlier studies concerning the role of project managers.

The contextual setting of a Big Room in which members are collocated and apply lean inspired working methods opens up for new ways to share and exchange knowledge (e.g, Garcia et al., 2004; Liker, 2004). Construction research has studied these types of design approaches, but has not looked into the spatial part of these approaches, nor the connection to project management. However, from other research in knowledge and learning, the environment in which people work is often discussed as an important factor (Newell et al., 2009). Such an environment can consist of a physical location and possibilities for collaboration, but also the communication infrastructure.

Research on organizational space has become more prominent in construction management, in which there has primarily been a focus on the physical space and how the physical space as well as architecture and buildings influence how people behave and interact (cf. Kornberger and Clegg, 2004; Van Marrewijk, 2010). Other studies have identified that organizational space can include narratives on organizational identity and culture (Ford and Harding, 2004; Taylor and Spicer, 2007) and how individuals experience a space or feel connected. Research on space has been widespread and in many different disciplines, but several authors have reviewed the spatial theory and combined them into a more holistic framework consisting of three elements: physicality of space; materialization of power and social relations and how people experience a space (Dale & Burrell, 2008; Kornberger and Clegg, 2004; Taylor & Spicer, 2007). The notion of project space applied in this research is based on these three elements but focuses primarily on a socially constructed space in a temporary project setting (Tjell, 2016). Our study primarily focuses on the role of the project manager within a project space.

3. Methodology

To explore how a spatial perspective provides insight in the temporary organization and the role of the project manager a comparative qualitative case study was applied (Easterby-Smith et al., 2014). We studied three cases of design projects qualitatively. All three cases were in-house residential housing projects. The cases were selected based on their resemblance in project size and budget, as well as on their similarities regarding work method, team size, physical setting and geographical collocation of the design team members. The design team members who actively took part in developing the design documentation worked in a collocated environment for one full-day per week and were supported by lean inspired structured methods and multiple visual means to support collaboration and improve the sharing of knowledge and information. We only studied the one-day work sessions because in these sessions most of the work should be performed. Most interviewees mentioned that in their own office they had email contact with the team members but that most work was work within their home office. The studies were conducted at one of the largest contractor companies in the Nordic countries. All cases

had team members from the following disciplines represented at every collocated session: client, architect, structural engineering, heating, ventilating and air conditioning (HVAC), electricity and project manager (PM), forming the core design team. We followed the cases during two phases: (1) the design and (2) the detailed design phase.

All three projects were followed throughout the entire design process and 26 semi-structured interviews were held with key members of the three projects (see table 1). These interviews were recorded, transcribed and coded. Some of the key persons worked in two or all three case studies – i.e., project manager (case A-B), architect (the same firm was involved and in case BC one senior architect was involved, in case A,B and C the same junior architect was involved), structural engineer (all cases), and HVAC (all cases) - and interviews were held on all the cases they were involved in. In addition to interviews and secondary data collection, we performed continuous structured observations of more than 60 hours of the collocated design sessions. We observed interaction, configurations, movements, activities, discussions, artifacts used and took notes, timestamps, photographs and made sketeches of configurations. We applied a coding methodology related to the grounded theory analysis approach (cf. Lincoln and Guba, 1985). The first coding was done with color coding in rough themes, after this initial coding, several rounds of coding were performed in which the labelling of themes became more refined. The coding labels and themes were inspired by literature concerning space. After the coding of the interviews, the observation data was connected to the coded themes.

Example Table 1: A summary of collected data

Case / *Type*	*Case study A*	*Case study B*	*Case study C*
Size of the core design team	*6 -13 members*	*8-12 members*	*8–10 members*
Number of interviews	*20*	*12*	*17*
No. of full/half day observations	*4 (16 hours)*	*3 (16 hours)*	*6 (28 hours)*

4. Findings

We have structured the findings section around the project manager's role in the project space. From our interviews as observations, the role of the project manager (PM) is influenced through working with a Big Room concept.

4.1 PM's use of the project space

The physical space that was used during the one-day per week collocated design sessions contained various visual means on the walls like a time schedule, lists of decisions made, upcoming questions per disicipline etc. The visual methods and means enabled the work of the project manager (PM), but also required that the PM facilitated the use of these means and engaged the involved disciplines in aspects such as coordinating workflow, upcoming questions, keeping track records, discuss and solve issues as well as resolve clashes in the BIM model etc.

The team only uses the collocated project space once a week and are supposed to perform a large part of their work in this particular time and space. Even though several members communicate with each other over email during the week and work on their own in their home office, the focus has been on the collocated space only. Because the team only meets once a week, the PM feels that s/he should facilitate these intense working sessions and the PMs we observed were very active in supporting team members to use the space as well as the multiple viausl means provided within the space. From our observations, the PM changed the spatial configuration of the space depending on the goal of the working session so that different subgroups that needed to work on a design part could be seated together. For example, in case A the PM changed the seating configuration into two separate parts. In one part of the room, a selection of the team – consisting of HVAC, electritiy, PM and BIM coordinator - participated in a BIM clash control projected on the wall. While another part of the team - consisting of architect1 and 2, structural engineering, and the site manager were sitting behind the first group and discussed 2D designs, making sketches and calculations. During the clash control, the architect1 and structural engineer jumped in at multiple times in order to comment or discuss clashes in the 3D model of the first group.

The PM not only changed the configuration before the sessions would start, but also during working sessions. We observed that the PM initiated sub-meetings with a smaller set of actors in areas of the physical room, to facilitate particular design discussions. The PM was very engaged in these sub-meetings. By creating these sub-meetings, the PM facilitated movability in the physical room, which involved different constellations of interacting between the team actors both formally and informally. However, it also became evident that the PM had to prioritize in which subgroups and with which questions she would work since it would not be possible to work on all the topics. *When I am in the project location I try to do as much as possible, but I cannot be everywhere, I'm sitting in small workgroups and I'm selecting the workgroups after what I think is most relevant to the project"* (PM).

In the observed cases, the PM is the role that moves around the physical space the most, and moves with her computer and chair to different team members and subgroups, thereby changing the spatial configurations. Not all team members follow that example and some team members stay put in one particular place for the whole day, while others are more aware of the space and start using the different options over time. When you are in the studio then you are constantly in dialogue, it is very seldom that you are sitting by yourself, and producing something. *... it is often with the architect, but then it becomes evident that it is affecting other disciplines as well and then they are there and then it is there where you are solving problems, so it is very different than working at my own desk – .... my experience is that the external consultants are not working in the big room – they are taking part in those events as if they are traditional meetings and then they are leaving after lunch or something ..* (Structural Engineer 3). From the observations it also became clear that the group who has been part of earlier projects in the Big Room – like the PM, structural engineer, architect1 and HVAC consultant – are more comfortable in the room, move around, change configurations and actively go to a team member or subgroup to ask questions. These members also mentioned that they appreciate the concept of the Big Room and that it fits with their way of working.

4.2 Creating a trusting environment

The PMs mention that their role in the project space is not only about steering the project, but more about creating social connections between the team members. One PM mentions*: "I usually say ...,*

you are not here as a tehcnial engineer, you will be working with social engineering. By building relations you will be building much better projects, ... you are creating a comfortable environment and you (PM) are a catalyst for that" (PM2).

The PMs view their role as facilitating interaction between the project members, and not a spider in the web coordinating all the project actors. However, such a facilitator role places more responsibility on the involved actors in the design project. *"It is more about them (project members) coming with their questions, get answers and coordinate and control that everything is as it shall be"* (PM).

A more facilitating PM role also requires mutual trust within the whole project team, which is something the PM mentions. Members need to prepare their work and questions for the project team at their home office before they come to the meeting and in the Big Room their work is shown to and discussed in the group. *"now I really have to rely on that the consultants are taking their responsibility. And now they are sitting in a group where they have to show what they have done both to me and the rest of the group, because I can only be at one place. So I think that it is a big difference that you now have to trust more on your coworkers and feel comfortable with each other"(*PM).

The PM views this relationship as both positive as well as a possible hinder: *"I'm very positive, and I really enjoy working this way. It requires that you can trust everybody that you work with, and that is actually a pitfall, the only one as I see it. I mean - if there is someone who is not performing, then it becomes more difficult for me to see that when it is not as structured as a traditional project*" (PM).

The physical project space offers a number of visual tools that support the project design work sessions. Some of these tools are common in construction design, while others are new to some of the members. The PM is especially involved when the team jointly develops their visual timeplanning and guides them through the different time steps. Especially during the time planning, we observed the usage of space in relation to multiple artefacts and how team members developed their own time planning with help of notes, measurements, 2D drawings and placed their deliverables and requests on sticky notes, discussed these with other team members (disciplines) and then moved to the visual time planning board to place their sticky note on the board. Once all members place their planning on the visual planning board, the PM facilitates a discussion around the sticky notes, asks members to confirm, acknowledge, review, change and consult others in order to develop a time planning suitable for the whole team. During the time planning sessions, important issues and problems come up that need to be solved – e.g. HVAC consultant has a different strategy in terms of design and cannot deliver what the structural engineer requests for a certain time. The PM facilitates the discussion and the structural engineer changes her sticky note deliverable from the board and moves it to another time period. The different deliverables and activities of the team members become very visible to the rest of the team, as well as particular issues and problems. This creates an understanding amongst the team members of the different disciplines and their way of working.

On the one hand such a trusting relationship is perceived as positive, however, on the other hand it also places demands on the team in order to perform in the particular project space. The PM has more a coaching type of leadership in that team members work together during the collocated workday and share their questions, concerns and deliverables together. However, this requires that people are prepared and are willing to work in the particular project location and are willing to show their work in the open space. the PM mentions that the outcome of the design sessions is fully dependend on the

project members and how they prepare for the sessions and engage during the design sessions. *"but if you have a lot of other things and therefore do not have the time to be prepared for a Big Room meeting, then I can imagine that it can be a long an unproductive day, where you will not get so much out of being collocated. I mean it is not like that there is anything happening during a Big Room session, it is very much dependent on oneself what you get out of a day. You need to have your own agenda so that you progress in your own work and in the interest of the project obviously"* (PM).

How a project space is experienced and how this affects the project members engagement in knowledge sharing within such a collocated project space is very difficult for a PM to control and influence: "So much is depending on the people that are engaged in a project, how disciplined and qualified they are. No matter how you work it is the people involved that make the difference" (HVAC consult).

5. Discussion

Based on our findings and use of a spatial perspective consisting of an interrelation between the different facets of project space we contribute with new insights in understanding the role of the PM within a project space. The use and awareness of space and spatial configurations as well as facilitation to create a trusting environment are two findings that concern the PM role.

For the research we only focused on the working approach of the Big Room in which construction design members are collocated for one day a week and work with structured working methods (Garcia et al., 2004; Liker, 2004). The particular environment in which the team works is defined as a project space in which elements of spatial theory (Dale & Burrell, 2008; Kornberger and Clegg, 2004; Lefebvre, 1991; Taylor & Spicer, 2007) play an important role.

The combination of a phsycial collocated space and a work method in which people have to be prepared, work during the work session and should be pro-active to receive the results they need for their performance, has implications for the role of the project manager. The role of project manager is not only into steering the project towards a good end result, but also to support the project team in the use of the physical space, in order to support social interaction, sharing of information and knowledge between the different actors. The PM needs to be aware of the space, - spatial awareness - in terms of the physical configurations as well as the social configurations to be able to support the project team in their work.

From the findings, we observed that the involved project members are more inclined to take responsibility for their own performance and general progress in the project. The project manager has to rely on the fact that project members are prepared, ask questions and have their own agenda for the joint work day. The possibility to work together in a collocated space, supports face-to-face communication and social interaction which facilitates sharing of information and knowledge (cf. Newell et al., 2009). From our observations an important part of the PMs role is to create an environment in which people can collaborate and share knowledge and information. The physical collocated space can support this partially, but the role of the PM becomes important in terms of social engineering; creating social dynamics through physical movability; facilitating the process and use of multiple visual means, as well as engaging the involved actors in cross collaboration in order to share knowledge and information. The particular focus of social engineering opens up discussions on how space can influence leadership as well as project teamwork.

Especially since the construction industry is focusing increasingly on a physical design space, a theoretical spatial lens could supply more insight in a number of project related topics and shows a need for conceptual and empirical work concerning project space and project spacing. Future work would encompass not only the phsycial project space in which the team is working, but also the moving between spaces like the Big Room, home office and other spaces.

6. Conclusions

In this paper we have studied the role of the project manager within a collocated design space from a spatial theoretical perspective. The spatial perspective supports understanding of the project space as a combination of physicality of space, social and power relations and experiences within a space. From a qualitative, comparative case study based on observations and interviews we found that the use and awareness of space and spatial configurations as well as facilitation to create a trusting environment are two findings that concern the PM role in a project space. The focus on project space gives insight in the role of the project manager and how a project manager could work within a project space during construction design. Having a spatial perspective on the role of project management and projects can give new insights in project management literature.

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Competitive Strategy as Narrative: Turkish Contractors in International Markets

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Abstract

Recent years have witnessed the increasing acceptance of the 'narrative turn' in the study of strategy. Such approaches accentuate the socially constructed and discursive nature of competitive strategy. However, as yet little attention has been given to narrative approaches within the specific context of construction management. This paper discusses the way in which a narrative approach can provide new insights into the competitive strategy of Turkish contractors. The rationale for focusing on Turkish contractors is that they have followed a different trajectory from their international competitors. Turkish contractors consistently demonstrate a high propensity for risk by operating in markets, which others perceive to be politically instable and hostile. The central argument of the narrative approach is that individuals -and by extension practitioners involved in strategy- make sense of the world by telling stories. Such stories are mobilized to constitute an overall sense of coherence and direction with direct material implications. Narratives of competitive strategy typically connect the past, present and future by linking events and actors through a projected plotline. Drawing on this 'narrative turn', the current paper focuses on the deconstruction of a formal sector-level narrative derived from the grey literature. The source in question portrays four decades of strategic development by Turkish Contractors as a formal narrative. The narrative demonstrating the internationalization trajectory of Turkish contractors as an 'epic story' is positioned as a strategy text, which provides coherence and direction for further action. The research demonstrates what events, actors and actions are prioritized by the plot structure, and what narrative building blocks are emphasized. The findings illustrate how a narrative approach provides an alternative understanding of competitive strategy to that currently represented in the construction management literature. More importantly, it conceptualizes strategy as a temporal, emergent and dynamic narrative temporally developed on broader discourses.

Keywords: Competitive strategy, narrative turn, international contracting, Turkish contractors, narrative analysis

1. Introduction

Competitive strategy in the construction industry has been investigated from several theoretical perspectives. Much of the literature is characterized by assumptions of economic and political stability (cf. Green et al, 2008a), or at least predictable trajectories of change. Such assumptions have limited validity in the context of the highly unstable markets within which international contractors currently operate. More recent research has moved the debate away from rationalistic explanations towards a focus on the dynamic interactions between contracting firms and the contextual landscape within which they operate (i.e. Kao et al, 2009). Such studies shift the theoretical and methodological orientation of the discussion from quantitative to more qualitative and constructionist perspectives. However, as yet little attention has been given to understanding competitive strategy from discursive and narrative perspectives. The research described accentuates the socially constructed and discursive nature of competitive strategy. Drawing from the assumptions of process ontology and the 'narrative turn' in organization studies, this study aims to understand how competitive strategy is conceived, enacted and communicated. The research is initially positioned against existing theoretical perspectives on strategy, which are too often characterised by assumptions of certain market environment. The narrative approach is then introduced as an alternative theoretical perspective. Emphasis is given to the key concepts used in narrative analysis.

The adopted narrative approach provides a retrospective and contextual understanding of the competitive strategy of Turkish contractors through the deconstruction of formal narratives. The analysis is based on secondary data presented in a quasi-historical book Geography of Contractors, which is published to share the formal narrative of Turkish Contractors Association (TCA). The formal narrative in question portrays the strategic development of Turkish Contractors across four decades. It provides a rich tapestry of story fragments from senior level managers, institutional reports and historical documents. Due to space limitations the scope of the present paper is limited to the analysis of first decade commencing in the early 1970s. Data analysis aims to understand how the plot of the projected narrative portrays the key actors, events and turning points throughout the critical decade of the 1970s. It is argued that the epic story presented by the TCA constructs a narrative infrastructure, which provides coherence and direction for the future actions and narratives. 2. Shifting perspectives on competitive strategy 2.1 Strategizing in the face of certainty

Following the professionalization of strategic management as a discipline in the immediate aftermath of the Second World War, the notion of 'competitive strategy' has been of central importance for scholars of organisation studies. The debate initially focused on the supposed need for top-down rational planning in an assumed certain and predictable operating environment (i.e. Whittington, 1993). This approach continued to dominate the academic narratives of competitive strategy for decades despite the onset of a much less predictable world. Porter's (1985) conceptualization of competitive strategy and market positioning adhered to such stability and predictability of previous ages and informed the majority of empirical studies on competitive strategy (Green et al, 2008a). This is especially true of research studies relating to the competitive strategy of Turkish contractors (i.e. Öz, 2001; Dikmen and Birgönül, 2003; Özorhon, 2012).

However, the instabilities initiated by the oil crises of the 1970s and stagnation of Western economies challenged the assumption of a stable world. In response to the increasingly uncertain and unpredictable environment of the 1970s, the conversation shifted towards strategy formation in emergence (i.e.

Mintzberg, 1987; Miles and Snow, 1978). Of central importance was the recognition that strategy making is inherently political (Pettigrew, 1987). At the same time, organisation studies started to emerge as a distinct discipline with a strong focus on the routines and resources, which enable firms to influence and respond to external change. Discussions turned to the emergent and context-dependent nature of strategizing (i.e. Nelson and Winter, 2002). As a result, the storyline of Porter tended to give way to those derived from Barney's (1991) resource-based view (RBV), thereby shifting the emphasis onto internal resources and capabilities. However, the subsequent onset of globalization and technological change emphasised the need for continuous adjustment in response to changes in the market environment. Hence the emergence of the dynamic capabilities view (DCV) moved the focus to the ability of firms to continuously transform and reconfigure their resources and operating routines (Teece et al, 1997). However, such formal models pay scant attention to the consideration of geo-political factors in the broader landscape and contextually embedded nature of the actions.

2.2 From process perspective to the narrative turn

The strategy 'process' school emerged from the critique of objectivist notions of strategy that are disconnected from the context within which organizations operate. The alternative process perspective emphasises the importance of taking account of the broader historical and geopolitical context. Rather than focus on the analysis of 'comparative statics', the process school emphasises strategic change over time (cf. Pettigrew, 1997). However, the danger with this approach is that process is downgraded to a variable that supposedly shapes the outcome (Langley, 2007). Hence, it too often fails to recognise the inherently dynamic nature of organizational reality and the shift toward seeing organizations as temporally on-going processes (Nayak and Chia, 2011). Of further interest is Strategy-as-Practice (SaP) school which views strategy as something that people do rather than being an inherent property of organizations. The majority of research within the SaP tradition moves the discussion to actor level and focuses on doing of strategy in real time through ethnographic studies. However, a growing sub-theme follows the 'linguistic turn' and hence emphasizes the use of discursive and narrative approaches to understanding strategy (i.e. Brown and Thompson, 2013). Such studies accentuate the importance of talk, text and conversation as the means of 'doing' strategy. It is of course notoriously difficult to fully capture practitioners' daily practices of strategy. In contrast, the 'narrative turn' focuses on the narratives of competitive strategy as the object of empirical analysis. Hence the agenda moves towards understanding how practitioners make meaning, construct experience, and establish identity through narrative (Fenton and Langley, 2011). Such a perspective focuses on the way strategies are depicted, appropriated, and championed through stories (i.e. Barry and Elmes, 1997; Brown and Thompson, 2013).

2.3 Competitive strategy as narrative

The key argument of the 'narrative turn' is that humans make sense of the world by telling stories, and such stories frame the way they see the future (i.e. Czarniawska, 2004; Boje, 2001). Through the narratives told in an organization 'the present, past and future are all continuously retold, and rewritten, revealing organizations as fragile, transient and mutable accomplishments' (Brown and Thompson, 2013: 1149). Therefore, understanding the meanings embedded in narratives can provide insights into the discursive and socially constructed nature of competitive strategy. As De La Ville and Mounoud (2015:252) argues 'the basic function of a story is to organize a series of events and actors into a common, acceptable, and comprehensible temporal framework' to preserve and build the continuity of

actions. Practitioners mobilize narratives to give meaning to past events, and such narratives constitute an overall sense of direction in present day decision-making and generate possibilities for further actions.

Narratives do not emerge just as individual stories; there are also composite narratives, which reflect more formal and institutionalized macro stories. The narrators select, prioritize and connect the events subjectively in their particular context (Søderberg, 2003). Such delineation and interpretation of events of course reflects the personal aims of narrators as communicated through strategy narratives. As argued by Brown and Thompson (2013:1148) 'narratives allow their authors to attach themselves to putatively desirable ends, to think well of themselves, and to promote feelings of self-worth and self-efficacy'. More importantly, narratives shape how organizational actors understand organizational phenomena such as competitive strategy and reconstruct and promulgate it through their discourse and actions (i.e. Vaara et al, 2016).

2.4 Construction of strategy narratives

The key assumption which underlies the narrative turn is that organizations are polyphonic discursive spaces where organizing is constituted by storytelling. Hence strategies and strategizing are seen to emerge through constant interaction of multiple voices. In essence, organizations are seen as discursive spaces in which strategies are told and written through narratives (Brown and Thompson, 2013; Garud et al, 2011). Deuten and Rip (2000) introduce the concept of narrative infrastructure as the evolving aggregation of multiple narratives. They further point towards narrative building blocks as comprising the key themes around which narrative infrastructure in constructed.

It is notable that the narrative infrastructure is held to provide the handrails, which shape the direction of further actions and new emerging narratives. As such it becomes the means of creating a shared social reality in terms of where the organization has been and where it is going. Inevitably, in such a process some narrative building blocks are prioritized over others. Hence narrators 'implicitly express, construct, and reproduce legitimate power structures, organizational roles and ideologies' (Fenton and Langley, 2011:1173).

3. Research Method

3.1 Empirical study: The epic story of Turkish contractors

The research sets out to analysis a key strategy text which serves a continual point of reference for Turkish contractors. The text chosen for analysis is a quasi-historical book called Geography of Contractors: The Adventure of Overseas Contracting Services of Turkish Contractors, which presents the internationalization trajectory of Turkish contractors as an epic story. It was prepared jointly by the Turkish Contractors Association (TCA) and History Foundation of Turkey with the explicit aim of creating a common memory for the sector (Tayanç, 2011). The TCA, the main institution representing the construction companies in Turkey, publishes regular periodic sectorial reports on international contracting and hence creates a powerful formal/institutional narrative infrastructure of Turkish international contracting sector. It therefore plays an important role to creating coherence to the strategizing activities, which would otherwise be lacking. The narrative presented as an online book in TCA's web page comprises 'story fragments' as articulated by senior managers and industry

representatives. It also draws from other written historical documents as a means of providing sectorial level overscript. For those interested in narrative analysis the book provides an explanation how Turkish contracting firms have remained competitive over the course of several decades. It further provides a plot structure, which highlights the significance of certain actors, events and actions that have shaped the strategizing process over time. In short, the TCA's formal narrative provides a narrative infrastructure aimed at reinforcing the competitiveness of Turkish international contractors. Interestingly, the preface of the book is quite explicit in setting out the stated aims:

"In this book you will find the story of how the Turkish builders…have stepped abroad; how their markets, knowledge and skills, the way of doing business in overseas have changed under what internal and external factors…the exciting and sublime story describing how they have stretched from Libyan deserts to Russian steeps, Central Asia, Europe, the Americas to the depths of Africa, and how they have managed to fit such story in 38 years…(such story) will take place in memories and inspire future generations (President of TCA, 2010; cited in Tayanç, 2011)".

It is almost as if the editors of the publication were themselves students of the narrative turn as applied to competitive strategy. The narrative analysis on the TCA's formal narrative provides an alternative understanding to the enactment of strategy in international construction industry.

3.2 Analysing the strategy narratives

The narrative provided in the *Geography of Contractors* organizes events, actors, actions and contextual parameters into a whole with the aim of providing an explanation of the competitive strategy of Turkish contractors. Linking such concepts along a temporal dimension and identifying supposed causalities is conceptualised as an intrinsic part of the process of narrative construction. Barry and Elmes (1997) identify two complementary methods of narrative analysis. One focuses on the structural elements of narrative and questions how the story is constructed. Such an approach tends to deconstruct the narrative to the plot structure, actors, actions, events and contextual setting that constitute the coherence of the narrative. The second method identified by Barry and Elmes (1997) concentrates on the communication perspective emphasizing the role of the narrative in creating a shared social reality for the benefit of the audience. The analysis offered below draws from both methods. Firstly, analysis deconstructs the TCA text though an interrogative process resulting in the identification and coding of its key constituent elements. Rather than adopting a single structural analysis model the researcher created a coding structure on the basis of an iterative process involving oscillation between the empirical data and narrative analysis literature. Important points of reference included: Propp's functions and characters in folk tales (Propp, 1968); Greimas' actant model (Greimas and Courtes, 1982); Burke's Pentad model (Burke, 1969); Ricour's theory of mimesis (Ricoeur, 1984; 1986)). The important narrative elements were defined as a plot structure, actors, actions, events, time and details of the setting (c.f. Czarniawska, 2004). The importance and role of such narrative elements are discussed below before demonstrating the findings from data analysis.

As the key concept of narrative analysis, plot structure works as the primary organizing concept. It is the plot structure of a narrative that assigns the significance to the events, actors, actions and motives in the context and time in which the story takes place. In doing so, the plot transforms the chronological array of narrative elements into a meaningful and coherent whole. As argued by Polkinghorne (1988:19) the construction of a plot comprises abductive reasoning whereby a series of conjectures are

generated and then tested against the textual data. Hence the analysis of the plot structure and embedded story fragments provide insights in the conceptualization of competitive strategy, which is not available simply from a casual reading. The analysis focuses in particular on the way goals and motives play an important role in shaping the preferred plot structure over others and the selection of emphasized narrative building blocks to set up the narrative infrastructure. The essential point is that the plotline of the narrative infrastructure constitutes an overall sense of direction thereby generating possibilities for further actions.

Narratives connect past events into a coherent story by emphasizing their significance and impact on other events. Czarniawska (1998) argues that few are aware that an important event is happening at the point at which it takes place. As events are not routinely abstracted from their spatio-temporal contexts, socially constructed narratives provide important contextual knowledge, which would not otherwise be readily available. Phrased rather differently, such narratives are constitutive of a retrospective sense-making process (Brown and Thompson, 2013). A narrative analysis of the Geography of Contractors offers the opportunity for a contribution to knowledge on the basis of a historical, temporal and specific rendering of causality in respect of the trajectory of Turkish contractors (cf. Tsoukas, 2004). In addition to events, actors and actions are other important ingredients of a narrative, and hence important components of any narrative explanation. Actors and actions also tend to predate the events emphasized in the narratives. Narrative understanding views action as 'an expression of existence and that its organization manifests the narrative organization of human experience' (Polkinghorne, 1988:142). Actions take place as a result of particular motives and goals within the circumstances of specific contexts through interaction with other actors and contextual parameters. The narrative explanation interprets the relationship between actors, actions and events in the context within which the interactions occur, thereby, provides an embedded and contextual understanding (cf. Pettigrew, 1997). Different plot structures assign different roles to the actors such as protagonists and villains (Czarniawska, 2004). By assigning such roles to specific actors, narratives are variously structured as epic or tragic stories in accordance with aims and motivations of the narrator.

In addition to analysing the structural elements of the narrative, the adopted approach also seeks to identify key narrative building blocks. These are identified through a process of multiple readings with the aim of identifying 'similarities, dissimilarities, and recurrent words and themes' across story fragments (cf. Brown and Humphreys, 2003:127). Following Polkinghorne (1998), special attention was paid to underlying patterns by iterating between the data and the emerging interpretation of underlying patterns.

4. Findings and Discussion

4.1 Deconstruction of the TCA's grand narrative

The formal representation of Turkish contractors' narrative was plotted as a full story in a chronological manner. The story fragments in the text tend to reflect the retrospective accounts of company managers and hence are often not ordered chronologically. The plot structure tends itself to interpretation as an epic story constructed from the voices of senior managers who often see themselves as heroes of international contracting operating in conflict zones. The formal narrative hence puts great emphasis on describing the barriers that needed to be overcome and their role as quasi-heroic characters in subjugating such difficulties. The key question for further analysis, then, moves from the narrative to

the function of the narrative and becomes how epic stories provide the narrative structure for the future strategic direction of Turkish contractors.

The analysis demonstrates that the starting point of internationalization is frequently associated with two different narrative building blocks. The first relates to the size of the firm and its capability to operate in the specific overseas market. The second relates to the (recurring) economic crises in Turkey and the resultant stagnation in the domestic market. Typical story fragments include:

(i) "After the port project in [Turkey], he did not find a project in his size and ability in the domestic market (Company founder, 1996; cited in Tayanç, 2011)" / (ii)
"With domestic market crises in 1979…I was officially bankrupt. At the end, I had to go Libya… (Company owner, 2005; cited in Tayanç, 2011)"

In both scenarios highlighted above the main underlying theme is that involvement in international contracting became part of the Turkish government's policy agenda to increase foreign earnings with a view to overcoming the economic fiscal deficit, which prevailed throughout much of the 1970s. According to the story fragments drawn from Libyan officials, several companies were given permits to work without their technical and financial capacities (Tayanç, 2011). For many companies their initial overseas contracts were acquired through their connections with Western firms for whom they had previously worked as subcontractors on domestic projects of 1940s and 1950s. Key building blocks for the strategy narrative of 1970s include (i) learning from foreign companies, (ii) early project completion, (iii) repeat orders with key clients on the basis of trust and (iv) setting up subsidiaries with local partners. Of particular note is the emphasis on the adventurous stance of Turkish contractors to create their own destiny despite barriers and set-backs.

"I am one of the first who went to Afghanistan…there was no place to stay. We stayed in the Turkish Embassy building by suplicating the acting embassador…There was only one hotel...half of it was bombed, the other part did not exist…I said how we could do business in here? No concrete, nothing…Then, I thought the land of the embassy building is large and I offered to build a hotel there…Through convincing the ambassador, and arranging bureaucratic works in related institutions in Turkish government, finding money…and delivering construction materials by plane we construct a hotel …in in three months. There was bomb explosions outside… (Head of TCA's Advisory Board, 2009; cited in Tayanç, 2011)"

Above quotation is one of the several examples that emphasize the harsh working conditions and maverick behaviour of the contractors to find temporary solutions and create opportunities out of difficulties. As addressed in this quotation, the foreign offices have been underlined as the helper to the heroes throughout the narrative.

4.2 The role of international and governmental institutions

Some events are underlined as key turning points, which shaped the trajectory of Turkish contractors in their quest for overseas expansion. Of particular importance are the actions of the Oil and Petroleum Exporting Countries (OPEC). The increasing influence of OPEC, the reconstruction of Libya in the wake of Qaddafi's revolution, and the negative effects of 1970s oil crises on the domestic economy in Turkey are all emphasized as the critical events:

"When OPEC was founded in 1960…There is not any information / document about any person (in Turkey) who foresee that it will drag the world into a major depression in ten years, a part of the members who benefited from such depression will create a market for internationalization of Turkish construction sector and lead to the formation of a sector called 'foreign contracting services" (Tayanç, 2011:42)

The formal narrative underlies the international politics and the Turkish diplomatic outreach to Qaddafi as the key reasons for the 1970s expansion into Libya. Qaddafi's anti-Western stance denied opportunities to contractors from UK, and USA and his political disagreements with Egypt necessitated the withdrawal of Egyptian contractors from Libya. But equally important was that such happenings concurred with Turkish government's policy of incentivising export promotion in domestic agenda (Tayanç, 2011). As might be expected, overseas embassies and governmental agencies would seem to play a key role in developing trade networks in different markets. More importantly, trade agreements emerge as one of the main events shaped the trajectory to different markets. For example, the 'Turkey Libya Workforce Treaty' and the 'Establishment of Joint Economic Commission between Turkey and Libya' were of central importance to the increased involvement of Turkish contractors in Libya.

4.3 Allies and brothers

The cultural and historical proximity narrative building block find strong emphasis in several story fragments. The text highlights how Turkey and Libya saw each other as allies and brother countries in the troubled context of 1970s international politics. Several story fragments point strongly towards the important of these cultural ties to the increased trade relations. Similarly, religious proximity is highlighted as being of central importance the market entry into Saudi Arabia. The text stresses the idea that Turkish contractors managed to use cultural values strategically as a means of temporarily solved culturally sensitive issues. For example, a tunnel project in Saudi Arabia opened for the haj season with a temporary technical solution. This was seen as the main reason for being selected in subsequent phases of the project and thereafter in establishing market share in Saudi Arabia. Western contractors were clearly disadvantaged by their lack of religious proximity, and the way that history is too often structured around points of difference. In the case of Libya is was important that many Libyan government bureaucrats had been educated in Turkey through scholarships provided by the Turkish government. This seemingly resulted in Turkish contactors being given special dispensation from the more onerous contract conditions that were maintained ruthlessly for contractors from elsewhere:

"Through my help, Turkish firms were exempted from this condition (50 US million work record in international market)…There was another point that [Turkish Banks] were not acknowledged, (therefore) they (the contractors) had to bring security deposits from [European Banks]…Through the decision that I had enacted, the security deposits from Turkish banks were accepted as well (Libyan bureaucrat; cited in Tayanç, 2011)".

Similarly, setting up good relationships with the client is emphasized as a means of securing involvement in successive projects and hence becoming embedded in particular markets. In this respect, Turkish contractors were more willing to play the 'long game' than their Western counterparts. This in part could be accounted for by the private ownership structures of Turkish contractors such that they were not required to return dividends to shareholders on an annual basis.

4.4 Heroes creating opportunities

The narrative repeatedly depicts contracting companies' founder managers as heroes who created opportunities out of nothing in the deserts of Middle East and North Africa. They are presented as the key protagonists, who perform heroically to find temporary solutions to complex problems in adverse conditions:

"*He won the agreement that he did with the PRENS, he digged both tunnels and got the project done before Haj seasons. He made a rough spray alum and openned the tunnels for haj..and with this job, our firm had settled in Saudi Arabia... (Company founder partner; cited in Tayanç, 2011)"*

The above quotation emphasize the company partner's action to acknowledge a culturally valued event, and the following part of the story fragment describes how such a temporary solution has enabled the company to become embedded in the market. Of course, consideration also needs to be given to the role played by the organization structure. The actions of the managers seem to benefit from the organizational structure of the companies. Managers within family owned private companies tend to act flexible in times of emergent decision-making and risks. In addition, diversification beyond contracting services and investment in supporting business lines seems to shape further actions of the companies; however investment in other sectors becomes a key narrative in the following periods. Of key importance is the recurring emphasis on entrepreneurial and risk taking behaviour of company founder managers in majority of story fragments.

4.5 Resonance and contradictions with existing literature

The findings from the narrative analysis provide empirical support to recent discussions that draw on narrative and discursive perspectives to understand competitive strategy. For example, maverick behaviour, the concept coined by Green et al (2008b), emerged as one of the key themes implicit in the TCA's grand narrative. The story fragments presented as direct quotations from company founders and senior level managers highlight the role of seemingly maverick decisions taken in isolation of the formalised strategy, which prevailed at the time. This finding would seem to resonate with the emerging concept of temporal work relating to through process which practitioners construct and reconstruct strategic accounts through the temporal linking of past, present and future interpretations (i.e. Kaplan and Orlikowski, 2013). Hence the very process of constructing a narrative, even if provisional, allows actors to shift from disagreement and confusion towards a shared understand of how to move forward.

The findings from the analysis of TCA's strategy text present a challenge to the current ways in which the process of strategizing is conceptualised within the construction management literature. They further point towards an explanation of Turkish contractors' successful internationalization as a process, which is shaped (and re-shaped) by a series of interactions between events, actors, actions within a broader dynamic geo-political context. In contrast much of the current literature on Turkish contractors continues to adhere to the static assumptions of the conventional literature. Empirical studies go little further than the analysis of external market forces and industry-level capabilities (e.g. Öz, 2001; Dikmen and Birgönül, 2003; Özorhon, 2012). The story fragments embedded within the TCA narrative rarely refer to strategic positioning or to the planned development of specific resources or capabilities. In contrast, the story fragments point more towards the idea of learning by doing and experience. For example, one of the quoted senior managers suggested:

"…Working in partnership with foreign companies in domestic market does not only help getting familiar with companies themselves but also learning the standards of international contracting… (Company owner; cited in Tayanç, 2011)"

Learning from foreign partners finds strong emphasis in different story fragments. The key themes emerged learning the project management, new technologies and use of international funding sources. Especially important is that Libya, as the initial market of the internationalization has been labelled as the 'primary school' of Turkish contractors (Tayanç, 2011). The findings support the argument that strategy practices are defined through a retrospective sense-making process via the post-rationalization of previous actions and their consequences. Hence the epic stories drawn from retrospective accounts provide a strong narrative infrastructure by using past achievements as a motivating factor and opportunities available to Turkish contractors.

5. Conclusions

The described research contributes to the current interpretation of competitive strategy presented in the construction management literature by drawing on the emerging interest in discursive and narrative processes. It accentuates an alternative theoretical landscape and introduces the concepts of narrative analysis for the purposes of empirical research. Conceptualizing competitive strategy as narrative, the historical interpretation offered by TCA is seen as a strategy text, which presents an industrial/grand level narrative. Empirical analysis demonstrates that the plot structure of the book depicts an *epic story*, in which founder/managers are seen as *quasi-heroic* characters. They are accredited with heroic attributes on the basis of their ascribed roles in overcoming risk and uncertainty in the successful pursuit of overseas expansion. The structural analysis provides a means of understanding how actors, actions, events and the broader geo-political context are temporally linked to constitute a narrative infrastructure for the purposes of guiding further action.

It is argued that TCA text constructs a sectorial level grand narrative through the selecting and prioritization of some stories over others. At the same time, it highlights challenges presented by risky and turbulent markets. Drawing on retrospective stories, the text creates a narrative infrastructure providing a continual point of reference for Turkish contractors. More importantly, the epic plotline of the narrative creates a sense of direction for future action. Hence, the data analysis provides empirical support for the generative role of strategy narratives. As argued by Brown and Thomson (2013), the strategy stories describe causal patterns and relations between events; they constitute winners and losers, successes and failures; they attribute responsibilities, then point to the role of serendipity; and they allocate blame for problems and praise for supposedly prescient thinking. The study demonstrates the findings from first ten years of an on-going analysis of narrative which across four decades. The key message of the empirical findings is that TCA's grand level narrative invokes historical stories to create a discourse that provides future. As such the production of such documents is constitutive of the 'doing of strategy'. Next step of the empirical research will focus on the analysis interviews with senior managers from contracting companies to ascertain the extent to which their interpretations of strategy conform with more formalised narratives.

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The role of the public client the social construction of BIM

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Abstract

Different actors with different work practices, behaviours and culture are currently implementing BIM in temporary projects, networks and alliances. In this change process, public clients are increasingly being promoted as the drivers of change via their ability to demand BIM in procurement. Thus, understanding public client´s BIM implementation from a sociotechnical context is important. The Social Construction of Technology (SCOT) allows for such an understanding. SCOT holds the public client, together with contractors, consultants, educators, etc, form relevant social groups that form the social constriction of BIM. Public client fill a particular important role in the social construction of BIM due to their large influence on the other social groups. A large Swedish public infrastructure client recently implemented BIM with the specific aim of driving industry change, innovation and productivity (SOU 2012:39, Trafikanalys 2015). This study aimed to understand the role and impact of the public client in the social construction of BIM in the Swedish AEC industry. For this, the sociological explanation for BIM at the public client needed to be understood. The findings showed that there are currently two conflicting sociological explanations for BIM that are being socially promoted at the public client (one accepting the implementation as a means for driving industry change and one rejecting it). These conflicting sociological explanations had two different implications for the public client´s role and impact in the social construction of BIM.

Keywords: BIM, public client, technology acceptance, social construction of technology

1. Introduction

The Architecture, Engineering and Construction (AEC) industry is facing major changes with the advent of digitalization. Although the industry has long relied on digitalization to support work practices (Eastman 1974), the expectations on digitalization, and in particular on Building Information Modelling (BIM), for an increased efficiency, innovation and change in the AEC industry have never been higher (Fox 2014). Yet, in the project-based, fragmented and interdependent AEC industry, different actors with different work practices, behaviours and culture implement technology in temporary projects, networks and alliances. Thus, it is important to study BIM implementation from a socio-technical view that regards the interaction between the technical system (BIM) and the social system (behaviours, expectations, social norms etc) (Davies and Harty 2013, Sackey et al 2014, Miettinen and Paavola 2014). One such view is the Social Construction of Technology (SCOT) (Pinch and Bikjer 1984) which holds that different social groups in society shape the design, use and impact of a technology based on their sociological explanations for acceptance or rejection of the technology. Certain social groups will have large influence. In the AEC industry context, one such social group is the public client. Public clients are promoted as change agents for the industry's implementation of BIM and change of work practices, behaviours, attitudes and culture via their ability to demand BIM in procurement (Linderoth 2010, Porwal and Hewage 2013, Wong et al 2011).

A large Swedish public infrastructure client recently implemented BIM with the specific aim of driving industry change, innovation and productivity (SOU 2012:39, Trafikanalys 2015). The purpose of this study is to understand the role and impact of the public client in the social construction of BIM (SCOT) in the Swedish AEC industry. To understand this role, the sociological explanation for the acceptance or rejection of BIM of the public client as a social group must be understood (Pinch and Bijker 1984). This means that the acceptance and rejection of BIM among the various individuals, groups and networks that are involved in the implementation of BIM at the public client and exert influence on the industry must to be understood. The Extended Technology Acceptance Model (Venkatesh and Davis 2000) is used for understanding the acceptance and rejection of BIM among the individuals, groups and networks involved in the implementation of BIM at the public client. This knowledge supports an understanding the sociological explanation for BIM of the public client and for understanding the public client´s role in the social construction of BIM in the industry.

2. Theoretical framework

2.1 Social Construction of Technology (SCOT)

Social Construction of Technology (SCOT) holds different social groups in society shape the design, use and impact of a technology based on their sociological explanations; the social contexts in which the arguments for acceptance and rejection of the technology have been promoted and socially supported based on the social group´s different interpretations, beliefs and expectations about the technology, its usefulness and the problems it is expected to solve (Pinch and Bijker 1984). The sociological explanations and social construction of technology form in a process of interpretive flexibility and stabilization. Interpretive flexibility means that different the same technology can be seen in different ways and used differently by different social groups. Certain social groups will tend to share common interpretations, beliefs and expectations about the new technology, its usefulness and what problems and conflicts the technology is supposed to solve (sociological explanations). The

relevant social groups can be the designers (e.g. software developers) and the users of the technology (e.g. consumers, firms). The social groups will favor certain technical designs such as certain application areas. SCOT involves identifying the different social groups and their sociological explanations. The relations, influences and power between the different social group's sociological explanations form in the stabilization process where either one social groups´ sociological explanations prevails over other ones´ or when competing social groups reach a compromise.

SCOT understands the social construction of technology (the social shaping of technology) in industries, economies and societies where the level of analysis is on different social groups that often represent larger entities such as firms, organizations, households, consumer groups etc (Pinch and Bikjer 1984). To understand the sociological explanations of a social group, the acceptance or rejection of the individuals, groups and networks that constitute a social group must be understood. TAM2 (Venkatesh and Davis 2000) is useful as it understands how acceptance/rejection form in the social context based on social influence and social cognition.

2.2 The Extended Technology Acceptance Model (TAM2)

The Technology Acceptance Model (Davis et al 1989) explains how technology acceptance/rejection is dependent on perceived usefulness (the degree to which a person believes that using a particular system enhances his/her job performance) and perceived ease of use (the degree to which a person believes that using a particular system is effortless) and by individual´s attitudes and behavioral intentions towards using the technology. In TAM2, Venkatesh and Davis (2000) add the impact of social influence processes (subjective norm, voluntariness, and image) and cognitive instrumental processes (job relevance, output quality and result demonstrability) on perceived usefulness. Subjective norm is one´s perception that most people who are important think that one should perform the behavior. Voluntariness is the extent to which the adoption is perceived to be non-mandatory. Image is the degree to which the use of a technology is perceived to enhance one´s status in the social system. Job relevance is one's perception that the target system is applicable to the one´s job. Output quality is the degree to which one perceives that a new technology can perform required task that match ones job relevance. Output demonstrability is the perceived tangibility of the results of using the technology. Subjective norm influences image because if an individual's work group considers it important to use a technology, then using it will elevate one´s image in the group.

3. Method

To understand the role of the public client in the social construction of BIM (SCOT) in the Swedish AEC industry, the sociological explanation for the acceptance or rejection of BIM of the public client as a social group must be understood (Pinch and Bijker 1984). This means that the acceptance and rejection of BIM among the various individuals, groups and networks that are involved in the implementation and exert influence on the industry need to be understood. TAM2 (Venkatesh and Davis 2000) allows for understanding the acceptance and rejection of BIM among individuals, groups and networks of three units at the public client involved in the implementation of BIM: a BIM Competence Group and the departments of Major Projects and Investment Projects (section 4). This knowledge is useful for understanding the sociological explanation for the acceptance or rejection of BIM of the public client and for the subsequent understanding of the role of the public client in the social construction of BIM in the Swedish AEC industry (Pinch and Bijker 1984) (section 5). The BIM

Competence Group is responsible for governing the BIM implementation and develops strategies and procedures for the implementation at Major Projects and Investment Projects. The actual implementation of BIM is conducted at Major Projects and Investment Projects by project managers using procurement contracts that demand BIM from suppliers. Their implementation is overseen by BIM implementation managers. Major Projects consists of large, complex and unique infrastructure projects and Investment Projects of smaller reconstruction projects. TAM2 is also useful for understanding how the BIM Competence Group´s idea of the public client implementing BIM as a means for driving industry change has been accepted or rejected by Major Projects and Investment Projects.

The findings are based on a four year case study of the public client´s implementation of BIM. It consists of interviews with and observations of the individuals, groups and networks involved in the implementation, including the BIM Competence Group; BIM pilot project managers, BIM coordinators, business unit managers and the implementation manager of Major Projects; and project managers, operations managers and the implementation manager of Investment projects. The case study also includes document studies, email correspondence and informal talks. Thus, the interpretation is based on a variety of empirical viewpoints (Yin 1994). The interviews allowed for understanding the individuals´ interpretations, beliefs and expectations about the BIM implementation, while the observations allowed for understanding how these were influenced by social interactions and networks and for how the groups and networks (e.g. the BIM Competence Group, BIM coordinators) formed their collective interpretations, beliefs and expectations about the implementation.

4. The acceptance and rejection of the BIM implementation

4.1 The BIM competence group

The BIM Competence Group consists of early adopters from mainly Major Projects who all share the belief of the importance of the public client driving the implementation of BIM in the industry in order to create industry change, innovation and productivity. Such an interpretation suggests a positive cognitive influence of job relevance and output quality on perceptions of perceived usefulness of BIM (Venkatesh and Davis 2000). The sharing and confirmation of this interpretation among such a group of early adopters also suggests a positive social influence of subjective norms (Venkatesh and Davis 2000). The BIM Competence Group promoted their idea and argument of having the public client implement BIM as a means to drive industry change to the departments of the public client by, for example, revising the procurement contracts used by project managers to demand BIM from suppliers, modifying the steering documents that control project managers work practices and engaging on various BIM communities. The procurement contracts demanding BIM from suppliers provided detailed instructions and demands to suppliers on how to use BIM. The BIM pilot project managers, BIM coordinators and the BIM implementation manager of Major Projects, who belonged to same department as the members of the BIM Competence Group, shared the BIM Competence Group´s interpretation that the public client role and mission from the government (see Svensk författningssamling 2010:185, 2 § line 10), was to implement BIM as a means for driving industry change, innovation and productivity. This supports a positive influence on technology acceptance through subjective norm and image (Venkatesh and Davis 2000). The BIM Competence Group had also put effort into trying to evaluate the business value of BIM at the BIM pilot projects. The focus was on the measurable effects of BIM on project performance, such as a lower spread in tendering bids,

less errors, rework and changes, increased worksite safety, earlier completion times and lower costs. However, it was difficult to discern any superior project performance in BIM projects compared to non-BIM projects. Still, the expectations on the future business values of BIM remained high (output demonstrability) (Venkatesh and Davis 2000).

Thus, evaluating the BIM Competence Group´s interpretations, beliefs and expectations about the BIM implementation using the social influence and cognitive influence processes in Venkatesh and Davis (2000), suggest an acceptance for BIM.

4.2 Major Projects

Major Projects had agreed with and also been able to implement the BIM Competence Group´s idea of having the public client implementing BIM in order to drive industry change in many of their BIM pilot projects. This was because of the projects´ size, complexity, availability of resources for experimentation with new ideas and the autonomy of their project managers. These characteristics enabled the project managers to implement the revised procurement contracts demanding BIM from suppliers, implement BIM on their own initiatives or on the initiatives from their suppliers. There was thus a positive social influence of voluntariness on the perceived usefulness of BIM and a positive cognitive influence of job relevance (Venkatesh and Davis 2000). Also, the experiences of the BIM pilot project managers, BIM coordinators and implementation manager of Major Projects influenced the work of the BIM Competence Group, suggesting a social influence of subjective norm and image (Venkatesh and Davis 2000). They also shared the BIM Competence Group´s interpretation of the public client´s role and mission to include actively driving industry change, innovation and productivity by demanding BIM (indicating a positive cognitive influences through job relevance and output quality) (Venkatesh and Davis 2000). The head of unit of Major Projects had also endorsed the implementation and a common view among managers of Major Projects was that BIM could help the public client to achieve its goals of increased productivity, innovation and sustainability. This further supports the strong positive influence of subjective norm on image (Venkatesh and Davis 2000). The BIM pilot project managers, BIM coordinators and the implementation managers of Major Projects had also perceived positive business values of BIM in their projects. Although these were highly experience-based and tied to certain individuals, the overall interpretation of BIM was that was useful and beneficial to their daily management of their projects (output demonstrability) (Venkatesh and Davis 2000). The interpretation of the benefits and usefulness of BIM also remained strong even when many of the BIM pilot projects and their BIM coordinators had perceived challenges and difficulties with actually using and implementing the new procurement contracts that demanded BIM from suppliers, suggesting positive cognitive influences of output quality and output demonstrability (Venkatesh and Davis 2000).

Thus, using the social influence and cognitive influence processes in Venkatesh and Davis (2000) for evaluating the individuals, groups and networks interpretations, beliefs and expectations about the BIM implementation at Major Projects, suggest an acceptance for the BIM implementation as a means for driving industry change.

4.3 Investment Projects

In contrast to Major Projects, Investment Projects are characterized by smaller everyday reconstruction projects where all project managers must follow the same work practices. Major Projects had been able to implement BIM on their own initiatives and voluntarily. However, at Investment Projects, the implementation of BIM was governed in a top-down fashion. From 2016 and onwards, the new procurement contracts demanding BIM from suppliers were mandatory for project managers to use (this was also prescribed in the management system governing project managers work practices). Thus suggests that the social influence of voluntariness may have a negative influence on the perceived usefulness of BIM (Venkatesh and Davis 2000). A few project managers interpreted this requirement as a sign that top management prioritized the BIM implementation, exerting a positive social influence on perceived usefulness of BIM through *subjective norms and job relevance* (Venkatesh and Davis 2000). However, the majority of the project managers perceived that top management prioritized the other parallel change initiative of becoming a more professional client (using less detailed contracts and leaving it to their suppliers to decide how to implement BIM). Many thus perceived that the BIM implementation, i.e. providing detailed instruction and demand on how to use BIM in procurement, clashed with the professional client role. Many did also not perceive any benefits of BIM and associated BIM with costs and complexity, suggesting also a negative cognitive influence of *job relevance and output demonstrability* on perceived usefulness of BIM (Venkatesh and Davis 2000). Also, it had been difficult for many project managers to actually use the new procurement contracts. They were too complex and confusing for both the project managers and suppliers. Thus, many project managers had to put time and effort on directing the work of their suppliers. In many cases, the procurement contracts had to be complemented with additional contracts or were simply put aside in favour of earlier versions of the procurement contracts that did not demand BIM. This was possible despite the requirement for using the new procurement contracts as it was difficult to follow-up that project managers used the new procurement contracts, the implementation manager explained.

Moreover, the implementation manager of Investment Projects argued that there were several middle and top managers of Investment Projects (including himself) that did not share with the BIM Competence Group´s idea of the public client acting as change agent in the industry by demanding BIM in procurement. In contrast, they did not interpret that the public client´s role and mission from the government (in Svensk författningssamling 2010:185, 2 § line 10) was to actively drive industry change, but to inspire and motivate change. The interpretation was that it was not in line with the public client mission to make detailed instructions and demands on suppliers on how to use BIM. This indicated negative social and cognitive influences of *job relevance and output quality* on perceived usefulness of BIM. In particular from top management, there was a negative influence of *social norms* on project manager's image (Venkatesh and Davis 2000). Management of Investment Projects prioritized the other ongoing change initiative of the professional client role over the BIM implementation, further indicating a negative influence of *social norms and image* (Venkatesh and Davis 2000). The purpose of the professional client role was to create a greater uniformity and clarity towards suppliers and leaving greater responsibility to suppliers. The BIM implementation (using detailed contracts) was thus perceived to clash with the professional client role (indicating a negative cognitive influence of *job relevance and output* quality Venkatesh and Davis 2000). The implementation manger also argued that many project managers viewed BIM merely as a procurement support and a product and tool. Once its purpose accordingly to the procurement contracts had been

fulfilled (e.g. used for visualization and early coordination), the models were put aside in favour of drawings and were not used for any further purposes.

Thus, using the social influence and cognitive influence processes in Venkatesh and Davis (2000) for evaluating the individuals´, groups´ and networks´ interpretations, beliefs and expectations about the BIM implementation at Investment Projects, suggest a rejection for the BIM implementation at the public client as a means for driving industry change.

5. Understanding the role of the public client in the social construction of BIM in the Swedish AEC industry

Several different actors with different work practices, behaviours and culture are implementing BIM in temporary projects, networks and alliances in the AEC industry. SCOT argues that these are all relevant social groups that will tend to share common interpretations, beliefs and expectations about BIM, its usefulness and the problems BIM is expected to solve (different sociological explanations for the acceptance or rejection of BIM) (Pinch and Bijker 1984). The social groups will collectively shape the use, design and impact of BIM and form the social construction and shaping of BIM based on their sociological explanations (Pinch and Bijker 1984). Together with contractors, consultants, educators, municipalities, software developers and other relevant social groups, the public client will take part in the social constriction of BIM and is particularly important to study as it exerts large influence on the other social groups.

Using TAM2 (Venkatesh and Davis 2000) to understand the acceptance or rejection of BIM among the individuals, groups and networks of three important units at the public client helps in understanding of the sociological explanation for BIM of the public client as a social group (Pinch and Bijker 1984). This section combines the findings from the application of TAM2 (section 4) with findings from applying SCOT to the case study in order to understand the sociological explanation for BIM at the public client as a social group (section 5.1) and to discuss the role of the public client in the social construction of BIM (section 5.2).

5.1 The sociological explanation for BIM at the public client

There were two conflicting interpretations of the BIM implementation at the public client. The BIM Competence Group and Major Projects seemed to have accepted the implementation of BIM at the public client as a means for driving industry change. In contrast, Investment Project seemed to have rejected the implementation of BIM at the public client as a means for driving industry change (in favor of the implementation of the professional client role). What implications do these conflicting interpretations of the BIM implementation among these three important entities have for the sociological explanation for BIM of the public client a social group and for the public client´s interpretive flexibility?

The two different and competing interpretations of the BIM implementation (one accepting it and one rejecting it) at the public client, suggests that there currently are two different sociological explanation for BIM at the public client. There are indications that the sociological explanation promoting a rejecting of the BIM implementation at Investment Projects may have had a large influence and impact on the public client as a whole. Despite that the management system required project managers of

Investment Projects to use the new procurement contracts, that the implementation of BIM had been sanctioned and legitimized by the General Director in 2013 (Trafikverket 2014) and that the professional client role (described in a report) lacked the same formal legitimacy as the BIM implementation (a report vs a decision), there were several examples of top management of the public client prioritizing the professional client role over the BIM implementation. For example, BIM was de-emphasized in top managements´ strategic development while the professional client role was increasingly prioritized. The role of BIM was small in the areas for future research and development (R&D) (Trafikverket 2016). This was also the case in the descriptions of the focus areas for increased productivity and innovation (Trafikanalys 2015). Yet, there are also indications that the sociological explanation promoting an acceptance of BIM also had influence and impact on the public client organization. The implementation of BIM had strong legitimacy among management of Major Projects and BIM was included in the management system governing the work practices of Investment Projects. Thus, the implementation of BIM at the public client is an ongoing and changing process and the same seems to be the case for the sociological explanation for BIM at the public client.

What is interesting in this context is that what seemed to be at the heart of matters and impact the arguments of acceptance and rejection was the interpretation of the public client role and mission from the government (see Svensk författningssamling 2010:185, 2 § line 10). The BIM Competence Group and Major Projects argued that they interpreted the public client role and mission to include driving industry change and thus accepted the idea of having the public client implement BIM as a means for driving industry. In contrast, Investment projects did not interpreted the public client role and mission to include driving industry change and thus rejected the idea of having the public client implement BIM as a means for driving industry change. Interestingly, arguments of business value of BIM, which the BIM Competence Group, Major Projects and Investment Projects initially all thought would be an important factor for gaining legitimacy and acceptance for the BIM implementation seemed little impact. Social influence and cognitive influences had large impact on arguments of both acceptance and rejection (Venkatesh and Davis 2000). One reason for this might be the social context in which the BIM Competence group was to promote their main idea and argument for the BIM implementation (Pinch and Bijker 1984). The social context in which this argument was promoted to Major projects was of an enabling nature as they all belonged to the same department and shared the same beliefs, interpretations and expectations about the public client´s role in the industry's implementation of BIM. However, the social context in which this argument was promoted to Investment Projects was more challenging. Here, there were other changes initiatives taking place at Investment Projects of higher priority and an overall scepticism and reluctance towards new technology and new ways of working.

Thus, the interpretive flexibility of BIM (the way BIM was understood and used for) at the public client was also twofold (Pinch and Bijker 1984): in the department of Major Projects BIM was being implemented as a means for driving industry change, while at Investment Projects there was a suspicion towards implementing BIM for such purposes and BIM was merely being used as a tool supporting visualization and early coordination.

5.2 The role of the public client in the social construction of BIM

What are the implications of the two conflicting sociological explanations for BIM and interpretive flexibilities for the public client´s role and impact in the social construction of BIM?

Firstly, the sociological explanation promoting an acceptance of the BIM implementation as a means for driving industry change at a department that conduct such large, complex and unique mega infrastructure projects (Major Projects) implies that the public client can have a significant impact and role in the social construction of BIM. The implementation of BIM at Major Projects was and could be pursued from the objective of creating industry change because of the autonomy, sixe, complexity, uniqueness, resources and prestige of these projects. Through the implementation of BIM at Major Projects, the public can fill a large role in shaping the social construction of BIM and exerting influence on the Swedish AEC industry actors by creating opportunities for changing work practices, roles, attitudes and behaviors and culture, experimenting with new ideas and creating new innovative ways of working.

However, the sociological explanation promoting a rejection of the BIM implementation as a means for driving industry change at a department (Investment Projects) of the public client that conducts the majority of the infrastructure projects consisting of thousands of smaller everyday reinvestment projects also has a significant impact on the public client´s impact and role on the social construction of BIM in the Swedish AEC industry. On one hand, Investment Projects are able to exert influence on the social construction of BIM in the industry when project managers are using the procurement contracts that demand BIM from suppliers (which they are also required to do since 2016). On the other hand, project managers reported difficulties and challenges with actually using the new procurement contracts on both their own behalf and on their suppliers´ behalf. For example, they perceived difficulties in understanding the formulations in the new procurement contracts and in understanding what it was that they were demanding. They also reported that the new procurement contracts caused confusion, increased uncertainties and misunderstanding for their suppliers and in that they still had to put time and effort on directing their supplier´s work with BIM. It was difficult for the implementation managers to follow up that the new procurement contracts actually had been used by the project managers. Projects managers also resorted to using the previous procurement contracts that did not include any demands on suppliers to use BIM. Via this implementation, the public client also exerts influence on the social construction of BIM in the industry.

The two conflicting sociological explanations and interpretive flexibilities for BIM at the public client are currently being communicated to the other relevant social groups of the Swedish AEC industry via different channels. On one hand, procurement contracts are used by both Major Projects and Investment Projects as a formal channel for communicating that the public client´s role is to implement BIM as a means for driving industry change and represents a say for the public client to take part in the social construction of BIM in the Swedish AEC industry. On the other hand, the project managers of Investment Projects and BIM pilot project managers and BIM coordinators of Major Projects also impact the social construction of BIM in the industry through more informal and social channels, including their day-to-day interactions with their suppliers, social relationships with suppliers and their shared work practices and shared cultural norms. The BIM Competence Group also exerts social influence on the social construction of BIM in the Swedish AEC industry via their engagements in various BIM networks (e.g. BIM Alliance). These two different ways in which the public client fills its role in the social construction of BIM is likely to cause confusion among the other relevant social groups (e.g. contractors, consultants etc) that take part in the social construction of BIM (social shaping of BIM) in the Swedish AEC industry. What makes this particularly challenging is the current regulations of the Swedish AEC industry that state that when there is conflict and confusion between parties, drawings are superiors models. Thus, more research needs to be conducted on the social

construction of BIM in the Swedish AEC industry where studies also regard the conditions and characteristics of the industry. As SCOT holds that all relevant social groups via social interactions and networking form the social construction of BIM (form its design, use and impact) (Pinch and Bijker 1984), future studies are also needed that apply SCOT to study other relevant social groups in the industry such as contractors, consultants, educators, software developers . These studies are important and need to be integrated with the findings from this about of the role of the public client in the social construction of BIM in order to fully understand the social construction of BIM.

6. Conclusions

Different actors with different work practices, behaviours and culture are currently implementing BIM in temporary projects, networks and alliances in the Swedish AEC industry. These all represent relevant social groups that form the social construction of BIM in the industry based on their sociological explanations for the acceptance or rejection of BIM; their common interpretations, beliefs and expectations about BIM, its usefulness and the problems BIM is expected to solve (Pinch and Bijker 1984). Together with contractors, consultants, educators, municipalities, software developers and other relevant social groups, public clients will take part in the social constriction of BIM. Public client may fill important roles in the social construction of BIM due to their large influence on the other social groups via their ability to demand BIM in procurement. A large Swedish public infrastructure client recently implemented BIM with the specific aim of driving industry change, innovation and productivity (SOU 2012:39, Trafikanalys 2015). The purpose of this study was to understand the role and impact of the public client in the social construction of BIM in the Swedish AEC industry. For this, the sociological explanation for BIM at the public client needed to be understood. The findings showed that there are currently two conflicting sociological explanations for BIM that are being socially promoted at the public client (one accepting the implementation as a means for driving industry change and one rejecting it). These conflicting sociological explanations have two different implications for the public client´s role and impact in the social construction of BIM which may cause confusion among the other social groups (e.g. suppliers).

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BIM research: Common perspectives and implications for future research

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Abstract

The expectations on the impact of digitalization, and in particular Building Information Modelling (BIM), are high in both practice and research. Both academia and industry have paid much attention to and invested major resources in BIM during the last decade. However, the research area is not new and has been developing since the 1990s. During this time, most studies have applied rational and technical perspectives to understand BIM implementation and only a have regarded BIM implementation from more reflective and critical perspectives. There are however those who argue that the large interest in BIM research on the rational and technical perspectives, that often proclaim the impact of BIM for increased productivity and efficiency, has created a hype around the concept. This study takes off from this notion and aims to build an argument for broadening the research on BIM. This study examines what knowledge interests and perspectives that are most common in the research on BIM that has been used by and gained influence on the research community. This study examined the knowledge interests of BIM research in terms of knowledge domains (technical, practical and emancipatory) and socio-technical interest. This study elaborates on effects of limiting research on BIM to technical and normative perspectives. By applying the concept of hegemony, this study contributes to the limited but growing interest in critical perspectives of technology driven change. Implications of a continued technological and normative predomination for future research and practice are also discussed.

Keywords: BIM, hegemony, knowledge domains, social power

1. Introduction

One area in which academia, the construction industry and the software developers have paid much attention to and invested major resources in during the last decade is Building Information Modelling (BIM). BIM, or IT in construction, is not a new research area, yet has been struggling to define its place as an academic field (Björk, 1999). The struggle has included a lack of a solid methodological foundation because the only paradigm that most researchers in the IT in construction domain seemed to share was the "object-orientation" (Björk, 1999, p. 3), a term Björk argue could be given many shades of meaning, depending on the context. Björk also acknowledge that the discussion often centred on the most recent tools offered, which he calls "a 'technology push' viewpoint" (p.3).

Most research on BIM is still conducted from technological and normative perspectives. BIM has been defined as "an emerging technological and procedural shift within the Architecture, Engineering, Construction and Operations (AECO) industry" (Succar, 2009, p. 357), an "emerging IT-based information systems which promote collaborative and integrated design, assembly, and operation of buildings" (Merschbrock and Munkvold, 2012, p. 208), and "a comprehensive accumulation of information (including documents) about the design, construction and operation of a building, anchored to a geometric (2D/3D) model of the building" (Demian and Walters, 2013, p. 4). The predominant technological and normative focus on BIM has been acknowledged by, for example, Fox (2014) and Miettinen and Paavola (2014) who argue that it is the promise that BIM will work as a driver for productivity that has created hype around the concept. BIM is also promised to increase inter-organizational and disciplinary collaboration and alleviate many of the construction industry's problems (Succar, 2009; Crotty, 2013). Cheng et al (2016) and Yalcinkaya and Singh (2015) also point to the technical and practical orientation in BIM research and argue for a change. Others have also pointed to a need for shifting focus in BIM research from technological determinism (assuming that technology shapes society, human actions and behaviours) towards a more socio-technical view that acknowledges the interaction between technical and social systems (Sackey et al 2014, Miettinen and Paavola 2014). Miettinen and Paavola (2014) claim that current BIM research is disregarding many of the social conditions and constraints and argue for more studies on openended processes for learning. There is also a growing stream of literature addressing the challenges and complexities of BIM (e.g. Fox and Hietanen 2007, Hartmann et al 2012, Fox 2014) and that argue that BIM needs to be studied as a multidimensional, historically evolving, complex phenomenon (Miettinen and Paavola, 2014). Hence, there is a need to reflect on the knowledge interests in and methodologies of current BIM research.

The purpose of this study is to build an argument for broadening the research on BIM. This is done by investigating the knowledge interests in current BIM research and by reflecting upon implications of a continued technological and normative predomination for future research and practice. This study has reviewed well-cited BIM articles (i.e. articles which have been used by and influenced the research community) to examine what the knowledge interests of these articles have been. The analysis of the articles includes studying whether the knowledge interests have been technical, practical or emancipatory (Habermas 1971) and whether there has been a socio-technical interest for the understanding of BIM (Trist and Bamforth 1951). This study elaborates on effects of limiting research on BIM to technical and normative perspectives. By applying the concept of hegemony to analyse the findings, this study contributes to the limited but growing interest in critical perspectives of technology driven change. Implications of a continued technological and normative predomination for future

research and practice are also discussed. The findings elaborate on the effects of limiting BIM research to normative and technical perspectives and thereby reinforce the hegemony of technology (Gramsci 1988). Such hegemony is upheld by, for example, the perspectives applied in research and the definitions of BIM. This links to what Bourdieu (1991) would call 'the social power' of the group of people that perform research and develop definitions. Other groups of importance for the development of BIM research and practice, besides researchers, are software developers, users and founding partners. Implicitly and/or explicitly they have impact on what is studied and how, and what becomes a hype or not. Still, when it comes to methodological choices, researchers have a great responsibility.

2. Theoretical framework

Limiting studies to normative and technical perspectives would reinforce what Gramsci (1988) call hegemony and by which is meant the influence and authority, i.e. domination, over others. Hegemony is upheld by and constructed through the perspectives and the ideal images of a dominant field. People in a dominant field have, what Bourdieu (1991) would call 'the social power', over others. It is also argued that the social power of those in the dominant field is sustained through the silence of those involved in similar practices, but don't have knowledge of the terminology of the dominant field.

The ideas by Gramsci and Bourdieu will reveal some of the blind spots of BIM research approaches – blind spots that have to do with what is studied, and not, and from what perspectives. Habermas´s (1971) model includes the following three knowledge domains, or ontologies: 1) the technical domain that supports a positivistic knowledge interest (prediction and casual explanation), 2) the practical domain that supports a hermeneutic knowledge interest (interpretation and understanding), 3) the emancipatory domain that supports critical knowledge interest (criticism, reflection) (Habermas 1971, Tinning 1992).

This model, which builds on a Marxists ontology of what is "critical" can be useful but should be complemented with postmodern ontologies such as the Socio-Technical Systems view (STS) (Trist and Bamforth 1951). In STS view, the technical system interacts with the social system. Underlying the socio-technical view is social constructivism; that social factors, such as human actions, behaviours and attitudes, also influence the use of technology and its success or failure (Trist and Bamforth 1951). In contrast, technological determinism assumes that technology is what influences society and that technological factors, and not social ones, determine the success or failure of technology (Smith and Marx 1994). An increased focus on a sociotechnical view in BIM research has also been called for (Sackey et al 2014, Miettinen and Paavola 2014) Hence, the socio-technical view will also be used here to complement the analysis.

3. Method

As mentioned in the introduction, this study has reviewed well-cited BIM articles in order to examine articles that have been used by and had influence on research. Journals were chosen based on that they had a focus on research BIM during and were peer-reviewed journals in English. Based on these two criteria, four journals were selected: Automation in Construction (AIC), Journal of Information Technology in Construction (ITcon), Construction Management and Economics (CME) and International Journal of Project Management (IJPM). The purpose here is not to perform a comprehensive literature review. That would have required a different approach. Instead, focus here is

on investigating knowledge interests in current high impact BIM articles from the perspectives in Habermas (1971) and Trist and Bamfoth (1951).

The analysis is based on the 10 BIM-related articles that have been the most used and reflected upon by the research community during the last decade (i.e. high impact articles as indicated in number of research citations). Articles related to BIM were identified using Scopus' document search engine. The criteria were that title, keywords or abstract had to include the phrase "Building Information Modelling" and "BIM". Synonyms, such as 3D CAD, 4D BIM, VDC and ICT, were excluded. A manual screening of the abstracts was conducted to determine that the articles were focused on issues related to BIM. The search results were narrowed down based on number of citations. The aim was to identify the 10 most cited BIM articles during the last decade (2007 – March 5th 2017) from each of the four journals.

The analysis of knowledge interest was done based on the knowledge interests of the articles. When categorizing the knowledge interests of the articles, keywords and phrases in titles, abstracts, introductions, aims and purpose statements, method descriptions and discussions (i.e. theoretical and practical research contributions) were categorized by the three knowledge domains by Habermas (1971) (technical, practical or emancipatory) and if the interest was on the impact of technology on society/people (technological determinism) or on the interaction between technology and society/people (socio-technical view) (Trist and Bamforth 1951). Examples of keywords and phrases from the articles that indicated a technical knowledge domain included application areas and benefits of BIM, efficiency and optimization and definitions and frameworks of BIM (rationalism). Keywords and phrases that indicated a practical knowledge domain in the BIM articles included, for example, understanding how BIM is adopted, interpreting how challenges of BIM impact decision making and understanding the role of cultural change. Examples of keywords and phrases that indicated an emancipatory knowledge domain were limited, but included questioning of the governing theories and methodologies that guide current research on BIM and application of critical realism. 4. Findings

Habermas (1971) ontology suggests that the dominating knowledge interest of the BIM articles in the journals of AIC, ITcon and IJOPM has been the technical knowledge domain followed by the practical knowledge domain (see Table 1). The majority of the articles have also been pursued from technological determinism (i.e the impact of technology on society/people) and only a few from a socio-technical perspective (Trist and Bamforth 1951) (see Table 1). The knowledge interest in the articles of CME was of more practical knowledge interest (Table 1). Only a few articles applied a socio-technical view in understanding BIM (Table 1).

4.1 Automation in Construction

AIC has published a total of 198 BIM related articles during the last decade. The majority have been conducted from a technical knowledge interest and included, for example, proposing BIM frameworks to serve as foundations for industry stakeholders, identifying the positive effects of BIM and identifying the potential and techniques of BIM for laser scanning and for rule-based checking (Table 1). One article had a practical knowledge domain and focused on extending the knowledge and understanding of how to facilitate a BIM adoption. The articles in AIC have been the most cited ones compared to articles in the other three journals.

4.2 Journal of Information Technology in Construction

ITcon has published 52 articles BIM related to BIM the last decade. Also in this journal, the majority of the BIM articles had a technical knowledge interest (Table 1) and focused on, for example, categorizing functional collaboration requirements in BIM systems, providing industry practitioners with simulations of virtual reality cloud based BIM platforms and proposing semiautomatic approach for generating accurate BIM facade models. One article had a practical knowledge interest and aimed to enable a better understanding of how digital collaboration technologies are actually being used in.

4.3 Construction Management and Economics

CME has published 13 BIM related articles during the last decade. Nine of these more than one citation according to Scopus. Thus, nine are included in Table 1. In contrast to the two previous journals, the majority of the knowledge interest of these articles was on the practical knowledge domain. These focused on describing and increasing the understanding of how individual beliefs and expectations impact the perceptions of perceive usefulness of BIM, the impact of different roles, responsibilities and decision making power and understanding challenges of BIM implementation. A few of these also took a socio-technical viewpoint in understanding BIM, such as diffusion of innovations and social elements in technology acceptance. A few articles ahad a technical knowledge interest, for example, identifying the advantages of BIM.

4.4 International Journal of Project Management

IJPM has published 11 BIM articles during the last decade. Among these, five have been cited more than once according to Scopus. Thus, five are included in the analysis of Table 1. The majority were from had technical knowledge interest in BIM and focused on, for example, identifying the project benefits of BIM and proposing a financial decision making framework. One article applied a socio-technical view by drawing on the unified theory of acceptance and use technology including also, for example, behavioural intentions.

Table 1: Knowledge Interests (KI) in 10 most cited BIM articles 2007 – 2017 based on Habermas (1971) and Trist & Bamforth (1951)

KI / Journal	Technical (Habermas)	Practical (Habermas)	Emancipatory (Habermas)		Socio – technical (Trist & Bamforth)
AIC	Succar 2009 Tang et al 2010 Schlueter and Thesseling 2009 Volk et al 2014 Zhang et al 2013 Singh et al 2011 Azhar et al 2011 Barlish and Sullivan 2012 Xiong et al 2013	Gu and London 2010			Gu and London 2010
ITcon	Shafiq et al 2013 Dore and Murphy 2013 Goulding et al 2014 Abrishami et al 2014 Van Berlo and Natrop 2015 Kassem et al 2014 Gledson and Greenwood 2016 Alhava et al 2015 Yung et al 2014	Ibrahin 2013			
CME	Demian and Walters 2014 Melzner et al 2013 Schade et al 2011	Davies and Harty 2013 Mäki and Kerosuo 2015 Korpela et al 2015 Fox and Hietanen 2007 Kokkonen and Alin 2016 Shibeika and Harty 2015			Davies and Harty 2013 Shibeika and Harty 2015
IJOPM	Bryde et al 2013 Bansal 2011 Chen et al 2015 Lu et al 2016	Howard et al 2017			Howard et al 2017

5. Dominating knowledge interests and implications for future research

In the light of the work by Gramsci (1988) and Bourdieu (1991), it becomes apparent that the need for more reflective perspectives on BIM research is not limited to the practical or theoretical significance BIM research might have in terms of new understanding of BIM practices and effects of BIM implementation. It also has to do with what is in focus and not. Hence, there is a power-dimension included which have implications on the development of the field of BIM and the development of the built environment.

According to Gramsci, there are groups of people with power based on their profession who exercise hegemony over other groups of people (Gramsci, 1988). As was said earlier, there are different actors that have influence, implicitly or explicitly on the development of BIM. One actor is the research community. In the BIM-context researchers constitute an influential community and play an important role to the development of BIM. Hence, researchers partake in exercising hegemony by the perspective used because that is when it is decided what is relevant to study and not. In addition, universities in

which researchers play an important role, have large-scale production of education in BIM. Consequently, researchers partaking in the process of developing and performing education have a position to exercise hegemony.

To be able to dominate a field, the discourse of the dominating group must be acknowledged by others to be an expression of power and influence since domination only exists in relation to agents endowed with schemes of perception (Bourdieu, 1991). In the BIM context, this is done via, for example, publication in peer-review journals and citations. Also, the sooner a group of intellectuals produce 'its own intellectuals' (compare with Hallin and Karrbom Gustavsson, 2010), the quicker the group will obtain hegemony. Therefore, followers such as students, PhD students, industry networks, sponsors and experts are important for a dominating field. The current hype around BIM (Fox, 2014) can thus be interpreted as a way to reinforce the normative and technical discourse as expressed by researchers and practitioners since they are expected to possess the secrets of successful construction project outcome.

The development of an institutionalised community of practice take place, or 'happens' in Bourdieu's terms (1991), when there is a development of a new language. According to Bourdieu, language is one of the major forms of the exercising of 'symbolic power' and learning to speak the language of the dominant is to become socially accepted (Bourdieu, 1991). Social acceptance in the BIM context thus means to learn to 'speak' the BIM tongue, for example by publishing from the same perspective and by citing the dominating intellectuals in the dominating field. Finally, hegemony also requires the consent of those who do not belong to the dominating group of intellectuals. Such consent is caused by the prestige and confidence enjoyed by the dominant group because of its position and function as producer (Gramsci, 1988).

There are however also limitation to this study. Firstly, it was based on a narrow review of the current BIM literature. The purpose was not to do a comprehensive literature review but to build an argument for broadening the BIM research by showing what knowledge interest are currently dominating the well-cited BIM research. The focus was also to elaborate on implications and point out a need for future studies to take on more reflective and critical knowledge interest. Still, there is a need for a more comprehensive review in order to fully understand how the research on BIM has developed since the 1990s and what the future needs are. Also, the framework used to understand the knowledge interests of the articles and for understanding of the term "critical" was largely based on Marxist ontologies (Gramschi, Bourdieu, Habermas). Although the socio-technical view was used to complement the analysis, future more comprehensive studies of the dominating perspectives in BIM research could benefit from applying more postmodern ontologies and from delimiting the understanding of what is meant by critical.

6. Conclusions

The main purpose of this study was to build an argument for the broadening of research on BIM. The reason is not only because that would contribute to better understanding of BIM and the challenges, opportunities and complexities of implementing BIM in construction project practice, but mainly to challenge the normative and technical research tradition that still dominates much of the BIM language and as a result hides or neglects the social and cultural dimensions of BIM development and implementation in the built environment.

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Experiences with Interstitial Space in Norwegian Hospitals

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Abstract

This paper reports on a pilot study of the use of interstitial floors in Norwegian hospitals. Interstitial floors are defined by Miller and Swensson (2002) as "intermediate service floors inserted between primary floors", enabling easier access to technical equipment and less interference on daily hospital activities. The interstitial concept gained some attention in the early 1980s, but was by most analytics judged to require excessive capital investment (Miller & Swensson, 2002). However, as flexibility is becoming crucial in the rapidly changing environment of hospital buildings, Miller and Swensson suggest that the concept might become more justifiable in this decade.

The research reported on in this paper is based on three case studies of Norwegian hospitals with interstitial floors. Rikshospitalet, St. Olavs hospital and Sørlandet hospital were studied. A literature review, interviews, document analysis and site visits constitute the main sources of evidence in this research. In total, 9 respondents with experiences from either planning, construction or operational phases of hospital buildings have contributed in this research.

Interviewees and other respondents express that interstitial space contributes to making the operational phase easier, more effective and less costly. It is also expressed how interstitial space can aid future changes and reconstructions at hospitals. Based on the interviews, additional investment costs seem to be the most significant disadvantage of building hospitals with interstitial floors. Other challenges are related to the design, such as insufficient space and floor height.

Findings indicate that there is a significant potential for long term savings associated with interstitial space in hospitals, however this is not well documented. Further studies should include a cost-benefit analysis of the concept. Findings also indicate that setting aside sufficient space and floor height is essential for the floors to create flexibility and ensure that they are beneficial in the operational phase.

Keywords: interstitial space, hospitals, adaptability, life cycle costs

1. Introduction

According to Høie (2015), rapid population growth and demographic change will place new demands on the professional health care system. In Norway, the population is expected to increase with one million by 2030 and the number of people over 70 years will likely double. Nationwide, Norway has approximately one square meter hospital building space per inhabitant. Based on present practice, indicates that we will need an additional one million square meters within 2030 (Gleditch, 2014). Only half of the Norwegian hospital buildings are reported as good or acceptable, both regarding the building's technical and structural state (RIF, 2015). Together, this implies that efficient new hospitals must be built, and existing hospitals must be improved.

In today's high-tech environment, the rate of change has increased substantially compared to the 1970s (Tusler, 2014). To maintain highly functional hospital buildings over time it is crucial to facilitate for future change. Recent research in the Norwegian context address how focusing on adaptability can increase the lifespan of a hospital building as well as making the buildings more sustainable (Larssen, 2011; Støre-Valen et al., 2014; Støre-Valen & Lohne, 2016).

According to BSRIA (2008), the operational costs in hospital buildings consume the equivalent of the investment cost every two to three years. However, low investment costs have traditionally been prioritized over low life-cycle costs (LCC) in the hospital sector (Bjørberg & Verweij, 2009). Bjørberg & Verweij argue that focusing on LCC-analyses rather than investment costs is a crucial measure to improve the efficiency and lifespan of a hospital building. Some measures intended to improve the adaptability of a building have been dismissed due to additional investment costs, for instance the concept of interstitial space (Miller & Swensson, 2002). However, having interstitial floors will typically increase the adaptability of the building as well as reducing operational costs due to simplified maintenance and repair. Miller and Swensson also argue that ease of access encourages preventive maintenance, which can improve the quality of the building over its lifespan.

To address the issues presented, this paper examines experiences with interstitial space as a way of increasing the adaptability in Norwegian hospital buildings. This is done in an explorative manner. To address this general enquiry, the following three research questions will be addressed:

1. What are the experiences with interstitial space in the cases studied?
2. What is found to be the most important challenges associated with interstitial space?
3. Which recommendations related to interstitial space can be given to future hospitals?

Question one and two will be addressed in the findings section of this paper, and question three will be addressed in the discussion section.

2. Methodology

Following an initial literature review in accordance with the prescriptions outlined by Blumberg et al. (2014), three case studies of Norwegian hospitals form the basis for the research reported on in this paper. Rikshospitalet, St. Olavs Hospital and Sørlandet Hospital were chosen, as they are all public hospitals with interstitial floors. Private hospitals were not included in this study. Recently constructed hospitals, such as Kalnes and Ahus, are not built with interstitial floors and were only studied briefly. Five semi-structured face-to-face interviews as well as one telephone interview was conducted, each with a duration of approximately 30 minutes. These interviews as well as email correspondence with other key persons, document studies and site visits form the case studies. Table 1 shows all respondents who have been involved in this research. Site visits were led by the operational managers at two of the hospitals studied, and many of the interstitial floors at these hospitals were examined. Documents studied included architectural drawings as well as internal documents explaining the hospital's technical system.

Contact form	***Case***	***Role***	***Phase***
Interview	*Rikshospitalet*	*Sectional manager HVAC*	*Operational*
Interview	*Rikshospitalet*	*Department manager HVAC*	*Operational*
Interview	*Trondheim University Hospital (St. Olavs Hospital)*	*Former sectional manager HVAC*	*Operational*
Interview	*St. Olavs Hospital*	*Head of planning and development*	*Planning*
Interview	*St. Olavs Hospital*	*Academic responsible of advanced rooms, such as laboratories and operational theatres*	*Planning and Construction*
Phone interview	*Sørlandet Hospital*	*Main construction manager from 1986-1990*	*Construction*
Email correspondence	*Sørlandet Hospital*	*Sectional manager, technology and eHealth*	*Construction*
Email correspondence	*Sørlandet Hospital*	*Assisting construction manager*	*Construction*
Email correspondence	*Sørlandet Hospital*	*Chief technology officer*	*Operational*

Table 1: respondents from the different hospitals and their respective roles

3. Theoretical framework

This chapter presents a theoretical framework for the topics discussed in this paper. This includes defining adaptability, presenting some background information about Norwegian hospitals as well as introducing the concept of interstitial space.

3.1 Adaptability of buildings

Several definitions of adaptability in a building context exist (Støre-Valen and Lohne, 2016). According to Bjørberg and Verveij (2009), for instance, adaptability ought to be analysed according to the three major dimensions: flexibility, generality and elasticity. Flexibility here expresses the possibility of changing the space distribution, generality expresses the possibility of changing functions, and elasticity expresses the possibility of changing volume. Adaptable futures (2011), on the other hand, define adaptability in a more general manner as "the capacity for a building to accommodate effectively the evolving demands of its context, thus maximizing its value through life". The Department of Veterans affairs (2006) presents a general and simplified definition of adaptability as "the ability to respond to, or be readily adjusted to, changing conditions". These definitions have in common that they, in different ways, explain adaptability as *the buildings ability to adjust to change*. This is the definition that will be used in this paper.

3.2 Norwegian hospitals-organization and frequency of change

In 2002, the Norwegian healthcare sector was divided into four regional health authorities under the Norwegian government (Norwegian ministry of health and care services, 2014). In total, these four health authorities consist of 28 regional health trusts. Up to this date, hospital buildings were owned by the 19 Norwegian county authorities. Larssen and Kvinge (2008) claim that much expertise was left in the county authorities after the restructuring and that it took time to build up competence related to facilities management in the four regional health authorities. Larsen and Kvinge (2008) also puts forward that the different health trusts now experience low priority of maintenance, and that short term budgeting is prioritized over long term planning.

Valen and Larssen (2006) conducted a study on the frequency of change in Norwegian hospital buildings. Their research showed that the rate of change has increased significantly over the past 100 years, indicating that facilitating for future change is becoming more important. Recent research indicates that long term planning is essential in this rapidly changing environment (Valen & Larssen, 2006; Larssen & Kvinge, 2008; Bjørberg &Verweij, 2009).

Neufville et al. (2008) express that a good hospital needs to be flexible and allow effective adaptions to changing circumstances. Figure 1 shows how hospital buildings have evolved from being a pure building construction to a complex integrated technical organism over the past 100 years (Larssen, 2011). Technical installations usually require much space. As a result, the building structure has changed drastically. Floor height has increased and rooms that demand advanced technical equipment, such as laboratories and operating theatres, have become larger.

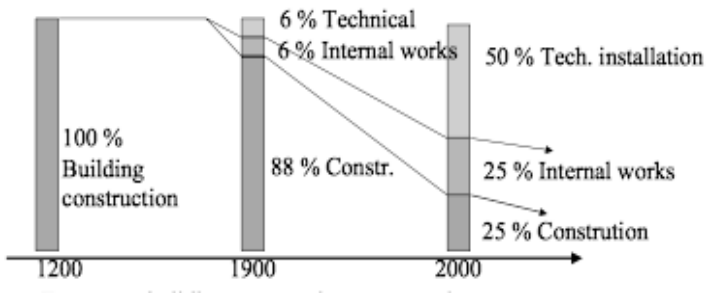

Figure 1 Evolution in hospital building design and construction (Larssen, 2011).

Only 50% of Norwegian hospital buildings are reported to be technically and structurally adequate or good (RIF, 2015). The remaining 50% needs improvements and upgrading to adjust to the healthcare services provided. This indicates that there is a backlog on maintenance, development and operational services. Hareide (2015) argues that this is mainly due to insufficient priority of Facilities Mangement (FM). Pilosof (2005) claims that many new hospitals are out of date the moment they open, mainly due to long planning and construction periods as well as rapid changes in technology. One of the largest challenges for designers, both architects and engineers, is therefore to design a flexible hospital to suit unpredictable future needs.

3.3 The concept of interstitial space in hospital buildings

The concept of interstitial space was introduced in 1960s, but is not widely accepted. Miller and Swensson (2002) defines interstitial spaces as "intermediate service floors inserted between primary floors". These floors are reserved for mechanical, electrical and plumbing systems. The main purpose of reserving full height floors for such use is that maintenance, upgrading and other adaptions can easily be done without disturbing clinical operations. How these floors are designed varies a lot. The interviewees who have contributed in this research have mentioned floor heights varying between 1,5 to 3 metres. Interstitial floors at Rikshospitalet and St. Olavs are easily accessed by lifts and staircases. Interstitial floors can either serve the floor above (lower distribution), below (upper distribution) or a combination. A research report from Rikshospitalet states that there are more benefits associated with upper distribution than lower distribution (Statens bygge- og eiendomsdirektorat, 1990).

Clear benefits related to having interstitial space in buildings where the mechanical system is highly sophisticated are identified in the literature (Statens bygge- og eiendomsdirektorat, 1990; Miller & Swensson, 2002), such as being able to do maintenance work without disturbing clinical operations. Tusler (2014) suggests that one of the reasons why the concept has not been widely accepted is that the it requires a new way of approaching design and construction by the entire team. The owner must accept a somewhat experimental design, and the architects and engineers must be open to new solutions. According to Tusler, there may be some additional first construction costs associated with interstitial floors. However, he expresses that lowest first cost should not be the main criteria for design decisions in acute care facilities. Achieving a sustainable design can typically add 6-12 percent to the overall capital cost, but will reduce the life cycle cost in the long run due to a higher adaptability and increasing usability (Rechel et al., 2009).

In Rechel et al. (2009), an award-winning approach to future hospitals by Venhoven/Guthknecht (Boluijt, P. & Van Bemmelen, L. H., 2005) is presented. The approach was based on asking which

functions are absolutely needed in the core hospital building, and which could be located elsewhere. They found that the area of the core building could be reduced by 50 percent, and the area needed in the core building was closely related to "hot floors". Hot floors are defined as floors with "capital-intensive functions unique to the hospital, including operating rooms, diagnostic imaging and intensive care facilities" (Rechel et al., 2009). Such areas have highly sophisticated technical and mechanical systems, and having interstitial floors in a core building could therefore be beneficial.

Miller and Swensson (2002) suggest that the main reason why interstitial concepts are not widely accepted is that they are simply too costly. However, they mention that such concepts may become more viable in the future as flexibility becomes more important in a rapidly changing high-tech environment. Interstitial space can make future changes easier and less expensive. The value of interstitial space depends on whether planned changes are carried out or not. This makes it challenging to quantify the actual value of interstitial space.

4. Findings

4.1 Experiences with interstitial space

4.1.1 Rikshospitalet

Both interviewees claimed that there are no disadvantages with interstitial space when it comes to the operational phase, as long as floor height and amount of space is sufficient. They both agreed that the most important advantage with placing technical equipment in full height floors is that it is possible to do maintenance work without disturbing other hospital functions. It was mentioned that the interstitial floors in section A at Rikshospitalet do not function properly due to insufficient floor height. This makes it challenging to access some installations, and maintenance workers do not enjoy working there.

Another important benefit mentioned is how interstitial space can accommodate change. Having interstitial floors at Rikshospitalet has increased the adaptability of the building severely, making upgrading and refurbishment easier. For instance, some simple operating theatres at Rikshospitalet have been upgraded to more advanced operating theatres. To satisfy the quality requirements for these advanced operating suites, large ventilation units were installed. Each suite has its own ventilation unit at Rikshospitalet, which takes up a lot of space. One of the interviewees argued that this upgrade would have been impossible without having interstitial space above.

4.1.2 St. Olavs

Being able to do maintenance work and changes to the technical installations without disturbing clinical operations is one of the clear benefits of having interstitial floors. A former sectional manager for HVAC explained how it is now possible to do maintenance tasks at daytime instead of night-time, leading to reduced operational costs. For example, changing gas cylinders during daytime is easily done from the interstitial floor without disturbing clinical operations.

At St. Olavs, parts of the interstitial floor at the Woman and Children's Centre is built up by steel decks. These are not water proof, and leakages can lead to water running down to the operating theatres below. Interviewees mentioned how this has been a challenge at St. Olavs, especially since operating theatres have strict requirements for cleanliness and patient safety.

One of the interviewees from Sykehusbygg HF mentioned that the use of interstitial space should not be based solely on the size of the hospital, but rather the complexity of the hospital functions. It was mentioned that the interstitial floors seem to be more beneficial for operating theatres than for medical imaging rooms. It was also mentioned that interstitial space has worked well over operating theatres, and that it could have been a good idea to have interstitial space above the laboratories as well. Placing laboratories and operational theatres at the same floor would make it possible for one interstitial floor to serve both laboratories and operational theatres. This idea is similar to the idea of organizing advanced hospital services in "hot floors" (Rechel et al., 2009). Having interstitial floors above "hot floors" in core hospitals could be a way of minimizing unnecessary additional space in interstitial floors.

The former construction manager mentioned that they experienced more dependencies during the construction process due to having interstitial space over operating theatres. This made parts of the construction process more complicated and time consuming.

4.1.3 Sørlandet hospital

The main interviewee from Sørlandet hospital was involved with the construction phase from 1986-1990 as the main construction manager. He mentioned that changes during the construction phase was easier to handle when having interstitial floors, and that coordination of technicians became easier. However, he emphasized that the most important benefits of having interstitial floors are shown during the operational phase, not the construction phase. He pointed out that people involved in the planning process of hospitals often have little knowledge about interstitial space, and that this may be one of the reasons why few Norwegian hospitals are built in this way. This strengthens Tusler's claim presented in chapter 3.2 on how the entire design team must be open for a new way of approaching design in order to plan for successful buildings with interstitial floors.

4.2 Main challenges associated with interstitial space

One of the issues related to interstitial space at Rikshospitalet is that the height in section A is insufficient, affecting the accessibility severely. It was also mentioned that parts of the interstitial floors are almost fully exploited, meaning that some installations must be removed when new installations are installed. Lack of storage space at hospitals has also been a challenge. At Rikshospitalet, it was mentioned that it is difficult to prevent people from using interstitial floors as storage rooms. Another challenge with interstitial floors is that there will be some additional maintenance costs as the facade area is increased and stairwells are extended (Statens eiendoms- og byggedirektorat, 1990). However, findings from this research indicates that the overall maintenance costs will be reduced severely.

Another challenge addressed by one of the interviewees at St. Olavs is that interstitial floors are expensive technical rooms. These floors have completely different fire requirements and sound isolation requirements compared to technical rooms located in the top floor, making them more expensive and complex. At St. Olavs, they have also had problems with making the transition between the interstitial floor and operating theatres good enough. The interstitial floor is made from steel decks that are not water proof. If leakages occur at the interstitial floor, water may leak into to the operating theatres.

Bjørberg and Verweij (2009) point out that there seem to be little awareness of the costs and benefits of investments, and that the concept of life- cycle economics in the healthcare sector is underdeveloped. One respondent from Sykehusbygg HF mentioned that they find it hard to argue for the use of interstitial space as they have limited knowledge about the costs and benefits related to interstitial space.

5.Recommendation

Based on comments from the interviewees, it appears clear that there is a significant economic potential in interstitial space. All the interviewees point out that the concept can lead to reduced costs in a long-term perspective. However, this is not well documented. To conclude on whether the concept of interstitial space is beneficial or not, a comprehensive cost/benefit analysis should be conducted.

When the decision of having interstitial floors at a hospital is made, it is important to design these floors in a way that suits the hospital organisation's needs. Setting aside enough space and floor height is crucial for the floors to be functional in the operational phase. The literature suggests that organizing technical installations in sections according to type is beneficial (The Department of Veterans Affairs, 2006). However, when visiting St. Olavs and Rikshospitalet, this did not seem to be the most important design factor. The operational managers expressed that it is more important to make sure that all installations are easily accessible.

6.Conclusion

To summarize the findings and discussion, a conclusion is presented by looking at the research questions found in the introduction; What experiences and challenges related to interstitial space are found, and which recommendations can be given to future hospitals?

6.1 Experiences

All the interviewees saw many benefits of having interstitial floors during the operational phase, such as being able to do maintenance work and changes without disturbing clinical operations. It is, however, important that these floors have sufficient space and height in order to be accessible and beneficial during the operational phase. Some of the interviewees also saw benefits during the construction phase, but others found it to be more dependencies when hospitals are built with interstitial space than without, making the construction phase more complex. Interviewees express that having interstitial space have reduced costs associated with maintenance, repairs and alterations due to adapting to new functions. In some cases, these alterations could not have taken place without having interstitial space.

6.2 Challenges

One of the main challenges associated with interstitial space in hospital buildings is the additional investment costs. The investment costs are traditionally weighted heavier than the life cycle costs. As the operational costs in hospital buildings consume the equivalent of the capital cost every two to three years, life cycle costs should be emphasized more in the future. As building hospitals is a government responsibility, decisions may be influenced by short term goals with political motives. A shift in the government's mind-set may be necessary.

Other challenges are related to the design of such floors, including size, height and type of materials used for the construction of interstitial floors. As mentioned, Rikshospitalet have experienced challenges with the interstitial floor located in section A due to insufficient space and height, making it difficult to access some installations. At St. Olavs they have had challenges associated with the floor construction as the transition between the interstitial floor and the operating theatres is not completely sealed. This is only the case where the floors are built up by steel decks instead of concrete decks.

6.3 Recommendations and further studies

Based on the research conducted, there seem to be a major economic potential in having interstitial floors at hospitals. New technology will keep developing and change the hospital services, and interstitial space can be a good way of facilitating future change. However, the economic aspect of interstitial space has not been addressed here. To give good recommendations to future hospitals, an analysis of the economic aspect is necessary.

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The housing market in Sweden: a political-historical perspective

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Abstract

The price of housing in Sweden has, over the past couple of decades, increased at a much faster rate than salaries. Politicians have tried to steer the housing market towards the provision of affordable housing, but have not succeeded. After 1993, the responsibility for regulating the price of housing transferred to the market, which is more interested in building for high-income earners. Despite several reports focusing mostly on productivity levels in the production of housing, little has changed. When problems persist without any significant change, it is necessary to look for fundamental, structural explanations. The study reported here offers a political-historical perspective of the Swedish housing market and its impact on the price of housing. The methodology encompasses an overview and analysis of governmental reports covering political actions to stimulate the production of housing. The findings reveal that prices depend on a malfunction in political control and unclear roles of the actors in the construction sector. It is difficult to control the price of housing because of the many actors involved, each of whom has different knowledge, practices and approaches that are not always conductive to innovation, lifecycle thinking or applying 'lessons learned'. Problems such as lack of cooperation and weak commitment among actors, a fragmented construction process and the absence of a holistic approach force up the price of new housing. This study argues for further empirical work to investigate and clarify the roles that actors have or should have in housing projects. The findings might then suggest the political incentives needed to stimulate the industry to provide affordable housing for average-income earners.

Keywords: housing market, Sweden, politics, actors, roles

1. Introduction

Economic growth depends on a properly functioning housing market (André, 2010; Bhatta, 2010). Currently, Sweden has a lack of available housing and an imbalance in the form of tenure between rental apartments and owned housing of one kind or another (Emanuelsson, 2015). According to the National Board of Housing, Building and Planning (2016), it is necessary to build 710 000 new housing units1 before 2025. An increased rate of house-building is necessary, but also insights into what has to be built as needs change over time. One of the largest problems is that the price of housing has increased at a much higher rate than the salaries in Sweden (National Board of Housing, Building and Planning, 2013). It is probable that the reason for this increase in prices has not arisen because of higher quality, but from a number of factors such as: financial deregulation; increased disposable incomes; low loan rates; too little housing being built over time; and the structure of the housing market in terms of location and types of housing.

Increased disposable income and low loan rates go hand in hand. The prices of housing in Sweden are high in general according to comparisons of European countries conducted by Eurostat (2015). There is a tendency for wealthy countries to have high costs for house-building, but that does not explain the gap between the consumer price index (or its equivalent) and building price index (Statistics Sweden, 2016a). The prices of housing normally increase the most in the regions of growth such as the larger cities. This can lead to lock-in effects, as the lack of housing in combination with high prices increases the indebtedness of households (Van Santen and Ölcer, 2016).

The availability of affordable housing might be a consequence of a deliberately restricted supply which forces up prices (Holmqvist and Turner, 2014). Moreover, because the developer and the constructor work close together and often are the same company, there is little interest in providing rental apartments, which in turn affects the structure of the housing market. In order to understand this phenomenon better, it helps to understand the history of housing in Sweden, in particular the political dimension.

The study reported here offers a political-historical perspective of the Swedish housing market and its impact on the price of housing. The research method incorporates an overview and analysis of governmental reports covering the political actions intended to stimulate the production of housing, as well as published research findings. The paper starts by explaining the cost and price mechanisms in the housing market followed by the political history of housing and discusses the impact of different roles on the housing market. Lastly, key findings are presented that should contribute to a better understanding of the housing market in Sweden from a political-historical perspective.

[1] The terms house, apartment, flat and dwelling are used variously in the literature to refer to a unit of housing to accommodate a single household. For consistency, 'housing unit' has been adopted in this paper.

2. Cost and price mechanisms

Different government reports (e.g. Construction Commission, 2002; Swedish Agency for Public Management, 2009; and Industry Ministry, 2015) have investigated the price of housing with varying degrees of explanation, but have consistently referred to high production costs and the need to make the production of new housing more efficient. According to the Industry Ministry (2015), total production costs can be divided into: building cost, developer cost, cost of land and value added tax. Land and developer costs are a significant part of total production costs and have increased over recent years; they comprise planning, financing and administration. Building costs comprise design and supervision costs, groundworks, the erection of the building and costs of connecting utilities (i.e. electricity, water, heating and cable TV). Moreover, profits for subcontractors and the developer are included in the total production cost (Statistics Sweden, 2016b). Government intervention, through a system for setting rents, means that the total production cost broadly equates to the price paid for housing on the basis that the total production cost can be shown to be reasonable (Hansson et al., 2009). As the production cost in this case includes profits, the actual costs incurred by the developer might not be significant in determining the price. Even so, market-led demand can force-up the price of housing, thereby increasing profit margins (Lind, 2003).

In order to obtain insights into production costs, three different concepts are generally used: consumer price index, building price index and factor price index (Swedish Competition Authority, 2015). The consumer price index (CPI) is intended to reveal trends in consumer prices over time for private national consumption. The building price index (BPI) concerns the development of prices over time for new housing. The factor price index (FPI) measures the development of prices for production in terms of components, for example carpentry, mechanical installations, electrical installations, salaries, machinery, transportation, fuel and electricity. According to Statistics Sweden (2016a), the BPI has risen much more than the CPI and the FPI over time. The BPI reveals that it was twice as expensive to buy a house in 2014 compared to 1992 (Swedish Competition Authority, 2015). This acceleration of prices can only partly be explained by the increase in building costs during this period as the FPI has risen less than the BPI since the mid-1990s.

3. The political history

In the beginning of the 1900s, the left and the right wing political parties were united in housing politics. ‘Good workers’ should be supported to build and own their homes (National Board of Housing, Building and Planning, 2007). More than 100 years later, few can afford their own home in spite of being much wealthier. The history of housing politics can be summarized as follows (Ibid.).

1900-1945: *Housing politics was about sanitary problems in the cities and poverty among people living outside the cities*. During the First World War, building costs and rents increased significantly, forcing some people to live in the street. The housing market was regarded as troublesome and the purpose of construction projects was to keep the workforce busy. During the 1930s, there was a political breakthrough in the housing problem, when politicians began to acknowledge that not only the lack of housing, but also its poor quality, was a political question. The Second World War made housing expensive again with high interest rates on loans for building construction (National Board of Housing, Building and Planning, 2007).

1946-1974: There was a lack of housing built to a good standard. High on the housing politics agenda was solving the housing problem in terms of space and equipment. The building construction process was seen as outdated and the municipalities were ill-prepared to deal with new demands. The average household could not afford new housing. According to a state housing investigation, the cost of a newly-built two-room apartment should not be more than 20% of the salary of an ordinary industrial worker's salary in order to be regarded as reasonable (National Board of Housing, Building and Planning, 2007). The goal of housing politics became a matter of 'catching up' with the need for housing by new construction and the refurbishment of existing housing.

A public investigation (Home Office, 1965) showed that as salaries increased, people wanted bigger and better housing. Forecasts during the period of 1960-1975, pointed to the need for 1.5 million new housing units. Moreover, it was decided that new construction was prioritized over the refurbishment of old housing. In April 1965, the Swedish parliament agreed on the production of 100 000 housing units a year over a ten-year period. This became known as the 'million program'. Its aim was simply stated: "People shall have sound, spacious, well-planned and purposefully equipped accommodation of good quality and for a reasonable cost". To achieve the goal of the 'million program', an industrial, mechanical way of building was regarded as necessary. This meant that the design professions and the building materials industry had to be rationalised and expanded. Planning, purchasing and construction were now coordinated by construction companies, making design-and-build contracts a common feature. A government investigation of industrialized building (Home Office, 1968) expressed the view that: "The projects shall have a high degree of uniformity. A strict limit of variants shall be maintained with regard to measurements of building components, stairways, floorplans and configuration in general. The number of house types should equally be limited." Both the belief and ideal situation was that everyone had the same needs which could be analysed by scientific methods. As the goal was to give all people better housing, the government had to keep down rents on new housing. In the beginning of the 'million program', this was accomplished through government subsidies, which later disappeared. In 1970, Sweden was building more housing units per capita than any other country. During the final years of the 'million program', overcapacity in production occurred and, in 1975, Sweden was considered 'built for a long time forward' (National Board of Housing, Building and Planning, 2007). In many places, there was now an excess of housing and many of the areas of the 'million program' were labelled 'physical and socially poor'. A strong and often loud political left-wing began to criticize the current situation. The October War in the Middle East in 1973, led to the oil crisis resulting in electricity rationing and energy saving measures. These made people realize that the world's resources were limited. A movement that cared about the environment developed into a national debate. People began to move out from the big cities. The 'green wave' was a reaction to the 'million program', with areas of single-family housing taking shape.

1975-1986: The 'million program' housing project was further debated and regarded as having created social segregation. The environment surrounding this 'brave new housing', the lack of influence, and poor accessibility and services made it less attractive. Improved accessibility and a living environment became new targets. The 'goal of neutrality', where the capital cost of housing should be neutral to type of tenure, was formulated as a fundamental requirement. Parity loans were introduced where the total cost of payment and interest would gradually increase with inflation. This type of loan was supposed to balance the costs of old and new housing and type of tenure, and make housing costs align with inflation. The parity system presupposed that the government should decide every year on

how much of the debt should be paid: this was politically sensitive. Debts then grew faster than inflation, which meant that the whole experience was an expensive affair for the government.

1987-1996: The financing of housing becomes a focus of attention. Classical political housing concerns such as the lack of housing in general, and outdated and crowded apartments were seen as addressed. In spite of this, the government continued to subsidize new housing construction to a considerable extent. The subsidies were conditional upon a maximal rent that almost made the Swedish economy collapse during the financial crisis in the beginning of the 1990s. In 1988, the new conservative government repealed a large part of the housing legislation. The government declared that a housing market based on competition and freedom of choice were prerequisites for housing at a reasonable price. The reformation of the tax system in 1991 meant that the financing system of housing had to be adjusted. The financing system of housing was seen as a problem and threat to the rest of the economy. To remove the pressure of taxes, the subsidies had to decrease. A standard interest funding system was applied that effectively deregulated the housing market. In this way, the responsibility for housing financing was transferred to owners and the credit market (Finance Ministry, 1992). The transformation from a regulated and subsidized housing market to a competitive and market-financed sector also affected facilityrelated services. In 1990, value added taxes were introduced on water supply, sewage system, waste disposal and electricity (National Board of Housing, Building and Planning, 2002). Deregulation between 1985 and 1995 increased housing costs for tenants and owners alike by 30% and depressed the demand for housing, so making prices fall substantially between 1992 and 1995 (Statistics Sweden, 2005). Despite criticism and the change to a socio- democratic government in 1994, the deregulation of the housing market was maintained.

1997-2006: The move from an excess of housing to a lack of housing. A fragmented picture occurs with economic recovery after years of crisis and, at the same time, a divided housing market. There is a lack of housing in the regions of growth with an increase in prices and, at the same time, an excess of housing in a large part of the country leading to financial losses among housing companies. The construction of new housing was limited by: lack of competition, taxation, a slow and cumbersome planning process with high land prices, fluctuation in construction workload and undeclared work, poor quality and the formation of cartels on the supply side. This called for action by the authorities. The report Construction Commission (2002) was a result of a government decision to examine the construction industry and suggest measures to increase competition. A new government Construction Commission (National Board of Housing, Building and Planning, 2007) was charged with finding ways to lower the price of total production and increase quality in the construction sector, both in terms of the end- product and the process. The measures would, moreover, strengthen the competence of the developer and clarify the responsibility for larger work packages within construction, for example mechanical and electrical installations. The Construction Commission was further assigned to work from a consumer perspective where the need was to achieve 'good quality' and assure the health of end-users whilst at the same time lower building costs. Furthermore, the Construction Commission suggested how work between different public bodies should proceed. The report of the Construction Commission (2002) concluded that the problem of the construction sector depended to a large part on "existing knowledge not being utilized and that where the knowledge exists, it is highly fragmented and often hard to access".

2006-present: A low rate of construction, lack of housing, high prices of housing and consumers with large debt characterizes the housing market. In 2008, the Swedish Agency for Public Management was assigned to prepare a follow-up to the report of the Construction Commission (2002) and which was

subsequently presented (Swedish Agency for Public Management, 2009). In this later report, it was concluded that no improvement had occurred in the construction sector's way of working or attitudes since the recommendations in the earlier report. Similar arguments were presented by the Housing Crisis Committee (2014), Settler Commission (2014) and the Industry Ministry (2015). A sector that is constantly exposed to examination and ignores its critics is bound to raise questions. For instance, is the construction sector really as bad as claimed? Or is it so called 'domino effects' that mirror these critical reports. In an anthology by Landin and Lind (2011), 35 questions were identified and distributed to nine researchers: eight responded. The reflections on the findings of the survey were summarized as follows.

"The answers that have come in say something about the construction sector and the research about the construction sector. If we start with the construction sector, it is by its very nature the case that researchers are a little careful to generalize and tend not to overly praise something. If we look at the most general questions about the current state and the potential for improvement, the main perspective is still that everything is not right in the construction sector! There is the potential to increase the efficiency that is not being realized. So far, the picture agrees with the public debate, the investigations and the view of the researchers. Otherwise, maybe the most remarkable finding is the wide distribution of answers from the researchers on the different causes and the role of individual factors. One would think that over the years, the researchers would gain knowledge that would lead to a common understanding on how different factors are interconnected. This is obviously not the case. Perhaps this result is something that indicates it is not just the construction sector that needs development but also the research about the construction sector. Such a step would, to a larger extent, confront different views and through deep common studies we might try to understand what seems to add up and what does not add up."

Apart from the discrepancy and differing views among researchers about how things 'hang together', there are also shortcomings in the ability of the construction sector to assimilate the results of research and development. The belief is that this stems from research results being written remotely from where the phenomenon exists and that the gap between the research community and practice is too big. In addition, it can be hard to know where to access research results. The knowledge of the actors involved about factors that affect house-building is important. These are laws, regulations, the planning process, location and environment, demographic and economic factors.

The development of knowledge and competence can be seen as central concepts in order to create welfare. The transfer of knowledge between members of organizations is not easy, because individuals create different 'worlds of ideas' and form their own way of prioritizing and legitimizing knowledge (Wei et al., 2011). The individual actors' contributions have changed; for example, the extent of the architect's work has been significantly diminished. The architect no longer has, with few exceptions, the lead responsibility for planning, cost estimating and overseeing production. This has meant that the knowledge and competence for identifying optimal solutions have in large part been provided by project managers, with the result that there is no single owner of the process. Architects of today are often involved in the early stages of the building process only and work with the concept and architectural treatment. The role of the architect is thus characterized by low influence and with a minor role of responsibility in the process. Meyer and Land (2003) introduced, in a UK research project, the idea of a 'threshold concept'. The threshold concept is characterized by transformative thinking that

allows new possibilities to be explored. With an understanding and correct handling of the threshold concept, not only is there a better understanding of the problem per se, but also new insights.

Today, the housing stock in Sweden comprises a little over 4 700 000 housing units, where a third of them are tenancies (Statistics Sweden, 2016d). Over a long period, too little housing has been built with the lack of tenancies viewed as particularly problematic. Those with low incomes to a large extent live in such accommodation. To have access to an adequate place to live is a basic condition for people to handle their everyday life. High housing costs create barriers to this. An interesting feature is that in the housing market of today those with the lowest incomes are, depending on availability, referred to the most expensive housing alternative, namely a newlybuilt rental unit. Lind (2016) notes that, if households with low incomes are to be able to realise their desires: *"Housing needs to be built that is not demanded by high-income earners, for example simple housing with properties and location that do not make it attractive for highincome earners."* Lind further argues that those developers with a land allocation agreement from the municipality should, in central and attractive locations, be required to provide a certain number of housing units at an affordable (i.e. lower) rent.

4. Political intransigence

Over many years, the political process can probably be assumed to have been a contributing factor to the housing market's problems. Political ideology and electoral appeal have often been the basis for decision-making. Political debates about housing often seem to involve vested interests that are active in narrowly-defined areas. There appears to be a mismatch between proposed solutions and the goal (Holmqvist, 2009).

Occasionally, comparisons have been made between the car industry and the housing sector to demonstrate how innovation, productivity and cost optimization for the customer is achieved in the former but not in the latter (Goulding et al., 2015). Yet, the most interesting comparison between them is that the car's basic function is based on a common platform, while the end product is often individualized, depending on end-user preferences and financial means. This is a principle that could apply to the housing sector. A further development of Lind's (2016) line of reasoning could be to build housing on the basis of a flexible base model geared to end-users' preferences and financial means. The form of ownership can be seen as largely irrelevant in this context; however, in the case of tenanted housing, a middle way could be introduced with cotenancy between the tenant and the state based on government-backed loans. This would be similar in concept to the earlier settlement loan (to cover the cost of moving in, e.g. furnishings and appliances) administered by Sweden's Central Bank (Ministry of Social Affairs, 1976). In 1976, the maximum loan was SEK 10 000 which currently corresponds to about SEK 52 000 (or approximately €5 000). Since this would be a home loan instead of settlement loan, it would worth perhaps 3-4 times more in real terms – somewhere between SEK 150 000 and SEK 200 000 (or approximately €15 000 and €20 000).

5. Discussion

Housing prices in Sweden are high, even if some of this can be explained by external factors such as how the construction process is managed. A series of investigations and audits, many on the part of the government and its agencies, have pointed towards significant potential for efficiency gains. These have likewise highlighted a number of shortcomings including inadequate planning, misapplication of

existing knowledge (or no application at all), highly- fragmented knowledge that is often difficult to access, poor information transfer, construction errors and lack of competition (Construction Commission, 2002). It is important to analyse the structural challenges that these shortcomings represent in some detail to grasp the extent of action that is necessary.

Housing consists of a complex series of activities and involves a variety of actors. In order to ensure that the end-product is fit for purpose requires that the construction process is quality assured in terms of both the process and content. Practically, it is difficult to assure the quality in projects where so many actors with different knowledge and practices are involved. This can discourage innovation, lifecycle thinking and the application of lessons learned. Lack of cooperation, weak commitment and the lack of a holistic approach also threatens to result in an inadequate end-product because of low efficiency entailing higher costs (Ibid.).

A goal of housing is to satisfy end-users' economic, qualitative and functional requirements, but it must also provide sufficient profit for the developer. A common platform is missing today for those actors who can contribute to early and clear decisions, especially in change-related issues. The planning process and construction process must be seen in context.

The concepts of efficiency and productivity can be seen as the relationship between the result (output) and the resources required (input). The construction sector's actors should recognize that perfunctory appearance and poor motivation leads nowhere and that active communication, knowledge and experience transfer can contribute to greater efficiency and hence lower production costs. A focus on firm ideas about how housing can be achieved in a functionally- satisfying, sustainable, energy-efficient and value-adding way is within reach. It is vital that the knowledge, experience and skills required for optimal solutions permeates all stages throughout the construction process. The products and services delivered by the construction sector can be complicated, perhaps overly complicated. They are created by strong, yet fragmented, project organizations with many specialists and clearly-defined stages. End-users are not a single homogenous group and so there are gaps in understanding and communication between project organizations and end-users. Incentives for learning are weak, sometimes missing or poorly developed. This is especially true between the professions. Despite its importance, there is limited understanding of how learning and knowledge transfer is actually working on specific construction projects. There are generic models and theories, but these have not been tested sufficiently on the range of housing products. The early stages in the construction process are both creative and systematic in terms of design. How these early stages are planned and implemented, the actors involved and how they participate are important issues. The planning of these early stages should be faced by thinking strategically to identify problems, opportunities and potential solutions and in so doing might lead to a changed process. Knowledge and skills must therefore permeate the entire process. Housing needs should be focused on quality of life and be adaptable to society's changing needs and different life choices. Demand for new homes depends on how effectively the existing housing stock can be exploited and the extent to which legislation is used to create or prevent barriers to the effective use of housing.

Are reduced requirements, simplified or abolished regulations the only possible option to build affordable housing? Deprecation is no longer just a proposal, but also a reality. The previous government gave the National Board of Housing, Building and Planning a mandate to question the building codes with the purpose of lowering the cost of new housing. The design is determined from

the briefing stage. To provide a sound basis for thought-out design, there is a need to understand how different households look today, how people live their everyday lives, the activities that are important in the home and how space is used. The social aspects of housing are not well understood; for instance, how people are affected in their daily lives, why they are happy/unhappy in their neighbourhoods, and why some areas are problematic. There is a need to develop insights and knowledge about what end-users want and understand what drives their needs. Values that include emotional factors, as well as architecture and wellbeing, should stand alongside the technical, economic and functional factors.

One factor that is often identified in relation to inadequate housing is the lack of buildable land, which is surprising as less than 3% of Sweden's land area consists of development (Statistics Sweden, 2016c). The lack of available land is a lack of land for housing. Physical limitations, coastal locations or other types of environmental constraints can affect availability and is understandable; but in terms of the major cities and centres of growth, the availability of efficient infrastructure and well-developed public transport should not present any significant problems. The barrier, which is most difficult to overcome, is the boundaries between municipalities since the state has abrogated its responsibilities over planning at the local level.

6. Conclusions

Sweden has had a history of a governmental interventionist approach although has mostly adhered to a non-interventionist policy. Average-income households are no longer protected by governmental financial support. This has created a shortage of housing for many people, because they simply cannot afford the current market prices of housing. Apart from the basic cost of housing, every party or actor wants its share of the profit. The overarching question seeking an answer is: how might it be possible to increase housing while constructing at lower cost? Of greater importance than focusing on specific types of housing is the need to focus on changes in the regulatory system. These would, however, need to be considered carefully as the wrong kind of change could promote the establishment of economically-weaker households in the housing market.

A variation in terms of function, design and accommodation/tenure is important for sustainable social development. To construct housing for the future requires knowledge, skills and the benefit of lessons learned: it also needs research where there is doubt about the facts. Well- designed high-quality housing has been built before, and then there was research into the requirements for design and function on the basis of contemporary lifestyles. In conjunction with the abrogation by the state of its powers over housing in the mid-1990s was the dismantling of housing research. The passage of time has shown that the decision was at least highly questionable. Now and into the future, research should be concerned with whole rather than analysis or separation into parts, for example technical problems and details. Research and creativity must be supported and not checked. It is important that the conduct and behaviour of all actors are linked to performance so that important parameters such as the reduction of errors and shortcomings, responsibility for improvement, increased cost awareness and end-user value permeate the entire construction process. Changing conditions require new approaches.

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Area development 3.0: The Circular Approach

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Abstract

Purpose: The aim of this paper is to present a model of assessing a neighbourhood with a brownfield status to indicate potentials for redevelopment. This is an ethnographic research paying attention on stakeholders roles and responsibilities in area development.

Background: The urban planning practices as well as assessment methods are dominated by top-down planning theories; the so called system-approach has some disadvantages: large scale, big money and strong power. This model 1.0 cannot not solve problems in case of sharp economic downturn. A bottom-up, organic approach in urban planning, model 2.0 puts more emphasis to planning systems that considers the local needs more and allows greater citizen participation. Such approach has also its difficulties, peculiarities and shortcomings: the selfappointed ambassadors of the neighbourhood are thinking on a very small scale and island scope instead of a holistic view. The research question in this paper is how model Area development 3.0 could work for all the stakeholders and developing especially communication in urban planning?

Approach: The central focus of the paper is a presentation of a case study: The Binckhorst (150 ha) the biggest redevelopment inner city area in The Netherlands, in its third biggest city The Hague. The case study includes physical, spatial, social, cultural, and economical perspectives. With the research triangulation, analyses of different data from the transformation of diverse area development models and their strengths and weaknesses are presented..

Results: The result is a tentative model 3.0 of area development: it is not the system approach (top down) neither the bottom up, organic approach but the interference of these two. Model 3.0 is a circular approach and provides a new tool towards a sustainable and climate neutral urban environment. Practical implications: The results can be used for (re)development of existing, mostly inner city, neighbourhoods. Future research need to focus on refining the found criteria in the model and on the adjustability of the mode to the different cultural circumstances.

Keywords: brown field, urban redevelopment, assessment and circular approach

1. Introduction

According to Pissourios (2014) regional and strategic urban planning should be ascribed to topdown approaches, while local urban planning that encompasses physical planning to bottom-up approaches. Central to regional planning is the axis of economic development, in which planning standards have limited contribution. This paper aims to explain a top-down and a bottom-up approach in urban planning and presents a synthesis: the next level of urban developments: a circular area development 3.0. This conceptual framework adds on the system approach and adds on with so called " lifeworld"-approach. The concept of the "life-world'" stresses the totality of human experience as being the best way to understand how social structures develop and function. Central to the concept of the lifeworld within the field of urban studies is the fact that within cities very few of the phenomena surrounding us are natural. The buildings, parks, streets, harbours, sounds, surfaces and smells that make them are man-made constructs, however organic or natural their longevity and design may make them seem. The lifeworld approach includes variety of perspectives and approaches and it refractes the urban experience through a many faceted prism (Madsen 2001). Lifeworld is the domain of undominated communication where mutual understanding is sought. It is the realm of cultural production and reproduction of use values (Mäntysalo 2005).

The focus in this paper is on knowledge development and communication in urban planning. The central research question answered is: How can the gradual development of the Binckhorst, The Hague, be assets to indicate potentials for redevelopment? Sub questions are:

1. What were critical issues in the area development in the Binckhorst over the last fifteen years?

2. How can the knowledge gained during the process of development in the case study be benefical for all stakeholders?

3. What is the added value of a new urban planning model for other inner city bornwfields?

The paper will fire off with theoretical lense followed by a description of a case: The Binckhorst, an inner city brownfield in The Hague (The Netherlands) followed by an analyses, illustrated with insights from the case to conclude with a new proposal of a model for urban planning.

2. Transformation of area development processes

The urban planning practices as well as assessment methods are dominated by top-down planning theories; the so-called system-approach. Within planning theory, two main tendencies can be noted, which are very much at odds with one another: the top-down and the bottom-up approach to planning. The analysis of representative theories of these two tendencies revealed a clear relationship between each tendency and the use of standards. On the one hand, the topdown systemic and rational planning theories prompt the use of standards, even though they have not systematically considered a methodological framework of standards utilization. On the other hand, the communicative bottom-up approach lacks any methodological references as it stays at a highly abstract level and seems to refrain from the use of standards.

Linking top-down and bottom-up approaches of planning with discernible planning scales has been the key for an initial construction of Pissourios´ framework for planning standards utilization (2014). In particular, it has been possible to discern that certain types of planning standards are more useful than others in certain scales of planning. In the scale of regional planning, locational standards are foremost in terms of usefulness, while in strategic urban planning, locational and service standards are equally useful. Last but not least, in the scale of local planning, occupancy standards are undoubtedly the most useful. According to Suryawati and Helpiastuti (2016) regional development planning is a systemic, complex and **unstructured process.** They developed conceptual models by using soft systems methodology to outline unstructured issues with a structured approach. The conceptual models that were successfully constructed in their study are a model of consistency and a model of reconciliation. Regional development planning is a process that is well-integrated with central planning and interregional planning documents. Integration and consistency of regional planning documents are very important in order to achieve the development goals that have been set. On the other hand, the process of development planning in the region involves technocratic system, that is, both top-down and bottom-up system of participation. Both must be balanced, do not overlap and do not dominate each other.

Physical and cultural planning, social and educational policies, infrastructure projects and the implementation of innovative forms of governance and networking may achieve these objectives, but the policy context is made fuzzier and more complex by the unconventional nature of economic and social processes underlying cultural activities and creative production. Economic development is related to land uses closely associated with the function of the free market, such as industrial uses. However, the appearance of such uses in regional space cannot be standardized, as this appearance does not exhibit any regularity Pissourios (2014). Urban actors react to or anticipate exogenous changes engaging in a chain of actions that ultimately shapes the structure and the functions of the city at any moment in history. .

Governance in urban development should not be perceived as a traditional top-down restrictive action. Rather, it can be as a continuous management process that has a forward-looking attitude. Governance can be achieved through common direction, principles, and rules. Organizations should, therefore, be motivated to relate to and engage in the same principles. Worthington and Bouwman (2012) argue that successful control and governance requires a balance between creating and reinforcing vision and mission, and then managing the process of change through combination of regulatory controls and behaviour. A forward-looking attitude in management can be achieved through a common direction, principles and rules.

Two key phenomena related to collaboration are **complexity and diversity**. Collaboration should not be seen as restrictive practices, but rather as a set of process of creatively balancing between conflicting and mutual interests. It is about working across different scales, interests, functions and cultures with the aim of building up community spirit. A continuous series of small events is essential to gradually raise awareness and change perceptions. When building a community, it can help to have engaging individuals who are willing to be pro-active and responsible and who then spread a climate of confidence and opportunity for change – they help in achieving a paradigm shift.

Allen and Henn (2008) argue that increasing the opportunities for knowledge transfer, inspiration, and later innovation is achieved in organizations by maximizing the opportunities for communication. This

concludes the configuration of the organizational structure and physical space. Similarly, a connector in infrastructure does not guarantee connectivity in the social context if it does not serve mobility between the spaces, which also connect people through the processes of creating the area.

Sennett (2006) sketches an alternative for urban policy and planning processes. Urban future images and stories must have a direction but also a degree of indeterminacy. Physical and social domains should be **incomplete and permeable**. The move from the top down master planning with defined blueprints to a more open and undetermined form of planning is necessary for our 'disruptive' and 'uncertain' times. Politicians, policy makers, planners and designers need a new set of tools and characteristics to deal with changes and transitions in the city. And to provide companies and (collectives) of citizens and users the possibility to participate bottom– up and contribute in innovative urban policies, designs and projects. A new form of linking another type of urban planning with bottom up initiatives and developments. Both elements, planning and bottom-up, are necessary. They have to feed, stimulate and sometimes correct each other in a searching and circular process. What we define as "the long and winding road" towards Binckhorst circular area development 3.0.

3. Method

The research applies a phenomenological lifeworld and ethnographic research approach to grasp the descriptive level. It is explanatory by its nature. The main data collection focused on the Binckhorst case study.

Data was gathered by diverse methods. Observations were made by the researchers as well as observations by focus groups. Formal and informal interviews were conducted. Laymen and students, artists and urban planners were asked their opinion about the strengths and weaknesses of the area, of (im)possiblities to work together with the other stakelholders. The content analyses were conducted from interview material as well as from the official documents and specialized literature and grey literature. A theatre production and films about entrepreneurship in the area were studied. The use of multiple methods made it possible to achieve triangulation. Triangulation is a powerful technique that facilitates validation of data through cross verification from two or more sources.

Phenomenological concepts were used to focus the analysis on knowledge development and communication in urban planning especially identifying the role of the stakeholders in the area into account. Additionally the shifting identities of the neighbourhood were reflected.

3.1 Case study

The Hague, 520.000 inhabitants, seat of the Dutch government, is the largest and most densely populated city in the Netherlands, located at the North Sea. The government and services are dominant in economic structure,of the city. One area of the city called The Binckhorst will be focus of this study.

Figure 1: Map of The Hague (red spots = Binckhorst)

Figure 2: Binckhorst in more detail

Binckhorst is the largest inner city economic/industrial area (150 hectare) of The Hague (Figure 1 and 2). After WO II Binckhorst became a focal point of industrial activities and employment. But, it had, because of the presence of a castle, a cemetery and a modest residential area, a peculiar characteristic. The rapid de-industrialisation of The Hague in the 1960 and 1970 meaned an uncertain future for the Binckhorst.

The decline of industries in The Hague transformed Binckhorst in an undefined area in search of a new identity and destination. Binckhorst functions as an asylum area for urban functions that are less welcome in the rest of The Hague. The position of the Binckhorst as a "strategic reserve area" changed in 2002 as the area of The Hague was extended with green field locations in the suburban communities. This long awaited "border correction" or "annexation" puts the interregional road to Rotterdam back on the agenda. This was the begin of the process rrom 'reserve area' to master plan New Binckhorst.

Binckhorst could change now from a derelict economic area on the edge of the centre city into a central location with high valued functions. The city government decided for redevelopment, the area vision Binckhorst. The task for Binckhorst was complex and challenging for the local government with more

than 100 different owners in the area. Cooperation in the form of a public-private partnership was necessary with companies who want to invest in the area. Housing becomes the new business model in the transformation of the Binckhorst. In 2005 the city presented the vision Den Haag 2020 ("World City at Sea") aiming at a growth from 480.000 to 505.000 inhabitants in 2020. The Binckhorst became the most important housing location for the city of The Hague. Commercial companies showed large interest in the transformation of the Binckhorst. The city government chose for the consortium of a real estate developer (Rabo Real Estate) and a pension fund (BPF Bouwinvest) in order to establish a public private area corporation (50% The Hague, 25% Rabo, 25% BPF) and to develop a Master plan. In 2006 the Master plan New Binckhorst was presented as "**The largest inner city restructuring of the Netherlands**". New Binckhorst was a huge investment of € 2 billion consisting of 7.000 houses, 200.000 m2 office space, 65.000 economic space, a shopping centre, a park of 16 hectare with underground parking space and water catchment and the new road to Rotterdam, the Rotterdamsebaan.

In order to achieve this radical transformation to a "mixed residential area" a large part of the existing economic activities had to be removed. New Binckhorst should become an area with a robust image, with an enterprising character of world class charm and of high urban quality. OMA (Office for Metropolitan Architecture) of 'star architect' Rem Koolhaas draws a spectacular 'artist impression' with visionary images of the new Binckhorst, on the eve of a "extreme make-over'. The Master plan was a radical top-down approach by a public-private company for a radical and swift change of a large, diversified and complex area. The business model of this radical transition plan is based on (ever) rising real estate prices, supported with subsidies from the central government. It was a closed model without room for unexpected developments or alternative developments: a planned blueprint that ignored the existing qualities of the area without a connection to how the Binckhorst had been used and experienced by the companies and the users in the area.

4. Process Analysis

4.1 The collapse of the Master plan: the shift to organic approach Urban Development 2.0

The Master Plan New Binckhorst seemed to be vulnerable. The global financial and housing crisis after the fall of Lehman Brothers resulted in the withdrawal of the commercial BPF as partner in the area development company. A new partner could not be found. By scaling down the plan the city and Rabo Bank tried to save parts of the Master plan, in vain. In 2011 the Master plan New Binckhorst was finally withdrawn. The Model 1.0 did not work.

The Hague chooses a new Binckhorst approach, "**Organic area development**". The crisis had diminished the power and decisiveness of the city. The Hague was forced to depreciate on its real estate and ground positions in the Binckhorst. The realisation of the Rotterdamsebaan was the only remaining city investment (with state grants) in the area. Binckhorst will be developed out of the existing situation by bottom up initiatives and temporary use of space,

The development of Binckhorst changed drastically and would take much more time. The city council added an important decision. An amount of € 2 million was earmarked for supporting private initiatives that contributed to the development and the image of the area in order to stimulate new dynamics in the area. An evaluation of the new approach after three years was quite positive. The first new housing

project was developed in the former Asylum seekers building. In the Master plan this building of 9.000 m2 was bought by the city in order to be demolished for the construction of new houses. In the new reality the city was offering this building as 65 self-build lots. Before the lots could be offered the city had to reduce on the value and to invest in the building for several millions.

The office development in the south of the Binckhorst was another story. The real estate owners had to deal with increasing vacancies. Vacant buildings would be transformed to rental apartments. The remaining offices would be refurbished with an eye on other occupation like a hotel or housing for expats. The city money to promote private initiatives was used for various purposes. Things like a documentary about the Binckhorst, to organise Round Tables with different stakeholders in the area, temporary use of vacant plots and buildings and the I'M Binck a joint initiative of artists and entrepreneurs. The 'seed' money for private initiatives had contributed to a new form of cooperation and consultation between stakeholders and the city government. It had increased the creative dynamics in the area, resulting for example in new restaurants, a coffee company and a beer brewery. In addition to this developments the city was investing € 10 million in the improvement of the public space of the harbour areas of the Binckhorst. The creative hotspot "de Besturing" a former ship motor company was an important point in this development. The city has recognised their role and makes it possible for the users to buy 'de Besturing' for a reasonable/affordable/friendly price.

The major impact of the organic approach could very well be that it has changed the role of government in area development and city planning. Organic was originally a "hands off" approach by the government. "Sorry, we are out of money (and planners) thanks to the financial crisis so now it is up to you, good luck!" The Model 2.0 did not work, it had a minor impact on the scale of the area, it all was marginal. The area still had the image, as several respondents said, articles in papers mentioned, of "a poor, rundown, grey, unpleasant, spooky, unsafe" place you would not go to or live in. It attracted artists and start up companies, that was a benefit for the next Model.

4.2 Binckhorst on the road to circular approach Urban Development 3.0

But out of this emerged "**co-creation**" a new form of "city-making" between the local government and the stakeholders in the area. No more blue prints from above but room for cooperation and new experiments as "urban labs". As a reaction to the crisis and new unexpected developments and transitions the Dutch government has decided to implement new legislation in spatial planning, the "Environmental Code". In anticipation of this new farreaching law that will be in operation in 2019 the Binckhorst is designated as a pilot project.

In 2015 the city published a concept Area/Environment plan Binckhorst for consultancy exercise and comments. The Research Group Metropolitan Development of the Hague University of Applied Sciences (THUAS Haagse Hogeschool) commented that the choice for organic development and a modest role for the government was in the given situation a necessary move. But is it enough to develop Binckhorst towards a mixed and sustainable urban neighbourhood? Private initiative can achieve a lot but will the "market" realise necessary amenities as "green" and "cycle paths" in the Binckhorst?

The Research Group THUAS regards Binckhorst with its qualities as a central location and space for new and unexpected developments as a trump card for the future of The Hague. This type of area

development demands a careful approach and specific government intervention. The gradual transformation of the Binckhorst into an mixed urban neighbourhood requires a new planning approach.

Based on the thorough case study and literature review the result is a new model in multiperspective urban development: The area development 3.0. It does not mean the system approach (top down), neither the bottom up, organic approach (the life world) but the interference of the two. A metaphor of a well knitted network of parties, or stakeholders would appeal, if not some (private and public) parties are stronger (financially) and powerful (decision making bodies) than others acting in the same neighbourhood, that is why a picture of two ideal typical world is more appropriate: System (money and power) and Life World (consensus of understanding or making an interpretation of the situation). The balancing structure is presented in the following Figure 3.

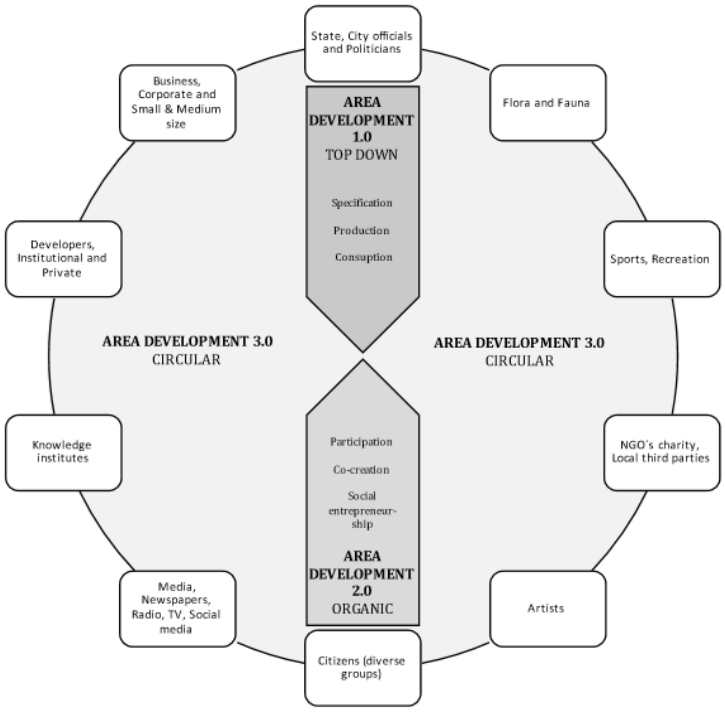

Figure 3: Three Generations of Area Development

5. Discussion

Interested parties may benefit from the insights and practices form the case: The Binckhorst. The first generation of urban planning used in the area, the top down one, stopped completely in the financial and real estate crisis. It was primary driven by thinking big, money centred without taking the very diverse stakeholders into account. The city (politicians and the civil servants) and real estate developers and investors embraced their mutual expectations and visions. Resistance from less powerful stakeholders were overcome easily.

The next (second) generation was born out of necessity to conquer the degradation of buildings and the public space. We have called the bottom up approach the organic one. Already present stakeholders, like small and medium entrepreneurs got company of new ones: artists, start-ups and the like. The media started to highlight the potential of the neighbourhood. The incidental financial support of the

EU (The Caballero Factory), of a housing association (Bink 36) and private initiative (MOOOF) helped to influence the public opinion for a better image of the area just a bit. Something more was needed.

The inevitability of a third generation of area development came to the forefront in which a circular economy and a more sustainable use of buildings and investments in the public domain (the physical part) are needed in conjunction with a sensitivity for the social aspects (communication between stakeholders in a less power hierarchy). We suggest in this paper to call this the circular approach. In which participants have an eye and a open mind for the unpredictability of future developments: be it political uncertainties, financial insecurities and or temporary solutions. This paper strengthens the idea of an ethnographic approach, stakeholderanalyses and a circular thinking not only as an assessment tool but also as possible solutions for socio-physical development of inner city brown fields.

6. Conclusions

This study with a case from an obsolete inner city area shows a necessity for a new paradigm of area development: the 3.0 approach. A circular one with references to the circular economy. It is an all-encompassing stakeholder approach. As said: Two-way communication (top-down and bottom-up) is a process in which participants create and share information to reach mutual understanding. Communications can raise awareness and change perceptions to support cultural, behavioural, and physical change. The paper presents an alternative i.c. a circular approach to inner city developments with more respect and valuing every stakeholders resource be it decision power, money, creativity, entrepreneurship etc. in the area development process. Governance of the area is based on knowledge created by the stakeholders.

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Financing Mechanisms for Disaster Risk Reduction in the Built Environment

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Abstract

The United Nations' Sendai Framework for Disaster Risk Reduction 2015-2030 estimates that, in the decade from 2005-2015, economic losses from disasters totalled more than $1,3 trillion. Whereas some progress appears to have been made in reducing mortality from disaster events in recent years, the economic consequences of disasters have significantly risen. A number of factors contribute to this: the increasing concentration of people and assets in cities, the tendency for cities to be situated in low-lying coastal areas and on the banks of major rivers, the extension of supply networks and the increased dependence on all kinds of networks which mass urbanization entails. Climate change predictions also suggest that both vulnerabilities of populations and the severity of disaster events are set to increase.

The collapse or failure of buildings and infrastructure is often the mechanism by which disasters occur and the economic losses incurred are directly associated with the extent of damage to the built environment. Much can be done by built environment professionals to improve disaster resilience through the incorporation of disaster risk reduction measures in urban planning, in the design and construction of buildings and infrastructure, in responding to disasters and in reconstruction after disasters. These all call for additional investment in the built environment and, although the current magnitude of disaster-related losses suggests that such investments in mitigation would be worthwhile, there appears to be a lack of suitable financing mechanisms available to enable them.

This paper reports the results of a desktop study into financing mechanisms for disaster risk reduction investments in the built environment. The aim of this initial study is to define and understand financing mechanisms and their applicability to potential investors and their specific contexts. A Facet Theory approach to defining and understanding the problem domain is adopted and the paper elaborates a mapping sentence that describes the ranges of financing mechanisms, investors and disaster contexts that need to be taken into consideration as a first step to gain a comprehensive understanding of financing mechanisms and their applicability.

Keywords: built environment investment, disaster resilience, financing mechanism, project finance

1. Introduction

The United Nations' Sendai Framework for Disaster Risk Reduction 2015-2030 estimates that, in the decade from 2005-2015, economic losses from disasters totalled more than $1,3 trillion. Despite considerable efforts by the international community to improve disaster resilience, the evidence suggests that, in overall terms, exposure to hazards has increased more rapidly than vulnerability has reduced. Although some progress has been made in reducing mortality from disaster events in recent years, the economic consequences of disasters have significantly risen (UNISDR, 2015). A number of factors contribute to this: the increasing concentration of people and assets in cities, the tendency for cities to be situated in low-lying coastal areas and on the banks of major rivers, the extension of supply networks and the increased dependence on all kinds of networks which mass urbanisation entails. In addition, Ghesquiere and Mahul (2007) suggest that substandard construction practices and low insurance penetration worsen the economic risk exposure of developing countries to catastrophic events. Climate change predictions also suggest that both vulnerabilities of populations and the severity of disaster events are likely to increase (IPCC, 2013).

The collapse or failure of buildings and infrastructure is often the mechanism by which disasters occur and the economic losses incurred are directly associated with the extent of damage to the built environment. Much can be done by built environment professionals to improve disaster resilience through the incorporation of disaster risk reduction measures in urban planning, in the design and construction of buildings and infrastructure, in preparing for and responding to disasters and in reconstruction after disasters (Bosher, 2013). These all call for additional investment in built environment assets and this is echoed in the Sendai Framework where one of the four "priorities for action" is "investing in disaster risk reduction for resilience" (UNISDR, 2015). Mechler (2016) confirms that benefits tend to considerably outweigh costs for most disaster resilience investments. However, cost-benefit analyses are often simplistic in that they misrepresent the probabilities of disaster events and result in the over-estimation of benefits from such investments (Mechler, 2016). Whereas a wide variety of financial mechanisms have been conceived of and already exist which could be used to finance disaster resilience investments, they appear to be under-utilized (Pollner, 2012) and many developing countries which could particularly benefit from them rely instead on international donor assistance which is often slow to materialize (Ghesquiere and Mahul, 2007).

This research considers financing mechanisms in relation to the investors who will potentially use them and to the contexts in which they can be applied. The complexity and multidimensionality of the financing mechanism choice problem and the inter-relatedness of the variables in play is explored. This paper reports an initial, scoping study aimed at defining the problem domain using a mapping sentence tool adopted from Facet Theory. In the next section, Facet Theory and the mapping sentence tool are introduced and a preliminary mapping sentence is drafted to reflect the problem domain by framing it as a problem of investor behaviour. In section 3, the extant literature on the financing of disaster resilience is drawn on to elaborate each of the 'facets' of the mapping sentence. Section 4 brings together the findings from the literature in order to compile an elaborated mapping sentence which then provides a basis for further, detailed and systematic data collection towards a comprehensive understanding of financing mechanisms and their applicability. This data collection is intended to take place in the next phase of the research.

2. Research Methodology

In this initial study, the focus is on understanding and defining the problem domain relating to financing mechanisms for disaster risk reduction investments in the built environment, so that the range of financing mechanisms can be identified and understood in the context of the conditions under which they are relevant and/or appropriate and to which types of investors. The research methodology employed is inspired by Facet Theory – an approach to theory construction and research design developed by Luis Guttmann for the social sciences. Facet Theory was elaborated in the context of behavioural research and reflects the need to first conceptualize and define what is being studied prior to designing the data collection and analysis tools. The attraction of Facet Theory lies in its formalized tools for conceptualizing complex, multidimensional problem domains to enable their systematic investigation in terms of data collection and analysis (Guttmann and Greenbaum, 1998).

Central to the application of Facet theory is the use of a 'mapping sentence'. This is a sentence constructed of a group of statements that express a concept through a specific process. The statements ('facets') are linked together by normal prose and they represent a series of hypotheses regarding the research domain (Koval et al., 2015). Each facet refers to a set of related variables that should then be observed or measured in subsequent data collection. Guttmann and Greenbaum (1998) describe the mapping sentence thus: *"A mapping sentence is a verbal statement of the domain and of the range of a mapping, including verbal connectives between facets as in ordinary language. It always consists of two main parts: a formal part made up of the facets and a less formal part comprising the phrases linking the facets together."*

The purpose of the mapping sentence is to set out the formal definitional framework for the design of the research (Guttmann and Greenbaum, 1998). It can be used as a device to bring conceptual order and insight to research design (Hackett and Foxall, 1997). The mapping sentence comprises three parts:

1. The respondents (population facet);

2. The stimuli (content facets);

3. The responses (response facet).

Its construction forces the researcher to identify and make explicit the theoretical constructs underlying the research and also the types of observations required to test them. (Guttmann and Greenbaum, 1998).

Figure 1 shows an example of a simple mapping sentence for the passenger evaluation of airport developments – the content of the mapping sentence is drawn from Hackett and Foxall (1997), its visual layout follows that from Guttmann and Greenbaum (1998). It serves to explicate the theoretical constructs in play and it is immediately apparent how data collection (and even analysis) can proceed. Note, however, that whereas in the example in Figure 1 the content facets are all described in binary terms this does not have to be the case and other examples in the literature show facet descriptions containing many elements (for example, in Guttmann and Greenbaum, 1998).

Figure 1: Example mapping sentence for the evaluation of airport developments (adapted from Hackett and Foxall, 1997 and Guttmann and Greenbaum, 1998)

A preliminary mapping sentence could render the resilience investment problem domain of this

person (x) being an air passenger at the airport

rates the { social / spatial } comfort features of the airport (*A: referent*)

which are of { primary / secondary } importance to their purpose at the airport (*B:focus*)

and with which they have { direct / indirect } contact (*C:level*)

→ as being { very satisfactory to / very unsatisfactory } (*Range*)

research by characterising it as a problem of describing and understanding investors' behaviour with respect to financial mechanisms for disaster resilience investments in the built environment. It could take the form:

Preliminary Mapping Sentence:

Investors ( ) with Built Environment assets ( ) that are vulnerable ( ) to disasters ( ) would invest in resilience measures ( ) by means of financing mechanisms ( )

In this case:

1. the investors ( ) represent the 'population facet';
2. the 'content facets' are: Built Environment assets, the vulnerability of those assets, the (nature and characteristics of potential) disasters to which the assets are exposed, the resilience measures which can be invested in; and,
3. the 'response facet' refers to the financing mechanisms applicable to the investment options.

On the basis of this preliminary mapping sentence, a desktop study of relevant literature was carried out in order to describe each of the identified 'facets' in more detail. By incorporating the desktop study findings into an elaborated mapping sentence (presented at the end of this paper), the multidimensionality of the problem domain is made explicit and this provides a robust basis for the definition and understanding of the research problem (appropriate finance mechanism choice) thus enabling future phases of the research.

3. Findings

In this section, each facet type (population, content, response) identified in the preliminary mapping sentence above is considered in turn. The intention is to further elaborate the facets by drawing on the extant literature.

3.1 The population facet: Investors

Rather than being a homogeneous group, potential investors in disaster resilience in the built environment range from individual households to supranational entities, have diverse interests and responsibilities and differ considerably with respect to their exposure and vulnerabilities to disasters and their means available for investing. Whereas much of the literature considers the issue of disaster resilience investments and their financing mechanisms at the national level (for example, the series of UNISDR working papers on public investment planning and financing strategy for disaster risk reduction, e.g. Leste-De Périndorge et al., 2015; Zarine et al., 2015), specific disaster resilience investments often take place at the household, individual business and local community levels to mitigate particular risks. The extent and diversity of assets and disaster risks vary from one extreme to the other, even at the same level of investor definition – large, wealthy nations enjoy far greater stability in the face of disasters than small, island nations (Ghesquiere and Mahul, 2007). At the household and business levels, there is greater reliance on insurance (at least in the developed world) while government assets and infrastructure are often not insured (Pollner, 2012). Insurance coverage varies considerably between regions of the world with 56% of North American disaster losses being insured losses compared with only 1% of African disaster losses being insured losses (Munich RE, 2016). Similarly, the relative wealth of households and communities influences not only their potential disaster losses and their ability to invest, but also their exposure to risk - their societal 'risk positions' in terms of Ulrich Beck's Risk Society (Beck, 1992).

Summarising, important attributes of the population facet: *Investors i*nclude that they can be considered to constitute a range of social entities which, for the purpose of investigating disaster resilience investment, can be defined in terms of their type (households, business organizations, nations, etc.), their scale (small to large), their wealth (low to high) and their exposure to disaster risk (low to high). In addition, these are seen to be interrelated with other factors, for instance, the extent and diversity of assets, their specific exposure to particular types of disaster, etc. These will be captured and defined in greater detail in the next section – content facets.

3.2 The content facets

The preliminary mapping sentence sets out an initial selection of content facets as Built Environment assets, the vulnerability of those assets, the (nature and characteristics of) disasters to which the assets

are exposed and the *resilience measures* which can be invested in. In this section, each of these facets is considered in turn in order to more fully define them.

3.2.1 Built environment assets

In the first place, the specification of asset type is important – what sort of assets are under consideration: buildings (residential, commercial, institutional, and so forth) or infrastructure (transport, energy, water, etc.) In the second, the criticality of the assets to the functioning of the investing social entity (household, community, city, nation, etc.) is clearly an important consideration - Moteff and Parfomak (2004) refer to this attribute using the terms 'critical infrastructure' and 'key assets'. Classification of buildings and infrastructure assets according to their expected responses to specific (disaster) events such as earthquakes, flooding and so forth is also central to planning including decisions regarding investment (Ventura et al. 2005), but such classifications are rather in relation to the next content facet – *vulnerability*. In association with vulnerability, Pollner (2012) notes that asset values are also directly related to potential losses and therefore have a role in determining investment levels as do portfolio effects where assets are diverse in terms of type, vulnerability, location, etc.

3.2.2 Vulnerability

Vulnerability assessments and classifications are essential for the design of disaster mitigation and planning including investment vehicle design (Pollner, 2012; Ventura et al. 2005). Mechler (2016) differentiates between physical vulnerability which may be reduced through preventative measures and socio-economic vulnerability which may be reduced by preparation. So that asset vulnerability is closely tied with both the 'hard' measures that can be invested in to reduce losses in a disaster event – for example, the strengthening of structures and physical components of systems against earthquake loading and flooding – as well as 'soft' preparedness measures (Mechler, 2016).

In terms of constituting a 'content facet', vulnerability clearly relates to asset type and is dependent on exposure to disaster events. Beyond the need to differentiate by type (physical / socio-economic), the degree of vulnerability lends itself to measurement on a scale of relatively low to relatively high.

3.2.3 Disasters

The *disasters* facet relates to types of hazard as well as the degree of exposure to these hazards and the estimated loss-frequency (Mechler, 2016). The probable return periods, impacts and losses associated with these hazards and combinations of them (multi-hazards) (Zarine et al., 2015).

3.2.4 Resilience Measures

Royal Haskoning (2012) categorized flood mitigation measures into resistance measures (aimed at physically preventing water from flooding properties) and resilience measures (intended to reduce the losses incurred in the event that the properties get flooded). Mechler (2016) refers to three different classifications of measures undertaken in the pursuit of disaster risk reduction:

1. 'hard' measures versus 'soft' measures as noted in section 3.2.2 above;

2. by type of risk reduction strategy into:

a. structural and non-structural;
b. exposure and property modification which includes land-use planning, building codes, etc.
c. behavioural including preparedness, awareness, warning systems, etc.

3. according to risk reduction and the modification of vulnerability:

a. prevention – reduces risk through modifying hazard, exposure and physical vulnerability;
b. preparedness – reduces risk which modifies socio-economic vulnerability during disaster response;
c. risk financing – reduces the variability of losses and thus modifies socioeconomic vulnerability.

Zarine et al. (2015) provide a more comprehensive classification of measures according to timing and with reference to the Disaster Risk Management cycle:

1. Risk reduction

a. Prevention, e.g. land-use planning
b. Mitigation, e.g. retrofitting
c. Preparedness, e.g. contingency planning

2. Risk Financing

a. Transfer, e.g. insurance
b. Proactive retention, e.g. contingency fund

3. Disaster Management

a. Response, e.g. emergency management
b. Reconstruction, e.g. build back better.

However, the examples of these measures (from Zarine et al., 2015) given in the list above under 2. Risk Financing can be considered both as measures and as financing mechanisms.

3.3 Response facet: Financing Mechanisms

Both Zarine et al. (2015) and Ghesquiere and Mahul (2007) emphasize the timing of financing mechanisms and point out that the capacity to finance post-disaster operations is highly dependent upon the sources of finance available. They suggest classifications which differentiate between ex-ante and ex-post arrangements.

1. ex-ante financing mechanisms, including:

a. Contingency fund
b. Contingent debt
c. Parametric insurance

d. Traditional insurance
e. Multi-country mutual insurance funds
f. Insurance-linked securities (e.g. catastrophe bonds)
g. Specific taxes

2. and ex-post financing mechanisms

a. Budget contingencies
b. Budget reallocation
c. Domestic credit and domestic bond issues
d. External credit and international bond issues
e. Tax increase
f. Donor assistance

The list above draws on the examples of financing mechanisms described by Ghesquiere and Mahul, 2007; Zarine et al., 2015; Pollner, 2012 and Ruffert, 2014. Although it relates specifically to financial mechanisms available at the national level, the parallels to other types of investor (scale of social entity) are easily made so that a similar list would apply to, for instance, a business organization.

4. Discussion

From the initial review of extant literature presented above, the facets emerging from the preliminary mapping sentence may be elaborated as set out in Table 1 below.

Population Facet	*Content Facets*				*Response Facet*
	Asset	*Vulnerability*	*Disaster*	*Resilience Measures*	
Attributes	***Attributes***	***Attributes***	***Attributes***	***Attributes***	***Range of Responses***
Type of social entity	*Type of asset(s)*	*Physical and/or socio-economic*	*Hazard types (incl. multi-hazards)*	*Risk reduction (prevention, mitigation, preparedness) and/or Risk financing (transfer, proactive retention) and/or Disaster management (emergency management, Build Back Better)*	***Ex-ante mechanisms:*** *Contingency fund* *Contingent debt* *Parametric insurance* *Traditional insurance* *Multi-country mutual insurance funds* *Insurance-linked securities* *Specific taxes* ***Ex-post mechanisms:*** *Budget contingencies* *Budget reallocation* *Domestic credit (incl. bond issues)* *External credit (incl. bond issues)* *Tax increase* *Donor assistance*
Scale	*Criticality*	*Degree of vulnerability*	*Degree of exposure*		
Wealth	*Value*		*Probable return period*		
Exposure to disaster risk	*Diversity of assets*		*Probable losses*		

Table 1: Summary of facets

The mapping sentence earlier proposed may now be restated in elaborated form (and presented in a similar geometric form to the example sentence in Figure 1):

Elaborated mapping sentence:

Investors {defined by type of social entity, scale, wealth, exposure to disaster risk}

with built environment assets {of type, criticality, value, diversity}

that are vulnerable {in physical and/or socio-economic terms, degree of vulnerability}

to disasters {of hazard type(s), degree of exposure, probable return periods, probable losses}

would invest in resilience measures {Risk reduction and/or risk financing and/or disaster management}

by means of financing mechanisms {range from ex-ante to ex-post mechanisms}

In this way, the key variables of the problem domain as well as the main logical interrelationships between the variables have been identified. This serves to define the domain and enables the collection of data to further define and test the relationships between variables in order to understand the range of financing mechanisms and their appropriateness for all investor types and their specific contexts.

5. Conclusions

Economic losses from disasters are extremely high and are rising owing to various factors including the increasing concentration of people and assets in cities and the tendency for cities to be situated in vulnerable locations. Climate change predictions also suggest that both vulnerabilities of populations and the severity of disaster events are set to increase. Cost benefit analyses typically show handsome returns on disaster risk reduction investments for built environment assets but this requires development of the financing mechanisms available to investors and a better understanding of their potential range as well as their appropriateness to the wide range of potential investor contexts.

The Facet Theory approach offers a method of framing a complex and multidimensional problem domain using the mapping sentence tool in such a way that it is conducive to further investigation. In this case the problem of identifying and understanding financing mechanisms for disaster resilience investments in the built environment has been explored with the help of a preliminary mapping sentence pertaining to investors' behaviour with respect to disaster resilience investments. An initial investigation of the relevant literature on disaster resilience investment has enabled the mapping sentence to be elaborated so that it defines the problem domain to the extent that more detailed data collection can now take place.

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Implementation of Early Contractor Involvement (ECI) in Norwegian Bridge Projects Procurement

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Abstract

According to the literature, even if early contractor involvement (ECI) has several advantages, international and national legislation often represent challenges for public owners considering implementing it in their projects. This might be caused by the obligations that public owners being obliged to use competitive and transparent contractor selection procedures based on both price and quality. In addition, they are obliged to treat all tenderers equally. However, fulfilling these obligations is challenging even in the traditional project delivery methods. Thus, it becomes extra challenging when it should happen together with ECI. Hence, the purpose of this paper is to add to the knowledge of abilities and constraints of using such an approach by studying how public owners use ECI approaches. This research was carried out according to a qualitative approach, based on a literature study, a document study and interviews. Fourteen semi-structured in-depth interviews were conducted with key client personnel from eleven case studies selected from Norwegian bridge projects. Various approaches of ECI have been used in the investigated bridge projects without violating public procurement legislation. Among the identified approaches are; direct contact with specialist contractors in the front-end phase of projects, idea competition, announcing the project with optional technical solutions, using a design & construct contract, information meetings with the contractor branch and a front-end partnering process. This study concludes that public owners might have several alternatives in order to implement ECI. However, the contractors' contributions vary a lot depending on which ECI approaches are implemented and at what time they are implemented in a project. Most of the ECI approaches identified in the targeted projects were implemented in the relatively late phases of the projects. Most of the approaches, however, could have been implemented earlier. Therefore, the ultimate potential of the approaches was not realised. This paper can help public owners to understand the full potential of ECI approaches. Likewise, it can help public owners to benefit more when they implement the approaches in the future.

Keywords: Early contractor involvement, ECI, Public procurement, Bridge

6. Introduction

The separation of the design phase from the construction phase of a project often entails problems. Contractors, specialist suppliers and fabricators should contribute to the design in addition to consultants to achieve a complete and functional design. Procurement procedures that neglect contractors` design contribution can increase risk. Furthermore, it can also lead to poor communication between team members, unnecessary delays and incorrect information that results in claims and disputes (Mosey, 2009). One of the solutions proposed by the literature for addressing this challenge is early contractor involvement (ECI). ECI is defined as a process where the designer and contractor work together with the client, based on a contractual relationship (Walker and Lloyd-Walker, 2015). It is also defined as a recently emerged construction project delivery approach that denotes the involvement of a contractor during the front-end of the project in order to work together with the client and/or a consultant. The main purpose of ECI is to assist in planning and buildability (Rahman and Alhassan, 2012).

The most important benefits of ECI identified in the literature are an opportunity for the better relationship between the contractor and the client, the effectiveness of contractor's input into the design, better risk management, effective resource utilisation, improve in quality, improved contract administration and overall improved project delivery (Rahman and Alhassan, 2012). Thus, the main driver for the client to implement ECI is to get more for less. Even if ECI has several advantages, public owners considering to implement it in their project, face barriers due to international and national legislations (Kolman, 2014). One of the international barriers is the EU public procurement directive. According to this directive, public owners should treat all tenderers equally and they should act in a transparent way during the procurement process (Wondimu et al., 2016b). Furthermore, public owners are obliged to use competitive and transparent contractor selection procedures based on both price and quality. These requirements possess a challenge during their use of ECI (Lahdenperä, 2013; Wondimu et al., 2016b).

Norwegian public owners have to follow the Norwegian Act on Public procurement, which is adapted to meet international agreements (Lædre, 2006). The Norwegian Public Roads Administration (NPRA) is currently planning several complex bridge projects along the west coast of Norway (E39 Coastal Highway Route). How to procure contractors for these bridge projects and how to bring in their knowledge and experience into the projects are two of the major challenges for the NPRA. A group of experts from NPRA has identified ECI as one of the solutions. Therefore, this paper studies how ECI approaches are used by public owners, to add to the knowledge of abilities and constraints of using such an approach. The following research questions are addressed in this paper:

- What approaches are used to implement ECI in Norwegian bridge projects without violating public procurement legislation?
- What type of potential for further improvements can be found in the various identified ECI approaches?

The paper proceeds as follows. Section 2 describes the research method. Section 3 summarises the definition of ECI and the various approaches of ECI identified from the literature. Section 4 presents findings and discussions, including the ECI approaches, which were identified during the interviews. The paper ends with a short conclusion.

2. Research Method

A literature study was carried in accordance with the five steps described by Bloomberg et al. (2011). 1) Building of an information pool, 2) application of a filter to reduce pool size, 3) a rough assessment of sources to further reduce pool size, 4) an analysis of the literature in the pool and 5) the refinement of filters or stop the search. The search words used were such as "Early contractor Involvement", "Public procurement" and "EU". The objective was mainly to identify ECI alternatives and to develop the theoretical background of ECI. It was also used to get a current international perspective of the topic. A combination of journals and conference papers were reviewed. The literature review indicates that ECI in the European public sector is a new phenomenon, as most of the identified literature has been published after 2010.

In order to address the research questions, multiple case studies were carried out based on the recommendation of Yin (2013). The cases were examined according to a qualitative approach, based on a document study and interviews. Fourteen semi-structured, in-depth interviews were conducted with key client personnel from eleven case studies selected from the Norwegian bridge projects. Personal contact with practitioners was used to identify the cases. The document study was based on contract documents and internal project reports.

The semi-structured, in-depth interviewees were carried out with the fourteen key professionals by using a common interviewee-guide. The interviewees had managerial positions in the target project. All interviews were recorded and transcribed to increase the reliability of the data.

3. Theoretical Background

3.1 Early contractor involvement

Several definitions for the concept of ECI exist. Equally, different approaches are used to implement it based on industry and regional needs and trends. The broader definition of ECI is the engagement between the client, the designer and the contractor during the early stage of a project (Turner and Riding, 2015). The authors of this paper defined ECI to be an approach to involve construction knowledge and experience in early phases of a project, directly or indirectly.

ECI is the best way to connect the design and the construction part of a project (Löwit and Dostálová, 2014). It creates an innovative environment by taking contractor's expertise, experience and understanding of the construction process to the design process (Rahman and Alhassan, 2012). The aim of ECI is to decrease the overall project cost by increasing the focus placed on the value of the contractor's ability, rather than a separate focus on price. This can be achieved through better facility arrangement, more functional assets and a better understanding of the time and scope of the project during the construction phase (Turner and Riding, 2015).

According to Walker and Lloyd-Walker (2012), there are five models of ECI depending on in which phase of the project the contractor becomes involved in and how long the involvement lasts. Figure 1 illustrates the five models. This was the only comprehensive model found, that could define ECI, during the literature study.

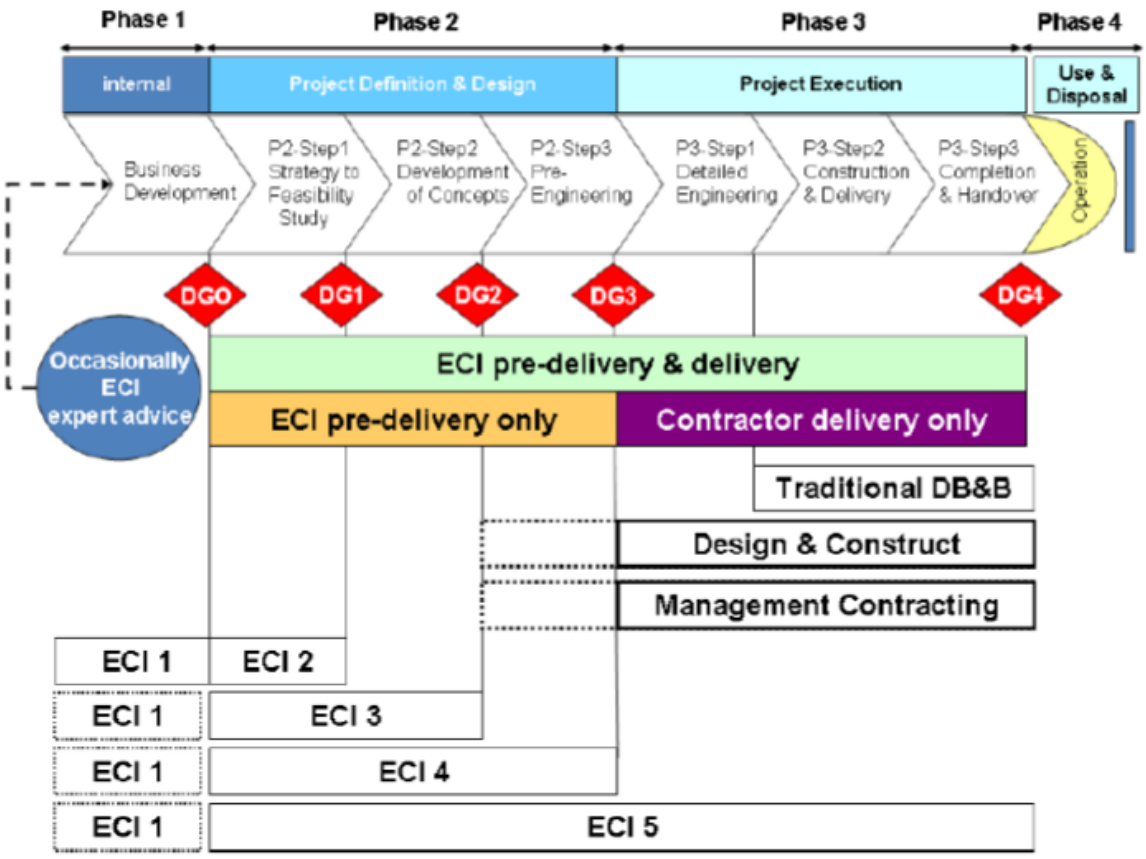


Figure 1: Project Life cycle phases: (Walker and Lloyd-Walker, 2012) adapted from (Klakegg et al., 2010). Decision gates: DG0=formally recognized idea, DG1=acceptable initiative to investigate, DG2=choice of concept, DG3=go/no go, DG4=accept outputs for the operation.

The ECI models are developed based on at which decision gate (DG) the contractor becomes involved in and how long each involvement lasts. They range from one-time involvement, ECI 1, to several phase involvements, ECI 5. Two example approaches of ECI 5 are project partnering and project alliancing (Walker and Lloyd-Walker, 2012).

3.2 Possible approaches to implementing ECI

There are various approaches to implementing ECI (Rahman and Alhassan, 2012). The three important dimensions that are relevant and may result in different ECI approach set-ups are timing, scope and role (Nijsten et al., 2010). In the discussion section of this paper, timing is used to evaluate the identified approaches. The various ECI approaches identified in the literature are presented in Table 1. They are a collection of possible approaches of ECI that are in line with the EU public procurement directive. This is because public owners can ensure competitive and transparent contractor selection procedure based on both price and quality by using one or several of these approaches.

Table 1: ECI approaches identified

11. Competitive dialogue – procurement procedure suitable for complex projects.	(Hoezen, 2012), (Kolman, 2014), (Lenferink et al., 2013), (Marique, 2013), (European Parliament, 2014)
12. Negotiated procedure - Procurement procedure looks like competitive dialogue but can be applied in simpler projects.	(Van Valkenburg et al., 2008), (Lenferink et al., 2012), (Hoezen, 2012), (European Parliament, 2014)
13. Integrated project Delivery (IPD) – integrates people, systems, business structures and practices through relational contracting.	(Gransberg, 2016), (Kent and Becerik-Gerber, 2010), (Lahdenperä, 2012) (Gokhale, 2011)
Approaches of ECI	Literature (Authors)
1. Building information modelling (BIM) – tool and process, enabling a high level of design integrity through the common use of BIM platform in early phases.	(Gransberg, 2016), (Kent and Becerik-Gerber, 2010), (Walker and Lloyd-Walker, 2015)
2. Integrated Project Insurance –an alternative form of insurance providing single cover for the construction project team as a whole.	(Ciribini et al., 2016), (Connaughton and Weller, 2013)
3. Framework agreement- a procurement arrangement to buy goods and services over a certain period of time.	(Walker and Lloyd-Walker, 2015), (Albano and Sparro, 2010)
4. Design & construct contract / Design & build contract- contract form where the contractor has the responsibility to design in addition constructing the project.	(Rahmani et al., 2014), (Song et al., 2009)
5. Management contracting- contract form where a project owner outsources the project management.	(Rahmani et al., 2014), (Walker and Lloyd-Walker, 2015), (Rahman and Alhassan, 2012)
6. Most economical advantageous tender (MEAT) – a qualifications-based selection of design and construction parties.	(Scheepbouwer and Humphries, 2011), (Lahdenperä, 2013), (Falagario et al., 2012)
7. Open book target pricing - pricing process that makes the contractor design or constructs the project on budget.	(Gransberg, 2016), (Scheepbouwer and Humphries, 2011), (Rahman and Alhassan, 2012), (Molenaar et al., 2007)
8. Cost led procurement- procurement methods that have been developed in the UK comparable to target pricing.	(Ciribini et al., 2016), (Williams et al., 2013)
9. Opening for alternative tenders- the client allows variant solutions by the bidders during the tendering phase.	(Riemann and Spang, 2014)
10. Best value procurement (BVP)- It is an award method to procure contractor with the best expertise to complete the task.	(Hoezen, 2012), (Kashiwagi, 2016)

The approaches identified from the literature are a combination of tools (1), contract types (2,3,4,5), contract award methods (6,7,8,9,10), procurement procedures (11,12) and project delivery methods (13,14,15,16). In actual projects, two or more of these approaches can be combined and implemented together.

4. Findings and discussion

This section presents the approaches used to implement ECI in the Norwegian bridge projects and it explains how the practised approaches could be improved. Twelve approaches of ECI identified during interviews, based on the interviewees' perception, are presented in this section. Approaches 1 to 9 have been used in the studied projects at different phases. Whereas, approaches 10 to 12 were not implemented in the case projects but were proposed as potential approaches for the future.

A matrix of ECI approaches vs projects is presented in Table 2. It shows the twelve approaches identified by this study in the first columns and the eleven target projects along the top row. The approaches are presented based on a sequence from most implemented (A1) to not implemented (A12). The projects are arranged from the project that has used the most of the approaches (1) to the project that has used the least (11). In column two of the table, L stands for approaches identified in literature and P stands for approaches identified in the assessed projects.

Table 2: ECI approaches (A1-A12) x projects (1-11) matrix

No	*L/P*	*ECI approaches*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*Sum*
A1	*P*	*Indirect approaches*	X	X	X	X	X	X	X	X	X	X	X	11
A2	*P*	*Information meetings*	X	X	X	X	X	X	X		X			8
A3	*P*	*A front-end partnering process*	X	X	X	X	X	X	X	X				8
A4	*P*	*Announcing the project with alternative technical solutions*	X	X		X		X	X			X	X	7
A5	*L/P*	*Design & construct contract*		X	X		X			X	X			5
A6	*P*	*Direct contact with specialist contractors in the front-end*	X			X								2
A7	*P*	*Idea competition*	X											1
A8	*P*	*Contractors sell their idea to the owner in the early phase*		X										1
A9	*L/P*	*Negotiated bidding procedure*			X									1
A10	*L/P*	*Opening for alternative tenders*												0
A11	*L/P*	*Competitive dialogue*												0
A12	*L/P*	*Project partnering*												0

According to Nijsten (2010), timing, scope and contractors` role are the three dimensions that determine the ECI approaches set-ups. Furthermore, the timing of implementation is also one of the identified success factors of ECI (Wondimu et al., 2016a). Due to this, the timing of implementation is used to evaluate and to come up with a proposal for improvement of the practised approaches. During the evaluation, the weaknesses of the practised approaches were identified. Based on the findings, recommendations are given for future implementation. The twelve approaches identified during the interviews are briefly described below, along with an explanation in which phase of the project has been used and in which phase could be used. The purpose of the explanation in which phase could be used is to illustrate the potential of each approach.

Indirect approach - This approach refers to the use of consultants and in-house construction experience as an approach to implementing ECI. Furthermore, it also denotes the involvement of contractors during the preparation and updating of handbooks and standards. These methods are categorised as an indirect approach by the authors of this paper as there is no direct involvement of the contractor in a specific project. Instead, the focus in these methods is in bringing construction knowledge to the early decision- making process. It is less demanding and less complicated compared to the other identified approaches since there is no direct contractor involvement. This approach was used by the various case projects at varying stages of their projects. Thus, it can be said that the full potential of this approach, in terms of time, is exploited.

Information meetings - It is an informal communication meeting between the owner and contractors. In this approach, the client gathers all interested contractors together in one room and officially discusses the challenges of the project. The purpose of this approach could be to get feedback on what the client is planning or to get new ideas from the contractors. It is noncommittal for both the contractors and the client. This approach could be used to implement ECI starting from business development step all the way until the end of the detailed engineering step. Furthermore, it can also be combined with all of the other approaches of ECI.

A front-end partnering process - It is an approach developed and used particularly by the Norwegian Public Roads Administration (NPRA). Usually, the client allocates four weeks during the project execution phase for this process. The process should start after contract signing and end before the contractor commences construction. The major purpose of this approach is to have a common understanding of the contract and to set-up a common goal with all contracting parties. Furthermore, it aims to let the contractor come up with optimisation ideas. This approach has been used in the beginning of the construction & delivery step and detailed engineering step. However, it could also be used in the pre-engineering step since the design and construct contract can start in this step as well.

Announcing the project with alternative technical solutions - In this approach, the client prepares contract documents that have more than one technical alternative. The primary motive of the client when using this approach is to reach a wider supplier market in order to get several bidders for a project and get the cheapest prices. Consequently, this approach increases the market competition. In the meantime, contractors get the possibility to influence the production method and material selection during the project delivery. In this approach, the contractor's involvement is in the tender calculation phase by evaluating the various alternatives given by the client, either in the detailed engineering step or during pre-engineering. This approach could not be used earlier than this phase as it is concerned

about technical matters. This approach was used in the case projects to its full potential, as it could not have been implemented earlier.

Design & construct contract - It is also called design-build contract. In this approach, the contractor has the responsibility and flexibility to design the project in addition to constructing it. Thus, the contractor is involved in the design phase of a project. This approach was used starting from the detailed engineering phase in the case projects. However, it could also be used starting from the pre-engineering phase. It depends on to what extent the client has designed the project before hiring the contractor. In order to use it in the pre-engineering phase, the project description should be rough or non-detailed.

Direct contact with specialist contractors in the front-end phase of projects - In this approach, the client has professional but informal discussions with specialist contractors. It can happen in the front-end phase of a project when the client faces challenges that could be solved by specialist contractors. This approach was used only in the detail engineering phase of the target projects. As the approach is informal communication as part of a professional discussion with experts, it could potentially be used in all steps of a project beginning at business development.

Idea competition - In this approach, the client invites contractors to come up with ideas for the project in the concept development phase. Mostly this approach suits consulting companies. Companies that have both consulting and construction in-house, however, can participate in this competition. This approach is used in the development of the concept phase to get ideas for the project's concept. It could also be used in a later phase of a project to get, for example, technical ideas by holding a "technical idea competition" in the pre-engineering phase.

Contractors sell their ideas to the owner in the early phase - In this approach, contractors can present their ideas during the early phase of the project. This can happen when the contractors have an idea or technology that can help the client to solve a project challenge. The client can then include the contractor's contribution as alternative solution in their bid documentation. The reason for including it as an alternative solution in the bid (not as the only solution) is not to give a competitive advantage to the contractors that sold their idea to other contractors that are not involved in the early phase. This approach has been used in the pre-engineering phase of the case projects but could be used anywhere starting from the business development phase up until the detailed engineering phase. To use this approach, contractors should be informed about the project challenges so that they can come up with their ideas. In addition, the client should be open to including contractors` solutions.

Negotiated bidding procedure - This is one of the procurement procedures that are identified by the EU-directive for public works, supply and service contracts. In this approach, negotiation is allowed with selected contractors. It was used in the pre-engineering step of the case projects. It could be used anywhere between the development of the concept and pre-engineering step. This approach could be difficult to use earlier than these steps. This is because there should be a feasible project to start with the negotiation procedure.

Opening for alternative tender - In this approach, contractors get contractual right to submit one or more alternative solutions than described by the client. In most projects, the client closes this option in order to avoid complication in the procurement process. It was not used in the targeted projects but was proposed as a potential approach by the interviewees. It could be used in the development of the concept

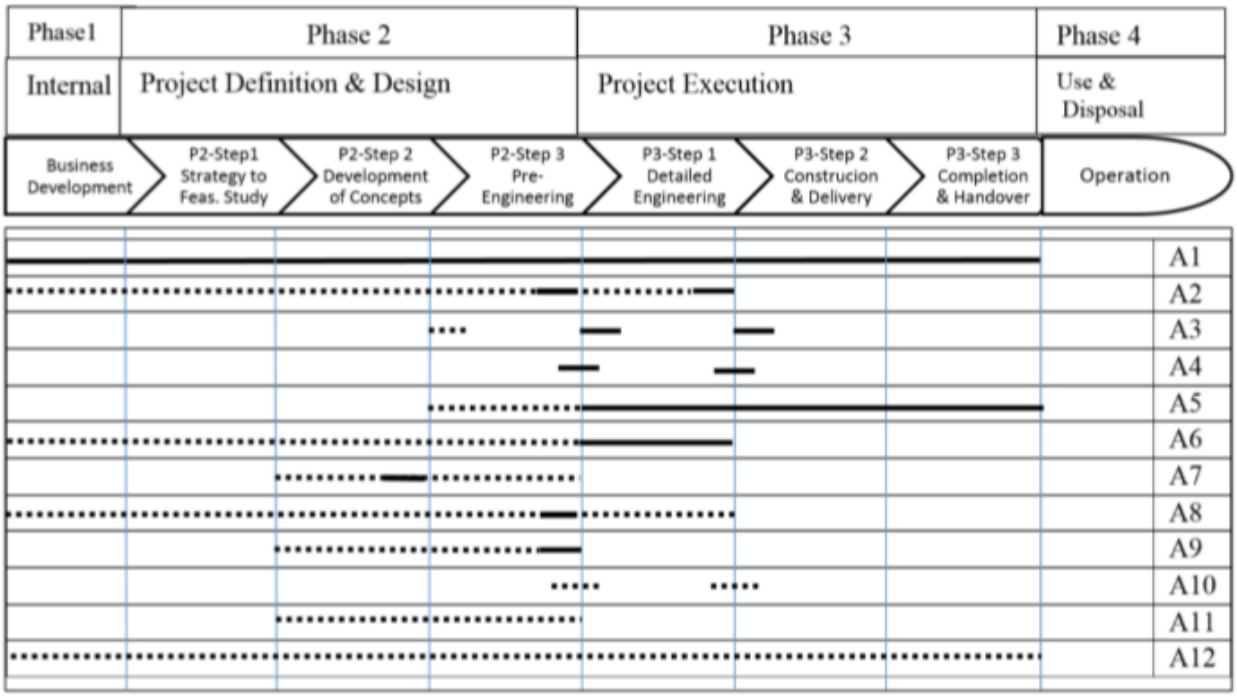
and the pre-engineering steps. However, it can't be used earlier or later than these phases. The reason is, if it used later than this phase, then all the detailed design would be wasted if the contractor came up with a new idea during the detailed engineering phase. If it is used earlier, then it is difficult for the client to have a tender that can be handed out as the first (base) alternative. As in this approach, the contractors should use the client's base alternative to come up with an alternative tender.

Competitive dialogue - This is one of procurement procedures identified by the EU-directive for public works, supply and service contracts. It can be used in particularly complex projects. In this approach, there is a dialogue phase during the procurement process to discuss possible solutions with the contractors. This approach was not used in the targeted projects, however, it could be used in the development of concepts, pre-engineering and detailed engineering steps. In order to use this approach, the client should justify that the project is "particularly complex". In order to show this, the client should conduct the feasibility study first. That means this approach cannot be used prior to the development of concepts step.

Project partnering - This approach is a long-term commitment by the client and contractor to achieve specific business objectives. It demands trust, dedication to common goals, and the effectiveness of each participant's resource use. It was not implemented by the target projects. This approach is a broad concept (Hosseini, et al., 2016) that could be used in all phases of the project by using the right partnering component that matches the project`s needs.

When the practised approaches have been implemented is explained in Figure 2. In addition, it also illustrates the potential of each of the twelve ECI implementation approaches based on the authors of this paper`s understanding. In which phase of a project the approaches could potentially be used for greater gain is the base for the explanation of the potential.

Figure 2: Potential of each of the approaches, based on when they are used and when they could be used. A1-A12= ECI implementation approaches. (Is already used= solid lines. Could have been used= dotted lines).



5. Conclusions

The research questions addressed in this study were what are the approaches used to implement ECI in Norwegian bridge projects without violating public procurement legislation, and what type of potential for further improvements can be found in the various identified ECI approaches. There are several approaches of ECI, which public owners can use. Seven new approaches that have been implemented by the NPRA on various bridge projects are identified and introduced by this paper. However, the contractors' contributions vary a lot depending on which ECI approaches are implemented and the timing that they are implemented in a project. Most of the ECI approaches identified in the targeted projects were implemented in the relatively late phases of the case projects. However, most of the approaches have the potential of being implemented earlier. This study reveals that essential consideration was not given to the timing of implementation of ECI by NPRA while implementing these approaches. Therefore, the ultimate potential of the approaches was not realised. This is likely to be due to culture, procurement procedures or lack of knowledge of ECI concept and its benefits. This study adds to the knowledge of abilities and constraints of using such an approach.

The improvement measures and recommendations to the practised approaches are then that proper consideration should be given to the timing of implementation while selecting and implementing the approaches of ECI. Owners that plan to implement these approaches, however, should also consider the other five success factors that have been identified by Wondimu et al. (2016a). These success factors are risk distribution between the client and the contractor, project owners` competence, compensation format, qualification of the contractors and trust. In the future, each of the identified ECI approaches could be evaluated by these five success factors. This study involves some limitations, as it does not prioritise the approaches after which one is the most useful ones. Furthermore, only the client perspective is studied. Further work could prioritise the most useful approaches in the context of bridges projects. In addition, it could also include the contractors` perspective.

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Health, safety and environment (HSE) in the bachelor education of construction engineers in Norway

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Abstract

The construction industry is more exposed to serious accidents than other sectors in Norway, and needs to improve its performance on health, safety and environment (HSE). Newly educated engineers quickly enter into management positions with responsibility for HSE, so our educational institutions ought to prepare their students for this kind of responsibility. One should therefore expect HSE to be part of the official educational strategy when educating construction engineers.

This paper 1) examines how aspects of HSE are included in the learning outcomes of the bachelor education of construction engineers in Norway, and 2) assess the emphasis on HSE topics in these learning outcomes. The investigation is limited to the HSE requirements under the provision of the Working Environment Act. Descriptions of learning outcomes were collected from five educational institutions in Norway, and the documents were subjected to content analysis.

We found that the inclusion and emphasis on HSE in learning outcomes vary among the different educational institutions in Norway. The paper argues that not all educational programmes in construction engineering have HSE high on their official educational agenda. Furthermore, based on our analysis of learning outcomes, we suggest that the educational programmes consider adopting a more holistic approach to HSE. The paper provides a starting-point for further research on how the engineering educations can contribute to improve HSE performance in the construction industry.

Keywords: Health, safety and environment (HSE), learning outcomes, engineering education, bachelor education, construction industry.

1. Introduction

In the Norwegian model of labour relations, employees expect personal development, codetermination and participation at company level, and to be protected against harmful accidents and other health consequences of their work (Løken and Stokke, 2009). The authorities and the social partners of trade unions and employers' associations all have high aspirations for HSE (Karlsen, 2010). The Norwegian Working Environment Act give all employees in management positions responsibility for health, safety and environment (HSE) within their own jurisdiction (aml., 2005§ 2-3 (3)). HSE are advertised as central values of many of the larger Norwegian companies, especially in the petroleum industry, and are used quite actively in reputation management (Falkenberg, 2006). Roberts et al. (2012) even suggest that companies that include HSE work on their top priority list will obtain a competitive advantage. Trade unions, on the other hand, regard HSE work as vital to improve working conditions for employees (Løken and Stokke, 2009). Thus, the actors in the labour market may have different motives, but they all seem to set high goals for HSE and depend largely on managers at different levels to achieve them.

During the post WW2 period in Norway, engineers dominated management positions in industrial and technical enterprises in both the private and the public sector (Nygaard, 2014a). Even though their dominant management position in the last decades has been somewhat reduced (Nygaard, 2014b), engineers still hold a vital position amongst managers (Ravn, 2015). A study from 2002 found that 27,2 percent of leaders in Norway have a technical background (Vie, 2012).

Judged by the absolute number of fatalities, the construction industry is currently the most dangerous industry in Norway, according to the Labour Inspection Authority (Arbeidstilsynet, 2017). The lack of safety measures, short deadlines, great work pressure and a significant number of foreign employees are some of the specific risk factors in the construction industry identified in earlier studies (Andersen et al., 2009, Ødegård et al., 2007, Bråten et al., 2012). According to these, there are discrepancies in the way HSE regulations are implemented by different enterprises, suggesting that there is a lack of common understanding of HSE in the industry. A status report from 2009 on HSE work in Norwegian enterprises discloses insufficiencies in HSE competence among managers and that that only 42 % of employers report to have procedures to execute required HSE training for their managers (Andersen et al., 2009, p. 52).

These earlier studies indicate that HSE training on the workplace is not enough to ensure the HSE performance in the industry. However, to our knowledge, no studies have been conducted on how HSE is included in formal education programmes that are designed to prepare students for working life in the construction industry. In a 2008 evaluation of the education of engineers in Norway, employers were asked what competences they need but find to be lacking when hiring newly educated engineers (NOKUT, 2008, 45). Competence on HSE was among the elements mentioned, however, this finding was not subject to further investigation. That is why this paper will take a first step to examine how aspects of HSE are included in the education of construction engineers. We will do this by 1) examining how HSE is included in the learning outcomes of the bachelor education, and 2) assess the emphasis on HSE topics in these learning outcomes.

2. Research methods

Our analysis is based on learning outcomes collected from the five educational institutions in Norway with the highest admission numbers of bachelor students in engineering in 2014 (Norwegian Centre for Research Data, NSD, 2015). The following educational institutions are included: 1) Høgskolen i Bergen (HiB)1, 2) Høgskolen i Sør-Trøndelag (HiST)2, 3) Høgskolen i Oslo og Akershus (HiOA), 4) Høgskolen i Østfold (HiØ), and 5) Universitetet i Agder (UiA).

The learning outcomes represent what competence the educational institutions consider essential that their students master before graduation. They are, thus, relevant indicators of whether and how aspects of HSE are included as part of the official educational strategy of the institutions studied. In this desk study, we have examined both the overall learning outcomes of the different bachelor programmes, and the learning outcomes given in all the different subjects included in these programmes. Although the overall learning outcomes are usually decided on a higher level of the institution, the process of formulating the learning outcomes of specific subjects is usually delegated to the teachers in charge of the subject at hand (Sørskår, 2015). There can evidently be some discrepancies between the written learning outcomes and the actual teaching in a specific subject. However, it is unlikely that what are regarded as important aspects of teachings are not mentioned in these documents. Thus, we regard the absence of HSE aspects in the learning outcomes as an indicator that these aspects are not regarded as sufficiently important to be part of the overall educational strategy, and that the eventual focus on HSE is left for the individual teacher to decide.

Our investigation is limited to the bachelor education of construction engineers and to the HSE requirements under the provision of the Working Environment Act. Thus, we exclude HSE requirements concerning the outer environment, consumers and the wider public, and concentrate on the health, safety and working environment of employees in the construction industry.

The collected learning outcomes were subjected to a content analysis to identify indicators of the HSE focus in the bachelor education programmes. This method allows the combined use of qualitative and quantitative approaches to the data, and we do not risk the data being influenced by the data collection itself (Weber, 2011). The analysis focus especially on the use of the term HSE, in what way the term is mentioned and in which context. Risk, regulations and project management are other terms commonly found within the field of HSE, and are included in the analysis to detect other possible indications of HSE in the education programmes. We have also documented the number of credit points and whether the subject at hand is required or optional. The scope (credit points) and status (required or elected subject) can indicate the general emphasis of HSE topics in the overall bachelor education.

[1] Høgskolen i Bergen (HiB) merged with two other institutions from January 1st 2017 to form the new Høgskulen på Vestlandet, and ceased to exist as an autonomous institution from this date.
[2] Høgskolen i Sør-Trøndelag (HiST) merged with NTNU from January 1st 2016, and ceased to exist as an autonomous institution from this date.

3. Theoretical background

The Norwegian model of labour relations is based on a tripartite cooperation at the national level between the state and the social partners. For the model to function it is, however, crucial that the cooperation between trade unions and employers is also practiced at company level, including cooperation on health and safety activities (Løken and Stokke, 2009). Several studies show that competent managers, employees and staff representatives are all crucial for effective local work on HSE (Andersen et al., 2009, Bråten et al., 2012, Ødegård et al., 2007, Karlsen, 2010).

We have already established the fact that the construction industry is a risky business. The construction engineers, however, are not the ones getting killed or injured. Such consequences are mainly left to the construction workers. Accidents occurring are often blamed on the victims themselves and causes of human error (Perrow, 1999, Swuste et al., 2012). We will nevertheless argue with Swuste et al. (2012, p. 1335) "that (safe) behavior cannot be isolated from its (i.e. the organization's) structure, processes, or culture". These factors are highly influenced by engineers, as they often hold managing positions in the industry. Additionally, studies have found that in the construction industry the design phase is highly important to safety. However, the potential for promoting safety in this phase is hampered by architects and engineers having limited knowledge on safety issues (ibid.). In their study of the construction industry in Norway, Bråten et al. (2012) concluded that the attitude towards HSE amongst project and construction managers are vital to HSE performance. Similar results are found in the construction industry in the United States (Abudayyeh et al., 2006) and Singapore (Teo et al., 2005). Thus, the knowledge of HSE among construction engineers seems a relevant focus to make this risky business safer.

Engineering is often regarded as one of the classic professions (Brante, 2013). Most scholars seem to agree that profession is a term that applies to certain occupations held by people with specialized training based on higher education, and that they have a particular obligation to work for the common good (Abbot, 1988, Macdonald, 1995, Brante, 2011, Saks, 2012). This would suggest that the education of engineers should include ethical components as well as technical training. Such ethical components could include HSE issues. When education of engineers was established in Norway, however, it was heavily influenced by German traditions with its strict technology and natural science approach (Nygaard, 2014a). This tradition might prevent ethical and other non-technical components from finding its way into the education programmes.

The Norwegian Working Environment Act commits all enterprises to ensure safe physical, organisational and psychosocial working conditions, and "a basis for a health-promoting and meaningful work situation" (Løken and Stokke, 2009, p. 15). This includes monitoring all aspects that influence the working environment (aml., 2005, § 4-1 (1)). Thus, a strict technology approach to HSE work will not suffice to fulfil the requirements of the law.

During the last two decades, there has been a growing interest in the influence of organisational culture on safety performance. Scholars agree that efforts to reduce accidents need to have a wider perspective than a purely technological one; both organisational and human factors need to be addressed as well (see f.ex. Antonsen, 2009, Perrow, 1999, Reason, 1997). A substantial part of the work on HSE and safety culture in Norway has been conducted in the field of the petroleum industry (see f.ex. Haukelid,

2008, Høivik et al., 2009a, Høivik et al., 2009b), however, the work done on this subject in the construction industry in Norway seems somewhat deficient (Bråten et al., 2012).

Swuste et al. (2012) have reviewed available literature on construction safety. They suggest two different approaches to improve safety in construction. The first is to establish a strict safety science route including "targeted interventions directed at clients, designers, top managers at construction companies" (ibid., p. 1341). Koch (2013) found that – when focusing on construction – projects rather than enterprises frame the constitution of safety cultures. Høivik et al. (2009b) found similar results in the petroleum industry. Wu et al. (2016) also identified a strong interaction between safety leadership and safety culture. Thus, it would seem that managers in general and project managers in particular are important to HSE performance. These findings could indicate possible ways to implement a strict safety science route in the construction industry and the education of construction engineers.

The second approach suggested by Swuste et al. (2012) is "frappez toujours", or to be persistent. An example of an initiative following this second approach is the Charter for a construction industry free of injury (our translation)3. The charter was established in 2014 and includes trade unions, employers' associations and some of the largest enterprises in the industry; thereby aligning well with the Norwegian model of labour relations. Among the participants, are also the Norwegian University of Science and Technology (NTNU), committed to the following goal: "NTNU will contribute to a construction industry free of injury. Health, environment and safety are included as a common thread in our teaching. NTNU will educate students with good attitudes towards HSE" (Charter, p. 6, our translation). The establishment of the charter suggests that the industry is aware of its HSE challenges, that educational institutions are recognized as part of the solution, and that good HSE work is recognized as not solely a matter of technical knowledge, but also a matter of attitude. A persistent HSE focus in education could therefore contribute to safety and improved HSE performance in the industry.

4. Findings

In the following, we present how different aspects of HSE are included and emphasized in the learning outcomes of the studied bachelor education programmes. We start with the general learning outcomes of the bachelor education on construction engineers before we turn to the required, specialized and elective subjects of the different educational programmes.

4.1 Overall learning outcomes of the bachelor degrees

When studying the overall learning outcomes, we found that most have some general description of learning outcomes that could indicate some focus on HSE. HiB, HiST and HiOA have simply copied the national guidelines from the Norwegian Association of Higher Education Institutions (UHR) when it comes to learning outcomes in construction engineering. Attachment 2 to these guidelines states that knowledge of HSE is required in the engineering professions (UHR, 2011, p. 49). Still, we find no explicit mentioning of HSE in neither in the stated learning outcomes of these institutions nor in the national guidelines themselves. They do, however, make a general reference to the candidate's ability

[3] For more information on the charter, go to
http://www.statsbygg.no/files/samfunnsanvar/sha/SHATiltaksplanOkt2015,pdf

to put his/her work into an ethical perspective, and having knowledge of the societal role of the engineering profession and consequences of the development and use of technology.

Both HiØ and UiA have made adjustments in their overall learning outcomes compared to the national guidelines. HiØ states that the bachelor candidates should be able to "ensure health, environment and safety in all life phases of the product" (our translation), giving the learning outcomes an explicit focus on HSE. UiA emphasizes its bachelors' "ability to apply current regulations for construction measures" (our translation). As the public regulations concerning the industry clearly emphasize HSE, we assume that this is an indication of HSE being included in the education at UiA. To find out whether these overall learning outcomes are reflected in the different subjects that constitute the bachelor degree, we nevertheless need to look into the specific subjects taught.

4.2 Learning outcomes of required subjects

Although, as suspected, the learning outcomes of the individual subjects are generally more specific than what we found in the overall learning outcomes, it is not always clear what the students are intended to learn about HSE when examining these documents.

At HiB, the bachelor students of construction engineering are all required to learn about project work. Perhaps HSE are included when learning about projects, but it is hard to say based on the learning outcomes that do not mention HSE. When learning about material science, the students are required to gain knowledge of health and environmental risks. The students must also learn some ground rules of working life that perhaps could include HSE. Nevertheless, it seems clear that aspects of HSE are not regarded as important topics in most required subjects taught at HiB.

The situation seems quite similar at HiST. Some of the required subjects have an environmental focus, however they do not seem to include the working environment. In the subject of Road building and geomatics, the students are required to learn relevant laws and regulations that could include HSE. When it comes to the students' work in model labs, the students are required to learn about HSE. We assume that the emphasis here is on physical health and safety. Even though the students at HiST are required to learn how to conduct their work in model labs in a safe way, we still cannot conclude that HSE are strongly emphasized in the required subjects in general.

Moving on to HiOA, this institution seems to have a more explicit focus on HSE in the required subjects compared to HiB and HiST. Even though, the inclusion of HSE is unclear in some subjects, the opposite is the case when it comes to the subject called The building process. The learning outcomes of this subject suggest a strong emphasis and persistent focus on HSE. Turning to HiØ, the findings are similar. The subject of Construction project management has an explicit focus on HSE, even though not quite as strong and consistent as HiOA. On the other hand, HiØ also teaches the students basic HSE in the subject of Physics/chemistry.

When studying the learning outcomes at UiA, the traces of HSE almost disappear. When analysing the learning outcomes it seems clear that UiA does not regard HSE as an important part of their educational strategy. Even though project work is included in the introduction course, there is no mention of HSE.

Based on the learning outcomes of the required subjects of the five educational institutions studied, the emphasis on HSE varies. Most of the institutions claim to teach the students project management. However, only two of them (HiOA and HiØ) connects project management explicitly to HSE. Additionally, only HiST and HiØ explicitly state that students learn how to work safely with chemical substances in labs. However, this picture can change as we look into the subjects taught at different directions of specialization in the bachelor programmes.

4.3 Learning outcomes of specialization subjects

While HiØ only distinguishes between required and elective subjects, all the other institutions make their students specialize in a specific field. According to the field the students choose, they are required to attend certain subjects.

Specialization in structural engineering is offered at all the studied institutions (except HiØ). However, none of the subjects included in these specializations mention HSE in their learning outcomes. HiST, HiOA and UiA all offer specialization in Technical planning. The learning outcomes of subjects offered in this specialization all include some understanding of rules and regulations relevant for the industry. This could imply some sort of HSE elements, and some even specifically mention safety, environment and risk. The same applies to the subjects offered at HiB as part of the specialization called Project and construction management.

The only specialization subject we found that explicitly mentions HSE is the subject of Construction engineering offered at HiST. It is interesting to note that in this subject one of the learning outcomes is "understanding and commitment to HSE". For the first time in our data, we see signs of an educational institution stating a very specific goal to influence the attitudes of the students towards HSE.

When looking at the learning outcomes of the specialization subjects, the overall picture, thus, remains the same: Most of the subjects taught have unclear stated goals regarding HSE.

4.4 Learning outcomes of elective subjects

The students' opportunities to choose elective subjects differ among the studied institutions. While students at HiST and HiOA only choose one elected subject (10 credit points), both HiB and HiØ let students choose 3 subjects, and at UiA students choose 4. HiB offers 14 elective subjects, but some of them are required subjects in specializations that are also offered as elective subjects. The other institutions offer between 6 and 8 elective subjects to their students.

The learning outcomes of elective subjects generally do not explicitly mention HSE. However, they do mention some aspects in which HSE could be relevant, such as knowledge of relevant regulations, coordination in construction projects and project management. Some elective subjects still mention HSE more explicitly, such as the elective subject of Controlled practice at HiB where knowledge on health, environment and safety is one of the stated learning outcomes. HiST offers a similar subject where the working environment is mentioned in the course description.

HiST also offers two elective subjects especially relevant for students who want to work in the petroleum industry. Here the focus on HSE is noteworthy in the learning outcomes, and safety concerns

are strongly emphasized. It is striking how the HSE focus seem to increase the closer the students get to the petroleum industry and away from the traditional construction industry.

5. Discussion

This paper 1) examines how the elements of HSE are included in the learning outcomes of bachelor education of construction engineers in Norway, and 2) assess the emphasis on HSE in these learning outcomes. We will now discuss the implications of our findings to these questions and suggest some possible improvements that should be subject to further research.

5.1 How aspects of HSE are included in learning outcomes

Swuste et al. (2012) suggest two options to improve HSE performance in the construction industry: 1) the strict safety science route, and 2) the "frappez toujours" (or persistence) route. Although Swuste et al. suggest these routes as possibilities for the actors in the construction industry, we argue that they are also relevant for the (bachelor) education of construction engineers. This distinction, thus, seems relevant when turning to our first research question.

The strict safety science route would seem to suggest that HSE should be taught either as a specific subject in the education of engineers, or at least HSE should be specifically highlighted in the teachings. As we show in this paper, none of the studied bachelor programmes uses the approach of HSE as a subject in its own right. When learning outcomes mention HSE, it is done as part of a wider subject, thus, knowledge on HSE is mainly just one out of a number of different learning outcomes and not the main focal point. Nevertheless, both HiOA and HiØ offer required subjects with a strong emphasis of HSE that could be part of a strict safety science route in the education of construction engineers. The same goes for the specialized subject of Construction engineering and some of the elective subjects at HiST.

Turning to the "frappez toujours" route, this route would suggest that HSE should be integrated in almost every subject taught, as the persistent common thread described by NTNU in the Charter for a construction industry free of injury. However, this description does not seem to fit our findings. For HSE to be an integrated, common thread through the bachelor education, we would expect the mentioning of HSE in the learning outcomes of a far greater number of subjects that constitute a bachelor degree. We only found explicit HSE focus in a few. We must therefore conclude that none of the bachelor education programmes of construction engineers we have studied follow the "frappez toujours" route suggested routes by Swuste et al. (2012).

Which elements of HSE are highlighted in the bachelor education programmes, are also important. It will not be sufficient to teach future engineers the pure technical side of HSE (although important in itself). All factors in the working environment interact with each other and are important for HSE. This resonates well with the findings of Swuste et al. (2012), notably when considering that all phases in the construction process are important to HSE, and that the behaviour of employees largely depends upon a variety of factors such as management, organisational structure, culture, conflicting goals, and design decisions. Thus, construction engineers need a holistic understanding of HSE. Our findings, however, suggest that, overall, the technical aspects of HSE are emphasized significantly stronger than other

aspects of HSE. Thus the legacy of the German engineering profession, as noted by Nygaard (2014a), still seem to manifest itself in the way aspects of HSE are included in the learning outcomes.

5.2 The emphasis of HSE in learning outcomes

We find that the emphasis of HSE in the learning outcomes of the bachelor programmes vary among the institutions. Only HiØ mentions HSE in the overall learning outcomes. Both HiØ and HiOA have 20 credit points of required subjects where HSE are strongly emphasised in learning outcomes, however, this is still a small part of the 180 credit points included in a bachelor degree.

When the students specialize, they will find the strongest HSE emphasis at HiST. At HiST, the specialization in construction engineering requires 20 credit points in Construction engineering and engineering geology where the learning outcomes include developing an understanding of and commitment to HSE. HiB, HiOA and UiA all mention safety and risks in some of their specialized subjects, but it is not clear if they refer to HSE risks or whether it is the safety of employees, consumers or the public which is addressed. When looking at elective subjects, only HiB and HiST offer subjects with explicit learning outcomes on HSE. HiB offers one such elective subject, while HiST offers three. However, two of these electives offered at HiST are directly related to the petroleum industry rather than to the construction industry.

Even though we find traces of HSE in the learning outcomes of all the bachelor programmes studied, the emphasis, when looking at the number of credit points and the content of required subjects, suggest that aspects of HSE are not main topics in the educational programmes. However, some educational institutions seem to emphasize HSE more strongly than others.

5.3 Suggested improvements

One way of including HSE in the bachelor education programmes of construction engineers would be to explicitly include HSE in the teachings of project management. For many engineers, the position as project manager is the first kind of management position achieved after graduating. The project manager faces many challenges – technical, organisational and cultural – thus, providing an opportunity to include a more holistic understanding of HSE. Technical challenges to the project manager include factors like type and method of construction and safety procedures (Teo et al., 2005). Main organizational challenges in the construction industry include the organic structure that characterize the companies (Swuste et al., 2012) and the complexity of most construction sites, including diverse activities and the presence of (many) subcontractors (Teo et al., 2005). A cultural challenge facing the project manager is safety culture, represented by safety behaviour and attitudes. The safety commitment of managers is important to enhance safety culture (Teo et al., 2005, Bråten et al., 2012, Høivik et al., 2009b). A more holistic approach to HSE, including technical, organisational and cultural elements interacting, corresponds well with the combined focus on the physical, organisational and psychosocial working environment, as prescribed by the Working Environment Act. Such an approach to the teachings of project management, would also seem to correspond well with the strict science route suggested by Swuste et al. (2012), though it should be subject to further research.

Another approach would be to further develop the “frappez toujours” route. One way of pursuing this route in the bachelor education would be to include HSE in the overall learning outcomes of the

bachelor programmes, and at the same time include elements of HSE as a common thread throughout many, if not all, of the different subjects taught. This would signal a strong commitment from the educational institutions to the goal of improved HSE performance in the construction industry. One starting point could be to look at how the common thread of HSE is implemented at NTNU because of their commitment in the Charter for a construction industry free of injury. Perhaps this can provide learning possibilities for other educational institutions on how to implement a persistent HSE focus.

We would argue that the suggested routes of strict science and "frappez toujours" are not necessarily mutually excluding, but can be combined in different ways. To find the best route for formal education to contribute to a safer construction industry, we nevertheless need to include the perspectives of clients, contractors, earlier students, the social partners, and the public authorities in the industry. As even more master graduates gain management positions than bachelor graduates, we will also need to look more closely at the master level of education.

6. Conclusions

In this paper we have examined how aspects of HSE are included in the learning outcomes of bachelor education of construction engineers in Norway. We have found that only one of the educational programmes studied explicitly includes HSE in its overall learning outcomes. Aspect of HSE are, nevertheless, included in the learning outcomes of the bachelor programmes, mainly as one of many elements of technical subjects. Thus, safety and the physical working environment are represented in the learning outcomes, while other factors are almost absent. According to what is presented in their learning outcomes, only HiOA and HiØ seem to leave newly educated construction engineers with more than only bits and pieces of what we would argue needs to be a more holistic understanding of HSE work.

We have also assessed the emphasis on HSE in the learning outcomes, and our findings vary. While HiOA and HiØ have some required subjects with a strong and explicit focus on HSE, the other institutions appear to leave their focus on HSE to specialized and elective subjects, if indeed aspects of HSE are at all mentioned in their learning outcomes. However, it seems clear that HSE can neither be regarded as a "common thread" in the education programmes (i.e. the "frappez toujours" route), nor as an explicit scientific focus (i.e. the strict safety science route). Thus, we conclude that, when looking at the learning outcomes, most of the studied educational programmes do not seem to follow any of the suggested routes by Swuste et al. (2012). Again, the possible exceptions are HiOA and HiØ who through their strong HSE focus when it comes to project management, may attempt to follow a strict science route.

Formal higher education could play a vital role when it comes to making the construction industry safer. Based on our findings, we have suggested some possible improvements to the educational bachelor programmes of construction engineers. We argue that the role of the engineers as project managers represent an opportunity to strengthen the knowledge and understanding of HSE among bachelor graduates. It is also possible to pursue the "frappez toujours" route by improving the integration of HSE in the general teachings of different subjects. The education programmes of construction engineers should adopt a holistic approach to their teachings of HSE which include technical, organisational and cultural elements and their influence on each other and on HSE behaviour

in the construction industry. Only such a holistic approach will prepare students for HSE responsibility in accordance with the intentions of the Working Environment Act.

This paper provides a starting-point for further research on how the engineering educations can contribute to improve HSE performance in the construction industry by mapping how aspects of HSE are included in current learning outcomes. Further work should investigate if the formulated learning outcomes reflects what is actually taught in bachelor study programmes. It should also investigate study programmes at master's level. An important part of further work should be to examine how to enable construction engineers to meet future practical HSE challenges.

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Drivers of industrialization in Norwegian building and construction projects

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Abstract

The aims of cost-efficiency and quality are important drivers in the evolution of the construction sector. Meanwhile, changing regulations and expectations from stakeholders with regards to environmental impacts and sustainability force the industry to approach projects differently both in planning and execution. This paper discusses the terms of industrialization and sustainability in the context of the construction industry and presents the findings from a questionnaire survey addressing how these are related.

Industrialization of construction projects is one development trend that encompasses the adaption and adoption of techniques and mindset from manufacturing and other industries. Use of parallelization of tasks by off-site production, prefabrication of components, units or modules, additive manufacturing techniques (such as "3D printed" concrete), emphasis on supply chain management, and approaches such as lean construction can all be regarded as examples of industrialization of construction projects.

Based on a survey of actors in construction projects (participants in the project SpeedUp and the network Bygdin) we present how arguments for increased industrialisation can be put forward based on cost-efficiency, quality and sustainability concerns. Although consideration for the three elements may appear to align nicely, our survey indicates that cost-efficiency is the main concern for actors in the building and construction industry. We then raise the question of whether this effectively limits quality to "good enough" and the sustainability aspects of construction projects to become "less bad" rather than actively "doing good".

Regulations can be effective in addressing concrete issues such as ensuring that buildings are adapted to harsher climate with more intense rainfall. In order to becoming the primary driver of industrialization however, sustainability must be interpreted holistically as consisting of the environmental, economic and social dimensions, therein recognising companies need for profit to sustain themselves.

Keywords: Industrialisation, sustainability, project roles

1. Introduction

The aims of profit, cost-efficiency and quality are important drivers in the evolution of any sector, including building and construction (Leikvam and Olsson 2014). Meanwhile, changing regulations and expectations from stakeholders with regards to environmental impacts and sustainability force whole industries to innovate and approach projects differently with regards to planning and execution (Pries and Janszen 1995, Testa, Iraldo et al. 2011).

The purpose of this paper is to study the relationship between sustainability and profitability on the one hand, and industrialization on the other. The following research questions are addressed:

• What are the drivers of industrialization in the Norwegian construction sector?

• How does sustainability affect construction projects?

• What changes to are expected for the execution of construction projects in the near term?

We start by looking at the links between productivity and sustainability on the one side and industrialization of construction/building on the other as presented in existing literature. We then look at the findings of a questionnaire survey designed to identify the drivers of industrialization of building and construction. But first, we provide a set of definitions of central terms and concepts.

Industrialization of building/construction: Sarja (2003) defines industrialization of building as *"(...)the application of modern systematised methods of design, production planning and control as well as mechanised and automated manufacturing processes". The CIB task group on industrialization of construction proposed a definition along similar lines describing it as "a rationalisation of the work processes in the industry to reach cost efficiency, higher productivity and quality"*(CIB 2010). The most prominent effect of industrialization is a movement of the value-adding activities upstream in the supply chain (Barlow, Childerhouse et al. 2003, Pan, Gibb et al. 2007, CIB 2010, Thuesen and Hvam 2011).

Productivity is the ratio between input(s) and output(s). At the micro-level, this typically translates to the number of person hours per unit of physical progress achieved (Dozzi and AbouRizk 1993). Measuring productivity in the overall construction industry is not straightforward (Allmon, Haas et al. 2000, Bernstein 2003, WEF 2016), but this is not covered here.

Innovation describes "*the actual use of a nontrivial change and improvement in a process, product, or system that is novel to the institution developing the change"* as defined by Slaughter (1998). The innovation can be characterized as incremental, radical, modular, architectural or system (Slaughter 1998). In this article we will focus on innovation that leads to increased industrialization.

2. Drivers and barriers to industrialization of building and construction

In the subsequent sections we also use the terms driver(s), enabler(s) and barrier(s) with respect to industrialization. The CIB task group on industrialized building (2010) defined the drivers as what motivate the industrialization; why we industrialize. It provided six examples of drivers to industrialize: need for safety, need for better quality control, need for better occupational health, need for better environmental care, need for cheaper production and lack of skilled labour (CIB 2010). We use enablers of industrialization to denote what the taskforce called "conditions"; these are the prerequisites or facilitators that allow for industrialization to take place. Examples of enablers (conditions) are mechanised tools, automated tools and intelligent tools (CIB 2010). Barriers to industrialization on the other hand are what stops or limits the industrialization. Identification of barriers to industrialization is not addressed in the questionnaire survey.

The drivers, enablers and barriers for development of the building and construction sector are evolving as needs, regulations and technologies change. A simple illustration of drivers, enablers and barriers is provided in figure 2.

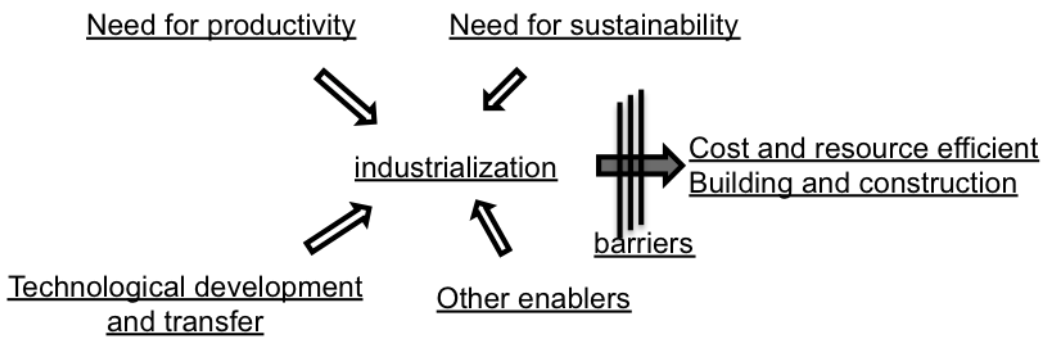

Figure 2: Drivers, enablers and barriers to realizing the potential from industrialization in the building and construction sector. We hypothesize that the need for increased productivity and sustainability are drivers of industrialization.

2.1 Productivity as driver of industrialization

The development in productivity for construction has been lagging behind other sectors at least since the 1970's (Arditi and Mochtar 2000, WEF 2016). Abdel-Wahab and Vogl (2011) show how the productivity development of construction industry has been falling short across regions (the US, Europe and Japan), and that the rate of change for the shortfall has increased over time. Other sectors' ability to profit from industrialization whereas construction and building have not is the primary reason for the shortfall (CIB 2010). Still, the construction industry remains an important sector globally with regards to the economic and social dimension, contributing 10 % of EU GDP along with 20 million direct jobs in the European Union (EU 2015). Xue, Shen et al. (2008) put the equivalent numbers for China at about 24 million direct jobs and a contribution of 7 % of GDP. The World Economic Forum (2016) put the sector's share of global GDP at 6 %. The large size of the sector ensures that gain from potential productivity increases is immense.

Industrialization of the construction and building process is presented as a potential solution to catching up to other industries and improving the productivity of building and construction (CIB 2010). Traditionally, industrialization revolves around attaining higher degrees of standardization of materials and processes. It allows for specialisation of steps or components in the production, allowing it to be split among several actors. Companies may invest in specialized equipment to handle capital intensive and highly specialized aspects of the production, allowing others to focus capital and knowledge in other areas (Richard 2005). In construction and building industrialization has traditionally resulted in approaches based on a higher degree of pre-fabrication and offsite production, moving the value-adding activities upstream in the supply chain (Barlow, Childerhouse et al. 2003, Pan, Gibb et al. 2007, Thuesen and Hvam 2011). However, on-going technological development of additive manufacturing (e.g. 3D-printed concrete) are introducing changes to this traditional vision of industrialisation of the construction process by simultaneously allowing for transferring value adding activities back to the construction site and moving the production of complex, non-standardized and labour-intensive components off-site to where specialized equipment is available.

2.2 Sustainability as driver of industrialization

Sustainability and environmental concerns are one of the mega trends that shape current transformations and developments in many industries. The UN Sustainable development goals consist of 17 goals (and some 169 targets) of which the member states are obliged to work towards (UN 2015). The Paris accord provides binding obligations in order to retain global average temperature increase at below 2 degrees (UN 2016). National authorities wield large influence over building and construction as clients and regulators and can use that power in order to meet national obligations. On-going urbanisation and population increases will additionally emphasize the key role of actors in the building and construction sector in handling these global challenges. The construction sector has long been identified as a culprit with regards to sustainability, and especially environmental impacts. It uses three billion tons of raw material, making it the number one global consumer of such (WEF 2016) and generates 20 % of the solid waste stream globally (Graham 2000). Still, it is probably through energy consumption that the sector's global impact is most severe. Buildings are responsible for 30 % of climate gas emission and 40 % of energy consumption (UNEP 2009). Operating energy represents by far the largest part of energy demand in a building during its life cycle (Sartori and Hestnes 2007).

"*Sustainability*" is a holistic concept that revolves around balancing local and global, short- and long-term consequences within the environmental, economic and social dimensions of projects. "*Sustainable construction*" is aimed at balancing these issues and encompasses design and planning phases of projects, as well as the phases following the construction (Hill & Bowen, 1996). Several authors identify industrialized construction and the use of prefabrication and modularization as suitable approaches to sustainable construction (Jaillon and Poon 2008, Jaillon and Chi-Sun 2010, Eriksson, Olander et al. 2014). Industrialized construction can contribute to sustainability in the form of reductions in waste generation and materials used, and potentially in higher quality products as the production takes place in a controlled factory environment (no variation in humidity and temperature) and allows for greater quality control. Build quality is of increasing importance if energy consumption in new buildings are to decrease. Continuous improvement and learning based on feed-back from buildings actual performance are more readily achieved and the documentation of materials used and work done is facilitated in a factory setting.

2.3 Barriers to industrialization of building and construction

There are several obstacles making practices from other sector hard to transfer to building and construction. The World Economic Forum (2016) split these arguments in two segments; those belonging to the construction industry's internal characteristics and those that dealt with the complex client context of construction projects. The "internal" segment included multiple stakeholders with diverse interests/needs, the uniqueness of each project, high industry fragmentation, low profitability and capitalisation, highly cyclical and volatile business cycle and the unstable workforce. The complex client context included immature project definition and technical assessment, over-preference for lowest bid, insufficient or incremental funding, conservative clients, increased risk transfer to contractors and complexity of contracts and dispute resolution. Jonsson and Rudberg (2014) identify quality, delivery and cost as drivers for off-site production while flexibility, performance and innovativeness represent the barriers.

3. Methodology

A questionnaire survey was conducted to collect professional view on the current trends and assumed drivers of the ongoing industrialization of the construction sector. The questionnaires were piloted in three consulting companies with follow-up interviews before invitations to participate were distributed by e-mail. Potential participants were selected among the member organizations in a network for industrialized construction and among selected member organizations in the research project SpeedUp. A total of 73 valid responses form the basis for the study. 23 of these responses came from the network for industrialized construction and 49 came from participants in the SpeedUp project. The response rate range was between 25 % and 30 %.

The questionnaire consisted of four sections. The first section was dedicated to background variables (regarding the respondent and the respondents organization). The second section was concerned with identifying the most influential current drivers of industrialization. The section consisted of a list of potential drivers from existing literature and suggestions from the respondents in the pilot study, along with a field where the respondents could add other drivers or comment on the selection. Fowler (1995) states that the list approach usually provides more reliable and valid answers than open-ended questions when the alternatives can be specified. The third section focused on expected changes in the close to medium term (10 years ahead). The section consisted of another list of changes derived from the selection of potential drivers, along with an open field where the respondents could add other expected changes. The fourth section dealt with sustainability and presented a set of statements about the influence of sustainability considerations on building and construction projects. The section also asked openended questions about the influence of various stakeholders on sustainability as well as on the construction process.

4. Results

A total of 72 valid responses form the basis for the study. 23 of these responses came from the network for industrialized construction and 49 came from participants in SpeedUp. Three organizations in SpeedUp were invited to participate, two of which are consulting firms and one of which develop, own and operate public properties and buildings. The resulting composition of respondents is split in three groups in the analysis: members of the network for industrialized construction (23 complete responses),

SpeedUp consulting partners (28 complete responses) and SpeedUp developer/operator (21 complete responses). The make-up of the respondents belonging to the network for industrialized construction is more diverse than the other groups, covering architects, contractors and developers. However, their stated interest in industrialized building and construction provide the rationale for casting them in one group. In the following section we look into what the respondents stated as the current drivers of industrialization, the role of sustainability in building and construction projects and in what ways the respondents expected the sector will develop over the next ten years.

4.1 Current drivers of industrialization of the construction process

Time and cost are influential drivers of the on-going industrialization of the construction process according to the respondents. The most frequently cited factor however, was the increasing use and development of building information modelling (BIM). Close to 70 % of the total number of respondents pointed to BIM as one of the top five drivers of industrialization, ranging from 47 % among the respondents representing the project owner perspective to 90 % among the consultants. Economic factors (lowering cost without changes to quality) were most frequently cited among the respondents representing the owner perspective (of which 62 % cited it), while only 27 % of the respondents from the consultancies cited economic factors. Of the responses from participants in the network for industrialization of construction an equal number cited economic factors and the rise of building information modelling.

Shorter delivery times for projects (construction and planning) were the third most frequently cited factor followed by standardization. Technological development of support/planning tools, machines and production methods, materials and logistics were cited by between one and two thirds of the respondents.

8 of the available alternative drivers were cited by a total of 8 or less people. Among these were drivers dealing with sustainability and environment, health and safety and building or construction regulations, suggesting these are not generally recognized as drivers of industrialization.

Table 1: Drivers of industrialization of the construction process

Drivers of industrialization of the construction process	**Total** (n=72)	**Bygdin** (n=23)	**Cons.** (n=28)	**Owner** (n=21)
Development and use of BIM (Building information modelling)	69%	83%	71%	47%
Economic factors (lowering costs at equal quality)	54%	78%	29%	63%
Shortened delivery time (construction and planning)	53%	47%	43%	42%
Standardization	47%	47%	43%	53%
Technological development of support/planning tools	44%	61%	43%	26%
Reduced number of faults/re-work	41%	65%	25%	37%
Technological development of machines/production methods (e.g. additive manufacturing)	40%	57%	21%	47%
Competition among contractors/suppliers	37%	65%	11%	42%
Development and improved logistics	33%	39%	21%	42%
Development of new materials	26%	17%	21%	32%
Least frequently cited drivers:				
Changing requirements regarding energy usage (11%), Environmental requirements or concerns (11%), Health and safety regulations/concerns for workers (10%), Ideas/suggestions from workers (10%), Sustainability concerns (9%), Other form(s) of technological development (9%), Concern for neighbours/local stakeholders (3%) and Changing quality requirements (3%)				

4.2 The role of sustainability

Sustainability considerations affect both output and outcomes of projects. In the questionnaire survey, the respondents in all groups most frequently cited requirements to documentation of materials used and documentation of work done as one of the most important effect of sustainability on the execution of building and construction projects. The consultants cited cost increases more often than the other groups. Although the majority of respondents noted that costs increased as a consequence of incorporating sustainability considerations, about an equal number of respondents also expressed that sustainability considerations made the projects better. Among the respondents for the network for industrialized construction, “projects are/become better” was cited most frequently (74 %), compared to 27 % of the consultants and 47 % of the respondents representing the owner perspective. Two effects that have received recurring coverage in the media, financial incentives for incorporating sustainability and the rendering of technical well-functioning solution being rendered unavailable due to sustainability requirements were barely cited by the respondents (cited by 11% and 4 % respectively).

Table 2: The effects of economic, environmental and social sustainability on the execution of construction and building projects (n = 70)

Based on your experience; how does economic, environmental and social sustainability affect building and construction projects	**Total** (n=72)	**Bygdin** (n=23)	**Cons.** (n=28)	**Owner** (n=21)
Requirements to documentation of materials used increases	69%	61 %	68 %	**79 %**
Requirements to documentations for work done increases	69%	57 %	**79 %**	68 %
Costs are increased	59%	52 %	**68 %**	53 %
Projects are better	49%	**74 %**	25 %	53 %
Environmental labelling are more important	46%	57 %	50 %	26 %
Project planning time are increased	39%	43 %	39 %	32 %
Proper craftsmanship are more important	36%	39 %	29 %	42 %
Least frequently cited changes				
Financial incentives becomes available (11%), Projects are delayed (11%), Well-functioning technical solutions are rendered unavailable (4%), Sustainability does not affect building or construction projects (1 %)				

The respondents were subsequently asked about which actors in their opinion were responsible for incorporating sustainability and sustainable solutions in construction and building projects. No alternatives were provided, in order not to steer the respondents in any particular direction. The resulting ranking had the authorities as most frequently cited actor, followed by "the project owner" and "all actors". Similarly, the respondents were asked about which actor is the most influential with regards to the construction projects. The responses identified the main contractor as the most influential followed by the project owner and the authorities.

4.3 Expectations for the close future

The respondents were subsequently asked to identify the most important or significant changes to how building and construction are executed ten years from now compared to today. The most frequently cited expected change is in the volume of off-site activities. The responses from the questionnaire survey regarding the execution of projects are uplifting from a project management perspective; the respondents expect facilitated communication through digitization, better planned and faster executed projects.

Table 3: Expected changes in execution of building and construction projects

What do you expect to be the most significant changes to how building and construction projects are executed 10 years from now compared to today?	**Total** (n=72)	**Bygdin** (n=23)	**Cons.** (n=28)	**Owner** (n=21)
More/larger volumes of activities are executed off-site	63%	**87%**	50%	53%
Digitization have facilitated communication	57%	**74%**	46%	53%
Projects are completed faster	46%	**70%**	29%	42%
Projects are planned in greater detail	46%	52%	39%	47%
Increased use of standardization	44%	35%	25%	42%
Increased time spent on documentation	36%	35%	39%	32%
Increase in the amount of tasks/activities carried out by specialists/niche companies	36%	43%	29%	37%
The projects are more standardized	33%	35%	25%	42%
Projects are executed by fewer/larger actors in the industry	30%	43%	18%	32%
There are fewer people involved	23%	39%	18%	11%
Projects become more expensive	23%	48%	-	5%
Least frequently cited changes				
Projects are more unique/one of a kind (17 %), Project costs are lower (17%), Digitization have impaired communication (16%), Project sizes increase (10%), Projects take longer to be executed (4%), Project sizes go down (1%)				

When comparing the subgroups, it stands out that the expectations of the group of consultants and owners are more closely aligned than that of the members of the network for industrialized construction. The members of the network are more aligned internally with very high percentage of respondents expecting increases in the volume of off-site activities (87%), facilitation of communication through digitization (74 %) and faster project completion (70 %). Within the other two groups, the most frequently cited factors were identified by just over 50 % of the respondents. The ranking, however, was largely the same across groups.

5. Discussion

One issue we addressed was drivers for industrialization of the Norwegian construction sector. BIM was highlighted as the most important driver. Several other issues were also identified as important by a majority of the respondents, including economic factors, shortened delivery time and standardization. The survey results do not support the notion of sustainability being widely recognized as a driver for innovation in the building and construction sector. The most frequently cited driver on the other hand, BIM, might not be a driver but rather an enabler of industrialization. The benefits of BIM have been thoroughly discussed before (Grilo and Jardim-Goncalves 2010, Azhar 2011, Eastman, Eastman et al. 2011, Barlish and Sullivan 2012, Bryde, Broquetas et al. 2013, Eadie, Browne et al. 2013). Among the

potential effects of BIM one finds quality improvements and reductions in re-work, along with better planning and potentially increased innovation. The fundamental driver behind the increased use of BIM depends on the stakeholder; some will point to quality or time, although most will identify financial motivation.

We also studied how sustainability affects construction projects. Sustainability appears to be closely associated with requirements for documentation of materials and work. In a wide interpretation, sustainability is related to environmental, economic and social dimensions of projects. One possible interpretation of the focus on increased documentation requirements is that the word sustainability is mainly associated with increased environmental, and possible social, requirements. Regarding economic issues, more than half of the respondent related sustainability to increased cost, even though almost as many also claimed that projects get better from sustainability focus.

The last issue was about what changes are expected changes for construction projects in a 10year perspective. The most highlighted aspect was an expectation that larger parts of project activities are executed off-site, and that digitization will facilitate communication. Combining the respondent's identification of important drivers and their 10-year expectations yields a vision of increasingly resource efficient design and construction. The expected development is i.e. towards doing more with less and thus potentially contributing to decreasing the negative environmental implications of the building and construction sector. This raises the question; rather than the other way around, is industrialization of building and construction a driver of sustainability in the sector? Although doing more with less can translate into eco-efficiency, it will fundamentally remain a "less bad"-approach (i.e. reducing bad effects) rather than actively contributing to "doing good".

6. Conclusions

We have studied industrialization of construction projects as driver of sustainability. Although sustainability and industrialization of the building and construction sector are linked, none is recognized as a driver of the other among the actors surveyed. The development and use of BIM was the most frequently cited driver of on-going industrialization. Somewhat sadly, in a sustainability perspective, sustainability is mainly associated with documentation requirements and increased cost.

The general expectation of future development of building and construction projects is characterized by increased proportions of off-site production, facilitated by digital communication and better planning. This implies that industrialization of the building and construction sector may contribute to increased sustainability in the sector. However, unless either regulators or clients put pressure on the actors in the sector, the development will likely be focused on better resource efficiency (or "causing less harm") rather than actively contributing to reaching the UN sustainable development goals.

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The theme for the 9th Nordic Conference on Construction Economics and Organization is *What happened to quality? Design, processes and outcomes.* The published papers attempt to answer the rather loaded question, reflecting a variety of both research and teaching approaches within the field of construction economics and organization.

The conference is a collaborative venture between the CREON research network, Construction Researchers on Economics and Organization in the Nordic countries, and the division of Construction Management, Department of Architecture and Civil Engineering at Chalmers University of Technology in Göteborg, Sweden. We have also been joined by a number of researchers outside of the Nordic countries whose contributions we like to acknowledge.

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