MSc In Business, Major Strategy

Digitalization within the Construction Industry

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Executive Summary

This is the preliminary report for our final Master Thesis, which creates a foundation for further work and research. We will introduce the topic of digitalization within the construction industry and discuss how the industry is today, including major challenges.

The construction industry has experienced low increase in productivity the last years, and is characterized as old fashioned and fragmented. Low degree of digitization and poor information flow are also areas where improvement is needed. Based on these factors, we find this to be an interesting and relevant area of research. In our research, we will conduct a multiple case study for one of the larger construction company in Norway, where we will compare two ongoing projects. We will examine the information flow, how the different actors interact and understand each other, and the knowledge sharing within the projects. These three areas of interest will be used as a mean to answer our research question.

In our study, we will draw on relevant literature and theory, such as Resource Dependency Theory and Knowledge Based View. We have emphasized the importance of knowledge within the construction industry, knowledge sharing, and digitalization in knowledge-intensive industries.

An inductive study will take place the spring semester of 2018, with a mixed method approach, meaning both qualitative and quantitative data collection. Semi-structured interviews, a focus group and one survey will be conducted in addition to collection of other project-related documents.

The aim of our study is not to generalize our results, but identify useful findings the construction industry, and especially the researched company, can draw benefit from.

1.0 Introduction

The construction industry suffers from low productivity and small margins. McKinsey reports that large projects typically take 20 percent longer to finish than scheduled and are up to 80 percent over budget (Agarwal, Chandrasekaran, & Sridhar, 2016). A need for improvement is evident from these numbers. The report points to several problematic factors; uncoordinated project planning, inadequate performance management and unsophisticated supply-chain practices are some of these. Other researchers have pointed to uncertainty and interdependence (Gidado, 1996), and a low level of integration (Shammas-Toma, Seymour, & Clark, 1998) as sources for inefficiency.

The topic of inefficiency in the construction industry has been widely researched for several decades. Authors and researchers have "attacked" the issue of inefficiency from several angles, however complexity is a common denominator in their results. Winch (1989) stated "construction projects are amongst the most complex of all undertakings", while Dubois and Gadde (2002) wrote "the complexity of the construction operations and the subsequent problem solving capability needed is perceived formidable". Scientists consider a system 'complex' when it is made up of a multitude of interacting elements. The construction process always consists of a multitude of interacting elements and actors, which indicates construction as complex by nature (Gidado, 1996).

The industry is based on project-based work, where each project is looked at as an "independent temporary organization" (Winch, 1989). A common problem for project-based organizations is the lack of knowledge sharing between projects. There is a tendency to 'reinvent the wheel' (Newell, Bresnen, Edelman, Scarbrough, & Swan, 2006) when a new project is started, instead of learning from previous experiences. With every project being complex and unique, it is hard to identify previously used practice as relevant, which leads to a low level of "lesson learned" (Newell et al., 2006). Project complexity is an evident challenge in construction, and with no available tool or technique for assessing the complexity, it tends to get neglected (Gidado, 1996). No two projects are identical, but that is no reason not to learn from experience (Blanco, Janauskas, & Ribeirinho, 2016).

Another important factor for inefficiency is lack of digitalization, and the construction industry is one of the least digitized industries worldwide (Agarwal et al., 2016). The level of digitalization varies across the industry, some use digital tools like BIM and VDC, while others still use paper-drawings (Agarwal et al., 2016). There is no common standard or digital infrastructure developed for the industry. Some of the main reasons for the slow digitalization are lack of awareness around digitalization in construction, lack of competence and the complexity of the industry (Sjøgren, Krogh, Christensen, & Olsen-Skåre, 2017). The number and variety of actors in the industry is also a possible reason for the low level of digitalization. In order to develop a successful common infrastructure for the entire construction process, it must be easy to use by architects, project managers, entrepreneurs, contractors and so on. Meaning, it should be manageable by people on several levels, with different academic backgrounds and knowledge, and with various working methods. The knowledge gap between the different actors could thereby be a barrier for digitalization.

1.1 Research Question and Propositions

With these issues in mind, we have decided to look at the interaction between the different actors in a construction project, and we have developed the following research question:

How can digitalization increase the quality of projects in the construction industry?

Further, there are three main areas we want to investigate:

1. *How can digitalization improve the information flow within projects?*
2. *How can digitalization decrease the knowledge gap between the involved actors in a project?*
3. *How can digitalization improve the knowledge sharing between the involved actors in a project?*

The research question is to guide our study and the three propositions will be used as means to answer this. The aim of our study is to identify useful insight the construction industry can draw benefits from.

2.0 Literature Review

2.1 Project Communication and Information Flow

Project communication and information flow are important in complex projects (Flyvbjerg, Bruzelius, & Rothengatter, 2003) such as in the construction industry. In their book of project communication Johannessen and Rosendahl (2010) draw upon the assumption that the larger and more complex projects are, the more important are the communication and coordination of the social mechanisms within the project. Flyvbjerg et al. (2003) stresses the importance of communication by saying:

> "communication with civil society, and with stakeholder groups, and media, should be given high priority. The task of communication and participation should be taken as seriously, and should be funded as adequately, as the technical, environmental and economic tasks in a project, right from the early planning stage" (p. 111).

They also stress the importance of the participation of stakeholders from early stages in the project and how feedback should actively be used in the decision-making process. Instead of managing information and data during a project, the archiving of data happens at the end of the project which causes limitation in information management (Vakola & Rezgui, 2000). Usually at the end of the project, the people with the overall information and knowledge of the project have transferred to another project. Haas and Park (2010) studied scientists that withheld information from their colleagues and promoted examples from other literature of how information withholding in an organization hinder transfer of best practice, innovation, and hinder learning from mistakes. Project communication and information flow can therefore be of major importance in the construction industry.

2.2 Resource Dependency Theory

As previously discussed, the construction industry is characterized by project-based work with several different actors involved. A construction company is dependent on the external environment – external actors – in order to be able to obtain the desired outcome. Many scholars within the field of organizational and strategic management have discussed the resource dependency theory (RDT) and argued that

all organizations are to a varying extent dependent on the external environment and that it exists interdependence between organizations (Aldrich & Pfeffer, 1976; Pfeffer & Salancik, 1978; Thompson, 1967). Organizations are seen as open systems that need to transact elements of the environment to obtain needed resources (Pfeffer & Salancik, 1978). The external factors influence the behavior of the organization, even though managers can act to reduce environmental uncertainty and dependence (Hillman, Withers, & Collins, 2009). In such environments, organizations are trying to minimize their own dependence by attempting to increase their power over others (Ulrich & Barney, 1984).

Pfeffer and Salancik (1978) distinguish between outcome interdependence and behavior interdependence, that can occur either together or alone. In an outcome interdependence situation, the outcome achieved by one company is interdependent with the outcome achieved by the other company. In a situation of behavior interdependence, the actions of other actors are what determine the activities. A distinction in the relationship between the participants in an outcome interdependence can be made whether the parties are in a competitive or symbiotic relationship (Pfeffer & Salancik, 1978). Relevant is the symbiotic interdependence, where the output of one participant is the input for the other. Through the lens of RDT the interaction between the involved actors are of importance in order to obtain satisfactory and desired outcomes.

2.3 The Concept of Knowledge

Several theories of the organization exist, such as economic theories and organizational theories that concern strategic management, competitive advantage and strategic choices. The knowledge-based view (KBV) addresses the nature of coordination within the organization, and organizational structure, as well as the role of management and the determinants of the organization's boundaries (Grant, 1996). According to the KBV, knowledge can be seen as the most important resource an organization possesses, and the organizations are institutions for knowledge application and exist to coordinate specialists (Grant, 1996). Knowledge has become more relevant and important when discussing an organization's competitive advantage (Peteraf, 1993; Von Krogh & Roos, 1996) and can be defined in several ways. One definition is "knowledge is information possessed in the mind of individuals: it is personalized information (which may or may not be

new, unique, useful, or accurate) related to facts, procedures, concepts, interpretations, ideas, observations and judgments (Alavi & Leidner, 2001, p. 109). According to Van Beveren (2002) "knowledge cannot exist outside of the human brain and that only information and data can exist outside of the brain" (p. 19). This emphasize the importance of knowledge and reinforce the argument of the existence of an organization according to the KBV.

Organizations store knowledge in norms, procedures and rules, and acquire knowledge over time (March, 1991). Knowledge is created through two types of knowledge, where some knowledge is easy to detect such as the organization's operational rules, customer data and manufacturing technologies (Kogut & Zander, 1992), and other knowledge is more complex and harder to recognize. The distinction goes between *explicit* and *tacit* knowledge. Explicit knowledge is the observable knowledge which can be codified and that is easy to transfer by language (Nonaka, 1994). Tacit knowledge has a personal quality, and is rooted in action and is difficult to communicate. The explicit knowledge is *knowing about* while the tacit knowledge is the *know how* (Grant, 1996; Spender, 1996). Tacitness has several definitions, but two ways to describe tacit knowledge are "an inability to articulate what one knows about how to achieve an observed performance outcome, or a personal nature of knowledge which derives from an inability to articulate the principles that affect the level of performance one achieve" (McEvily & Chakravarthy, 2002, p. 289). The tacit knowledge is difficult to transfer as it cannot fully be explained by verbal or written communication, it has to be learned through experience (Empson, 2001). Nonaka and Konno (1998) distinguish between two dimensions of tacit knowledge; the technical dimension that is the know-how, and the cognitive dimension that consists of values, beliefs and mental maps which are integrated in the mind. The tacit knowledge cannot be handled the same way as the explicit knowledge. This is because the tacit knowledge exists in the human beings, and is obtained by internal individual processes such as reflection, experience and the individual talent (Haldin-Herrgard, 2000).

The construction industry is highly fragmented with a high concentration of small professional organizations (Pathirage, Amaratunga, & Haigh, 2007). These organizations has a wide range of professionals involved, such as engineers and architects, and are characterized by a high degree of tacit knowledge (Løwendahl,

2005). Knowledge is not possessed by the organization, but by the individual, and therefore it is important to be able to integrate the tacit knowledge of the individuals in order to create a sustained competitive advantage for the organization (Pathirage et al., 2007). The explicit knowledge is not enough for the core competency in an organization, it is necessary with the tacit "know how" that embraces the ability to put the "know what" into practice (Brown & Duguid, 1998).

Each project in the construction industry is unique and complex, and this complicates the transfer of best practice between projects (Pathirage et al., 2007). Wetherill, Rezgui, Lima, and Zarli (2003) divide knowledge in the construction industry into three categories: domain knowledge, organizational knowledge and project knowledge. Domain knowledge is available to all companies and usually stored in electronic databases. The organizational knowledge is organization specific and consist of the intellectual capital of the organization, that also contains knowledge about project experience of the employees, personal skills and cross-organizational knowledge. Project knowledge include both project records and the, recorded and unrecorded, memory of processes, problems and solutions (Wetherill et al., 2003, p. 184). The movement from domain knowledge to project knowledge indicates a move from explicit to tacit knowledge.

2.4 Knowledge Sharing

The expression of knowledge transfer is commonly used by scholars for the movement of knowledge in an organization (Argote, 2012; Szulanski, 1996). The ability to transfer knowledge within an organization can contribute to the realization of organizational advantage (Ghoshal & Moran, 1996), but transferring best practice and knowledge can be difficult due to knowledge-related factors. This is what Szulanski (1996) refers to as internal stickiness. Internal knowledge transfer is dependent on the recipient's lack of absorptive capacity, casual ambiguity, and an arduous relationship between the sender and recipient. What we discuss is not knowledge transfer, but it is necessary to be familiar with the expression when we discuss knowledge sharing. Knowledge sharing relates to the willingness of an individual to share acquired or created knowledge with others (Bock, Zmud, Kim, & Lee, 2005). Knowledge sharing can happen either directly or indirectly, either via communication or some form of knowledge archive.

Scholars have examined the question of effectiveness of knowledge sharing in organizations, focusing on the difficulties of transferring knowledge of complex and tacit art across organizational subunits (Zander & Kogut, 1995). The ability to make tacit capabilities understandable to others and to transform it, derives from the collective experience of the members that is organized by rules of coordination and cooperation (Zander & Kogut, 1995). Sharing of tacit knowledge is difficult due to the non-ability for codification of the knowledge. Brown and Duguid (1998) discusses two different schools regarding the codification and externalization of tacit knowledge, one that states that tacit knowledge must be made explicit in order to be shared, and the other views tacit knowledge as always being tacit. Nonaka and Konno (1998) presented the SECI Model, a knowledge creating model distinguishing between four steps in the knowledge conversion process. Each of the stages can be seen as processes of self-transcendence, and the stages are socialization, externalization, combination and internalization. These stages are an ongoing circular movement, and the model can be an example of the first school. The other school suggests that tacit knowledge do not need to be explicit. The personal element in the tacit knowledge will be eliminated when transforming all knowledge to explicit and may lead to destruction of all knowledge (Polanyi, 1966).

Knowledge is important when working in project-based organization. A project team can be seen as an open system as it must interact with the environment continuously to obtain information and know-how (Cohen & Bailey, 1997). A study conducted by Haas (2006) on knowledge gathering in challenging work environments, proposed that project teams could benefit more from knowledge gathering if they had greater processing and sensemaking. What Haas (2006) characterized as challenging work environment was overloaded, ambiguous and politicized environments, such as the construction industry. The majority of construction knowledge resides in each individual (Vakola & Rezgui, 2000) and construction industry practitioners believe that a better management of the corporate memory would help to overcome several challenges related to improvement in the industry (Lundkvist, Meiling, & Vennström, 2010)[1]. One can say that there is lack of knowledge sharing within construction projects due to several factors. Project-based organizations usually becomes increasingly

[1] This article refers to Latham (1994), but it does not specify any more on the citation so we are not able to get access to the original source.

decentralized and loosely coupled (Lindkvist, 2004; Orton & Weick, 1990) where data usually is manually collected and the communication is poor. Knowledge sharing can also be difficult to facilitate due to the staffs' ignorance of feedback or the lack of time to facilitate feedback (Sterman, 2000).

Knowledge sharing among an organization's members is the most important mean that affect the value of knowledge utilization (Yang & Farn, 2009) and knowledge sharing is a collective course of action (Bock et al., 2005). As discussed previously, explicit knowledge can be codified, and sharing of this type of knowledge is well suited for information technology. On the contrary, tacit knowledge sharing relies on the social interaction (Käser & Miles, 2002; Nonaka, 1994) and is more difficult to codify. We have also discussed how tacit knowledge is individual based on personal skills (Berman, Down, & Hill, 2002) and know how (Grant, 1996). Some scholars argue that knowledge sharing can be difficult due to an individual's fear of losing their unique value and their unwillingness to share knowledge (Bock et al., 2005). Osterloh and Frey (2000) argued that knowledge sharing will only be facilitated by the intrinsic motivation which is the value for its own sake, or the obligation of personal and social identities (March, 1999, p. 377).

Group tacit knowledge

So far we have discussed tacit knowledge as individual (Haldin-Herrgard, 2000; Nonaka, 1994) and something personalized that is difficult to translate and share. As literature and research has focused on individual tacit knowledge, there is a gap in literature of the identification of *group* tacit knowledge. Some scholars (Berman et al., 2002; Erden, Von Krogh, & Nonaka, 2008) have discussed the concept of group tacit knowledge. We introduced the organizational knowledge creating theory with the SECI model with the four stages socialization, externalization, combination and internalization (Nonaka & Konno, 1998). Organizational knowledge creation is the process of making available and amplifying knowledge created by individuals as well as crystallizing and connecting it with an organization's knowledge system (Nonaka, Von Krogh, & Voelpel, 2006, p. 1179). Although each process is important in the knowledge creation, the stage of socialization can be highlighted. Socialization is the process of the creation of tacit knowledge through shared experience. This is the most crucial step since new tacit knowledge is constructed in the social interaction among or between individual,

and not alone by an individual (Nonaka, Toyama, & Konno, 2000). A "collective mind" was forwarded by Weick and Roberts (1993) as a storage for knowledge related to group activities, it is the combination of individual cognitive character and patterns, obtained through mutual experience (Berman et al., 2002). Weick and Roberts (1993) argued that:

> People in close relationships enact a single transactive memory system, complete with differentiated responsibility for remembering different portions of common experience. People know the locations rather than the details of common events and rely on one another to contribute missing details that cue their own retrieval (p. 358).

This means that if several individuals are working together on a common set of goals, each individual is assigned a role and does not have the full knowledge required to do the job for the others. The knowledge that is required to meet the goals are diffused among the individuals, it does not reside in one of the individual alone. It requires a constant adjustment from everyone. According to Berman et al. (2002) the element of tacitness in knowledge must also exists within groups for two reasons. First, the pattern-recognitions for each individual are difficult to express in a group related situation. Second, in a group with different individuals with its own knowledge component, each individual must be active in order to explain the overall knowledge in the group. This cannot be done by one individual or a subset of the individuals in the respective group.

2.5 Digitalization within the Construction Industry

We are living in a digital era, an era based on an infrastructure embracing information and communication technologies. This new infrastructure is helping us do things better and more efficient than before. Also, it is enabling new, more effective ways of control, coordination, and collaboration on activities, at a lower cost. It is also changing how and where we work, and the way we interact and communicate (Cascio & Montealegre, 2016). Previously, there has been a substantial focus on digitalization in labor-intensive organizations, and now the focus has changed to knowledge (Davenport & Kirby, 2015). Digitalization has the potential to fundamentally change the manner in which knowledge-intensive

organizations create and capture value, their strategies and the organization's structure (Breunig & Skjølsvik, 2017).

However, to exploit the opportunities this technology facilitates, a foundation for digitalization is needed. As mentioned, the level of digitalization varies across the construction industry but is in general at a low level compared to other industries (Agarwal et al., 2016). However, the possibilities for digitalization in the construction industry are numerous and this is an area many actors are focusing on. Several initiatives have been started worldwide to foster digitalization in construction. The UK government is working on *Construction 2025,* a long-term strategy working towards an industry which by 2025 is leading in research and innovation, drives and sustains growth, attracts talent, and is transformed by digital design (Blackwell, 2012). In Norway, similar initiatives have been developed. The project group Bygg21 is working on finding and applying the best practice from the industry, to increase the general efficiency of construction (Bygg21, 2013). Another initiative is *The Digital Roadmap*, a collaboration between several actors in the industry and managed by Byggenæringens Landsforening, which works towards a digitalized, competitive and sustainable industry (Sjøgren et al., 2017). The understanding on how technology should be integrated in knowledge-intensive work is increasing (Susskind & Susskind, 2015), but there is still work needed to assemble the industry and develop a common standard.

BIM - Building Information Modeling

A digital communication tool which has rapidly increased in use in the construction industry is BIM. Building Information Modeling is defined as "a modeling technology and associated set of processes to produce, communicate, and analyze building models" by the BIM handbook (Eastman, Teicholz, Sacks, & Liston, 2011, p. 13). Deutsch (2011) describes BIM as a "dynamic, continuously evolving strategy for designing and making buildings". Common for both definitions is the focus on BIM as a continuous design process. What BIM technology actually do, is constructing an accurate virtual model of a building digitally. When compared to the traditional methods of using paper drawings, the interaction when using BIM is more flexible and overlapped. The information is shared transparently between the different actors in the industry (Al Hattab & Hamzeh, 2013).

A common mistake when using BIM is to look at it as only a digital tool, and by this fail to exploit the full potential of the model. For an effective use of BIM, there must be a foundation of strong communication and collaboration. There must be a common understanding throughout the project as to why the model should be implemented, and routines for use of BIM must be developed (Deutsch, 2011). If used correctly, it helps architects, engineers and contractors to visualize the construction process and to identify potential design, construction or operational problems pre-building (Azhar, 2011).

Digitalization and Knowledge

In a McKinsey report from 2016, there are identified five main trends they expect will shape the construction industry's digital future: higher definition surveying and geolocation, next generation 5-D building information modeling, digital collaboration and mobility, the internet of things and advanced analytics, future-proof design and construction (Agarwal et al., 2016). These five ideas are designed to work together to deliver greater impact. Hence, shared knowledge across actors in the industry is vital for digitalization to succeed.

Digital tools have the potential to significant increase the efficiency of designing and managing construction projects (Froese, 2010). Through the development of new technologies more information can be absorbed and used (Prencipe & Tell, 2001), and a higher level of knowledge can be shared. However, to succeed with these improvements there needs to be more than technical solutions. The full potential of digitalization cannot be realized without also changing the work tasks and knowledge of the project participants (Froese, 2010). Charles Hardy, director of the General Services Administration's Office of Project Delivery, stated that the use of BIM is 10% technology and 90% sociology (Deutsch, 2011). There need to be a focus on the interaction between actors and their common knowledge to exploit the full potential of digitalization.

Information and communication technology has the possibility to improve knowledge sharing by reducing time-based and spatial barriers between actors, and simplify the access to knowledge (Hendriks, 1999). When an organization acquire new information, they interpret it according to previous knowledge and experience. It is acquired via organization-specific processes, and it affects the behavior of the

organization (Prencipe & Tell, 2001). As new knowledge is transferred between different units and actors, there is a high likelihood for information to get lost, and the possibility for acquiring new knowledge disappear. In particular, when information has to go through many agents, as in construction, it is likely to become distorted (Hansen, 2002).

In order to prevent losing valuable information and avoid misunderstandings, knowledge can be codified. Cowan and Foray (1997) defined the codification process as "the process of conversion of knowledge into messages that can be processed as information" (p. 596). Thus, codification refers to the ability to structure knowledge into identifiable rules and routines that can easily be communicated (Kogut & Zander, 1992). Codification of knowledge creates benefit, as knowledge becomes more understandable, and easier to share. This reduces uncertainties and information asymmetries in transactions between actors (Cowan & Foray, 1997).

In research, some look at codification as an outcome while other view it as a process. When looking at codification of knowledge as an *outcome*, it is often used to develop tools to provide routines and guidelines for future projects. In these instances, the codification is a way of facilitating routine replication (Zollo & Winter, 2002). However, when looking at codification of knowledge as a *process*, it has the possibility to enable the generation of new guidelines and changes to the organizations routines. Hence, it could identify the strengths and weaknesses of the current working routines (Zollo & Winter, 2002). This statement is supported by Lundkvist et al. (2010) who states that "several improvements in a construction organization could be facilitated by knowledge about common defects" (p. 837), which codification would help identify. By exploiting this in the construction industry, the level of "lesson learned" will increase (Newell et al., 2006).

However, the distinctiveness of tacit knowledge does not disappear with codification. First, not all knowledge can be codified. Second, there is a need for tacit knowledge to properly use the codified knowledge (Cowan & Foray, 1997). Nevertheless, with technological advances a larger part of knowledge has the potential to be codified, and thus to be shared and used efficiently (Cowan & Foray, 1997). Whatever the intentions motivating the codification, the process of creating

and using these codification tools requires an effort to "understand the causal links between the decisions to be made and the performance outcomes to be expected" (Zollo & Winter, 2002), and consequently shared knowledge is needed.

3.0 Research Design and Methodology

We will perform a multiple case study where we will investigate the information flow, knowledge gap and knowledge sharing in two different projects in the construction company BackeGruppen. In order to explore any possible quality growth digitalization adds, we will look at one project where BIM is implemented and one where there is a low degree of digitalization. By doing this, we are able to compare the quality of the knowledge-sharing and information flow between actors with and without digitalization.

Our research will be based on an inductive approach as the research question is phenomenon-driven (Eisenhardt & Graebner, 2007). The research will be focused on the importance of the phenomenon, digitalization, and we will seek to prevail empirical evidence as to how digitalization can increase the quality of projects in the construction business. As to now, the literature has focused on the positive effects digitalization could have for efficiency in general, mainly resulting from lowered time and costs. However, the relationships between digitalization and knowledge sharing is inadequately covered.

Further, we will use mixed methods for a best possible analysis of our research problem. As the construction industry consists of numerous actors, we believe a combination of several data collection methods will be needed to include all relevant actors, and to objectively analyze the problem. However, the qualitative method will be the principal-data gathering tool (Bryman & Bell, 2015) as the main weight will be put on the qualitative analysis, and the quantitative analysis will be used to develop a broader understanding. We will use convergent parallel design, as we will collect the data simultaneously and compare the results subsequently (Bryman & Bell, 2015).

3.1 Data Collection

Data collection is a time-consuming process and requires a lot. As we are using a mixed method we are both to collect data in a qualitative and quantitative manner where the project is the level of analysis. As part of these methods we are also going to collect secondary data, from project-specific information such as budgets, estimates and financial statements. When using more than one method or source to collect data on a social phenomenon it is called triangulation (Bryman & Bell, 2015). Using this approach, the findings are being cross-checked and it can increase the validity (see below). When collecting data, the informants will be anonymous, and the gathering of information will happen simultaneously.

Qualitative data collection. We will collect qualitative data using two approaches. First, we will conduct semi-structured interviews with key personnel and the different actors involved in the project. These interviews will be used to map the understanding and communication flow between the actors. As we are to look at two projects, we must interview all the same actors in the two projects, so approximately a total of 10 interviews will be conducted. The interviews will be recorded in order to transcribe the interviews afterwards. We will do all the interviews together, with one in charge that ask the questions. As digitalization is a "new" concept in the industry, we also want to have a focus group with people working with IT/R&D and strategy. The focus group will be facilitated by us asking open questions for the group to discuss. The focus group will be recorded and one of us will ask the questions while the other take observatory notes. The focus group should consist of 6-8 persons. The interviews and focus group will be held where the informants want, most likely where they are located.

Quantitative data collection. Our primary quantitative data will be collected by a survey sent out to the blue-collar workers in both projects. The survey will be available in both Norwegian and English in order to make it understandable for everyone. The survey will be sent out by e-mail.

3.2 Quality Criteria

When conducting a study, quality criteria such as reliability, replication and validity need to be considered. *Reliability* is concerned with the question of whether the results of a study are repeatable (Bryman & Bell, 2015, p. 49) and in qualitative

studies reliability can be divided into external and internal reliability. The degree to which a study can be replicated relates to the external reliability. We are trying to secure external reliability through the anonymous interviews and survey we will use. As the data collection is anonymous, informants will most likely provide us with honest answers. When a research team have more than one participants, the involved persons can have different interpretation of the observations. Internal reliability is whether a research team agree upon their observations. *Replication* is when a researcher want to reproduce the findings of other researchers (Bryman & Bell, 2015). To secure replication, we elaborate in great detail how our study is conducted by introducing the research method and design, and a detailed explanation of how data is collected. *Validity* is the last quality criteria and is concerned with the integrity of the conclusion that are generated from a piece of research (Bryman & Bell, 2015, p. 50). One way we will secure the validity is the use of triangulation. This method enables us to cross-check the data.

3.3 Ethical Considerations

As ethical issues may arise when conducting our research, we have discussed possible considerations beforehand to increase our awareness on these issues. In our study, we view harm to participants and lack of informed consent (Diener & Crandall, 1978) as most relevant.

Harm to Participants. We acknowledge that it is our responsibility as researchers to assess carefully the possibility of harm to participants, and ensure that the participants will not be harmed by our research (Bryman & Bell, 2015). As we will explore the relationship between the actors, and look at information flow and knowledge sharing between them, their private opinions are needed. Consequently, the participants will be anonymous. Further, as we are investigating two projects in BackeGruppen, we will also be open to anonymize the organization. If desired by BackeGruppen, we are willing to change the location and change the details of the characteristics of the companies as it will not affect our research, and it ensures full anonymity.

Lack of informed consent. When conducting our study, the participants will be fully informed about the nature of our research and why we view their participation as necessary. As we view our research as beneficial for all the actors, we see no reason

to avoid mentioning some parts of our research, or present the research as something it is not. We will give the participants the opportunity to withdraw at any point.

3.4 Limitations

There are several limitations in our research. Even though we are writing a case study for a specific company it may be difficult to get access to all the different actors involved in the projects, for example the architects. Project-related data can also be difficult to get access to if this is seen as confidential information to the company, and they are unwilling to share this kind of information with us. Another limitation is related to the survey. When sending out a survey on e-mail we risk low response rate due to factors such as unwillingness of the receiver to participate. Further, we might be exposed to retrospective bias. The research will be conducted in retrospect in some part of the project, thus some data will be collected subsequently. When conducting the interviews the interviewee will need to remember what happened in the past, and this could affect their response as their memory might deflect from the actual truth.

3.5 Project Organization and Plan

We have developed a thorough project plan in order to work systematically and meet required and needed deadlines (see Appendix 1). We will use January to read as much theory and literature as possible, and prepare for our meeting with BackeGruppen. Our goal is to finish data collection after Easter which leaves us with 1,5 month with data analysis. We will also agree upon a date with our supervisor of when we can hand in a first draft of our thesis in order to get feedback. We will deliver our master thesis within the 1st of July 2018. We have divided responsibilities between one and another. One of us will be in charge of the communication and planning with the project using BIM, while the other will be in charge of the project which do not use BIM.

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Appendix

Appendix 1

Timeline and project plan