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The influence of digitalization on the buyer-supplier relationships in the construction industry

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Table of content

List of figures.....iii

List of tables.....iii

Acknowledgement.....iv

Abstract.....v

1. Introduction.....1

Problem statement.....1

Empirical setting: construction industry.....2

Research question.....4

Limitations.....5

Structure of the thesis.....6

2. Literature Review.....7

2.1. Business relationship in construction industry.....7

2.2. Digitalization in construction industry.....9

2.3. Digitalization influence on business relationships within the industry 12

3. Theoretical framework.....13

3.1. The INA approach.....13

3.2 Partnering.....19

3.2.1 The concept of partnering in construction.....19

3.2.2 Challenges of construction partnering.....21

3.2.3. Differentiated partnering approach.....24

4. Research methodology.....26

4.1. Research strategy.....26

4.2. Research design.....26

4.3. Data collection.....27

4.4. Data analysis.....31

4.5. Quality of research 32

4.5.1 Reliability 32

4.5.2 Validity 32

5. Empirical base and analysis 33

5.1. Empirical base 33

5.1.1. Companies background 33

5.1.2. Introduction of project B, a different approach to collaboration in construction industry 36

5.2. Analysis 36

5.2.1. Activity links 37

5.2.2. Resource ties 39

5.2.3. Actor bonds 41

6. Discussion 43

6.1. Different digital tools have different effects on the relationship 43

References 45

Appendices 55

Appendix 1. Pre-interview short survey 55

Appendix 2. Interview guideline 57

List of figures

Figure 1 The construction project in its network context 8
Figure 2 ARA model 15
Figure 3 Purchasing model 23
Figure 4 Overview of the relationships among the observed parties and characteristics of data collected 30

List of tables

Table 1 List of technologies 12
Table 2 Interviews conducted 29
Table 3 Overview of the main contractors and their relationships with the suppliers/subcontractors* 35

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Abstract

Purpose - The paper aims at investigating how inter-organizational relationship in construction industry changes under the influence of IT; whether the companies involved will improve and prolong the relationship to develop further into partnership by using IT or IT is just a tool to facilitate the exchanges between them on operational level and keeps the relationship as arm-length.

Design/methodology/approach – Qualitative study of 03 largest contractors in Norway together with their subcontractors and material suppliers. Semi-structured interviews were adopted to conduct the research

Findings – Different types of digital tools have different effects on the buyer-supplier relationship. The companies are focusing on using BIM as a normal tool to facilitate the collaboration at the project level, thus BIM may help the parties involved develop local partnership but the partnership cannot be extended across the project border. Integrated web portal is an important tool for material suppliers and customers manage their relationship. The integrated system may promote the relationship to central partnership.

Research limitations/implications – The paper mainly focus on the dyadic buyer-supplier relationship between construction companies (main contractors) and their one subcontractor/ supplier.

Keywords – Information technology, inter-organizational relationship, business relationships, Industrial marketing, ARA model, partnering, construction industry

Paper type – Master thesis paper

1. Introduction

Problem statement

Digitalization has diffused in every facet of the society. In business, digitalization has been proved to be changing the basis of competitive advantage (Weinman & Euchner, 2015) with the abilities of improving firms' responsiveness to the market, productivity or customer value creation (Kim, Cavusgil, & Cavusgil, 2013; Strauss & Samkharadze, 2011; Wu, Yeniyurt, Kim, & Cavusgil, 2006). Especially, the enhancement of information availability and visibility has blurred the boundaries among parties, which facilitates inter-organizational collaboration (Liker & Choi, 2004; Tippins & Sohi, 2003). The major stream of research currently focuses on how to use IT for better performance at operational level of a focal company (Lindh, 2006). The effects of IT on the links between the parties involved, i.e. relationships have been mentioned in many studies (Bocconcelli, Cioppi, & Pagano, 2017; Day & Bens, 2005) but the research emphasizing on them remains limited (Obal & Lancioni, 2013).

Business relationships has played an increasingly important role in the firm's performance when companies outsource supportive activities and focus on their core activities to achieve competitive advantage (Porter, 1987). Developing relationships with suppliers have shown huge benefits in terms of reducing cost, improved quality, shorter time of introducing new products to the market (Liker & Choi, 2004; Tolstoy, 2010), consequently, supplier relationship management is also a critical issue that all the companies should concern. In the digital era with the rise of new communication channels provided by ICT (i.e. email, cloud computing, web-based technology, etc.), the way companies interacting with each other has changed and buyer-supplier relationship management is more dependent on IT tools such as Customer Relationship Management (CRM) or Enterprise Resource Planning systems (ERP), etc. (Obal & Lancioni, 2013). Some research shown that IT adoption can strengthen the business relationships by accelerating exchanges of business and information occurring over time (Ekman, Thilenius, & Windahl, 2014; Shi & Liao, 2015). Moreover, IT has been seen as a crucial element for knowledge creation (Davenport & Prusak, 1998), as it facilitates exchange of knowledge. Håkansson and Snehota (1995) argued that long and stable business relationships are formed in processes which require extensive inter-firm interaction and cooperation which has been proved to be supported by IT. Building on this idea,

the paper is to investigate to what extent the business relationship is strengthened under the influence of IT; whether the companies involved will improve and prolong the relationship to develop further into partnership by using IT or IT is just a tool to facilitate the exchanges between them on operational level.

Empirical setting: construction industry

Despite the benefits provided by IT, construction industry is still lagging behind automotive or mechanical engineering sector in integrating the innovative technologies (Kraatz, Hampson, & Sanchez, 2014; Moldof, 2015). This problem can be explained by the idiosyncratic characteristics which differentiate the construction industry from other industrial sectors:

- Project uniqueness: construction industry is a project-based industry. Each project is unique in terms of quality specifications, locations, budget and time (Cox & Thompson, 1997). A project is characterized with different requirements and specification of technologies for different clients. Every time a project is conducted, a specific cluster of actors with specific combination of technologies will be created in order to produce a product for particular client and the cluster will be dismissed after the product is delivered (Pryke, 2009). The emphasis on site-specific activities leads to the transient and discontinuous nature of the relationships among the parties involved, which consequently hampers the long-term innovation and learning (Dubois & Gadde, 2002).
- Complexity: Gidado (1996) pointed out two different categories of complexity. One is "uncertainty" in the operation of individual tasks, which results from the lack of uniformity of the resources employed (material, work, and team) across projects or from the environment. This kind of uncertainty also creates the situation which fosters decentralized decision-making. The second type of complexity is the "interdependency" among tasks taken by various actors in the projects. This is inherent when the industry operates based on "the practice of subcontracting portions of a project to special trade contractors by primary contractors" and a variety of trades (Eccles, 1981).
- Fragmentation: The construction supply chain is fragmented with a huge number of small and medium size firms with the same products and services (Arayici & Coates, 2012). Norway Construction Industry consisted of 20,855 construction companies with the turnover of 433 billion NOK in 2013 and the total of 9,934 companies operating as building material manufacturers, traders, machines and

equipment renting, consultants, and architects (see more Espelien, Theie, & Bygballe, 2015, p. 13). Consequently, the small and medium size companies with low turnover compared to the big players in the market have limited capabilities for investment in new technologies (Kraatz et al., 2014).

- Separation of design and production: the main problem in construction is the separation of design and production process. Usually, the design is often created by the consultants who in the early phase of the project is ill-aware of the resources and capabilities the suppliers who conduct the constructing activities at the later phase. This practice can lead to major cost stem from the redesign activities when the real conditions at the site could not meet the features specified in the drawings (Love, Li, & Mandal, 1999). Moreover, knowledge gained from the design phase (e.g. the application of new technology) cannot be passed down to other later phases because of the change of participants (Holmen, Pedersen, & Torvatn, 2005).
- Adversarial relationships: the fragmented supply chain with many suppliers providing homogeneous products or services combined with short-term thinking with focus on individual project lead to the situation in which the parties involved in the project develop their own objectives, goals and value systems without considering the impact on others or the effects on project performance (Love et al., 1999). Furthermore, each party in the supply chain tries to minimize their own exposure to risk by passing risk down to the next level in the supply chain (Pryke, 2009, p. 25). This practice increases the tension and conflict in the various interfaces across the supply chain, which consequently leads to increased cost and reduce efficiency (Cox & Townsend, 1998, p. 31) as well as hinders the knowledge exchange among the parties.
- Competitive tendering: Companies in construction industry select suppliers based on bidding process to assure that subcontracting is carried out at the lowest possible cost (Cox & Thompson, 1997). The focus on cost has resulted in the market-based, arm's length relationships among the parties in the project, which eventually impede learning and innovation (Miozzo & Dewick, 2002). This tradition of price focus hinders the possibility for experimenting new alternatives and technology (Bygballe & Ingemansson, 2014).

These specific characteristics also explain the relationship patterns in the industry and how the main contractors manage their long-term relationships with their suppliers to extract benefits from close collaboration with the parties involved (Bresnen & Marshall, 2000). However, with the market-based perspective and the traditional bidding process which results in different set of actors in each project (Bygballe & Ingemansson, 2014) together with the mistrust and skepticism among actors (Dainty, Briscoe, & Millett, 2001), the long-term relationship is hard to be achieved. Dubois and Gadde (2002) depicted construction industry as a loosely coupled system with tight couplings in individual projects and loose couplings in the permanent network. Besides the practice of strategic partnering – long-term commitment between partners across several projects (Beach, Webster, & Campbell, 2005; Cheng & Li, 2001; Winch, 2000) – which is popular in manufacturing context (Midler, 1995), the industry also applies project partnering which emphasizes on tight collaboration among actors within a specific project (Cheng & Li, 2001). The latter attracts more attention from both conceptual and empirical settings than the former does because of the project – based, one-off nature manifesting in the industry (Bygballe, Jahre, & Swärd, 2010).

Research question

The rise of IT in construction industry (e.g. BIM, Cloud Computing, Mobile Computing) has not only facilitated the collaboration within the projects but also changed the way the parties involved cooperating with each other (Alreshidi, Mourshed, & Rezgui, 2018; Y. Liu, van Nederveen, & Hertogh, 2017; Oesterreich & Teuteberg, 2016). Aligned with the mentioned argument of Håkansson and Snehota (1995) about the strengthened relationships derived from intensive interaction and cooperation facilitated by digitalization, under the specific conditions of the industry, the purpose of the paper is to investigate how the adoption on digitalization or IT influences the interactions between the main contractors and their subcontractors and suppliers in order to achieve better efficiency and effectiveness. Therefore, our paper's research question is formulated as:

"How does digitalization influence the supplier-buyer relationships in the construction industry?"

With sub-questions:

- To what extent does digitalization change the dimensions of the relationships between the actors?
- Will the increasingly tight collaboration which is facilitated by digitalization result in project partnering practice? With which subcontractors/ suppliers?
- If the project partnering is generated by IT adoption, will the main contractor can extend the close relationships across other projects in longer time span? With which kind of subcontractors/ suppliers?

Limitations

Construction project consists of several actors at multiple levels within the supply chain working together to deliver the product. The network in the construction industry is complex, a client can choose a main contractor for the project, subsequently, the main contractor subcontracts the project to another subcontractors (see more Pryke, 2009). As a result, there exists multiple supplier-buyer relationships across the construction network. In this paper, we mainly focus on the dyadic buyer-supplier relationship between construction companies (main contractors) and their one subcontractor/ supplier.

Because the purpose of the paper is to look into the potential development of partnership beyond one specific project and the adoption of digitalization has far-reaching implication for the whole industry (Oesterreich & Teuteberg, 2016), we consider the point of view of the purchasing managers of the main contractor companies as well as of the managers from the central offices of the suppliers/contractors.

We have limited our research to a specific selection of companies who are among the largest construction companies in Norway. They are some of the foremost main contractors within the Norway construction industry and as such have adopted digitalization developed over many years. Large contractor companies are claimed to have an obvious interest in taking advantage of potential economies of scale in purchasing (Gadde & Dubois, 2010). However, the construction industry also comprises of numerous small companies that are not the focus in this study.

Structure of the thesis

In the first section, we have presented our problem statement, introduced our digitalization concept, stated the construction industry situation and proposed our research interest and question. The following section presents our literature review on business relationships and digitalization in construction industry. This section included our basis introduction into the state of the art of the technologies used in the construction industry as well as the current practice of handling collaboration with subcontractors/ suppliers by main contractor companies. From then on, we propose a theoretical framework as a guideline to analyze different dimensions of relationship and business interactions in construction industry. In Section 4, research methodology is presented, followed by our multiple-cases study introduction and analysis based on the proposed theoretical framework in section 5. Section 6 serves as our findings' discussion. Finally, conclusions and a final outlook will be provided.

2. Literature Review

2.1.Business relationship in construction industry

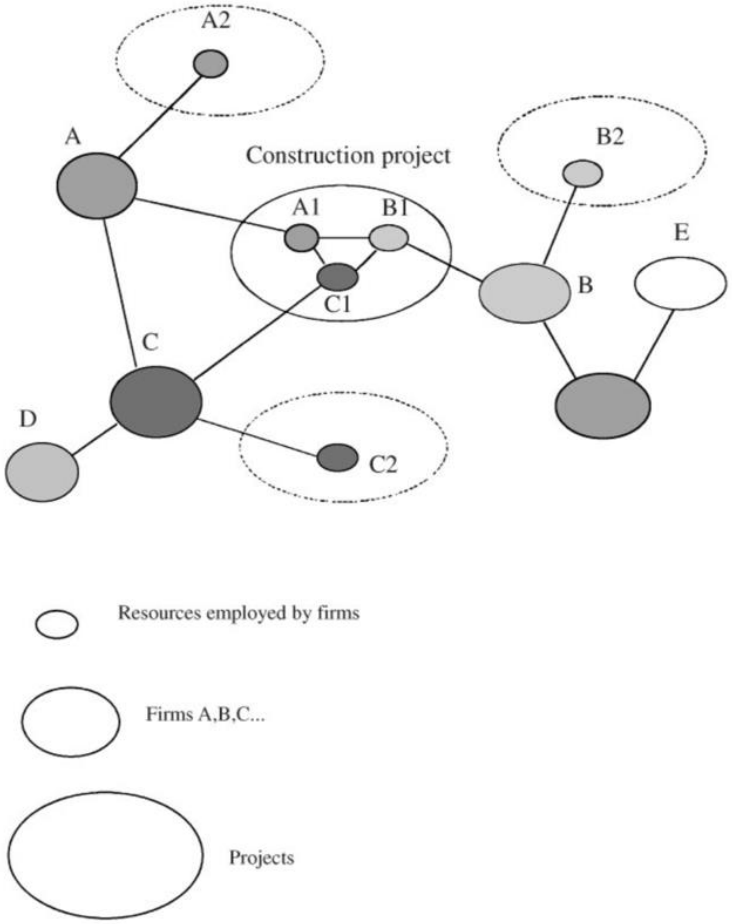
In order to cope with the complexity inherent in the industry, the companies involved just focus on the efficiency of a specific project, as Shirazi, Langford, and Rowlinson (1996) concluded that construction is mainly about coordination of specialized and differentiated tasks at the site level. Thus, the relationships among the actors within the project exist until the products are delivered. A buyer tends to switch suppliers for other project, as a result, even though buyers and suppliers have been involved in business with each other for a long time, their transactions are irregular and intermittent (Gadde & Dubois, 2010).

The emphasize on individual projects also leads the contractors to follow the competitive tendering procedures which are assumed to be the most appropriate means of securing efficiency in operations in terms of achieving the lowest possible costs (Cox & Thompson, 1997). This approach enables the buyer to get access to many interchangeable suppliers, consequently, provides the contractor the benefits which Gadde and Dubois (2010) listed: "(i) reduce uncertainty in single transactions since alternative suppliers are readily available, (ii) avoid becoming 'locked' into the technical solutions of a single supplier and (iii) encourage competition in order to stimulate supplier performance, primarily in terms of price".

However, Dubois and Gadde (2000) also argued that, due to this project-based characteristic, the construction industry was stated to be a loosely couplings system, with tight couplings in individual project, loose couplings in the permanent network and collective adaptions in "the community of practice" and that the construction industry and the construction process has been described as a "temporary multiple organization" (Dubois & Gadde, 2000). While a firm is involved in one project, they may simultaneously join another project, which means the resources have to be shared and coordinated with partly different set of other firms and different actors. Hence, the project could be considered as a specific temporary network within a more permanent network (Dubois & Gadde, 2000).

The **Figure 1** below illustrated the complexity of construction projects in its network context.

Figure 1 The construction project in its network context



(Dubois & Gadde, 2000)

As Gann (1996) described the relationships within the traditional craft housing production "typified by market-based, short-term interactions between independent businesses", transactional exchange is the dominant form of business in the construction industry (Dubois & Gadde, 2000) and that firms paid more attention to contractual rather than relational elements of transactions (I. Thompson, Cox, & Anderson, 1998). However, as the loose coupling hinders the continuous interactions among firms and causes the frequent change of the actor constellations, it becomes an obstacle for innovation and knowledge transfer across the projects and the buyer will also suffer cost inefficiencies as a new learning curve is climbed by the supplier each time (Cox & Thompson, 1997), while tighter couplings might be more beneficial (Dubois & Gadde, 2010). This triggers the interest among firms to develop closer relationships (Lena E Bygballe & Ingemansson, 2014), that "the search for more collaborative contractual relations has become a contemporary theme in the construction industry" (Cox & Thompson, 1997).

Like other industries, partnering has increasingly gained interest among management agenda in the construction industry (Gadde & Dubois, 2010) that it "represents a fundamental shift from the traditional adversarial relationship in construction" (Lena E. Bygballe, Jahre, & Swärd, 2010). Dubois and Gadde (2000) argued that the long-term relational exchanges needs to replace the short-term transactional exchanges, which means a shift from traditional arm's length relationship to a closer collaboration one.

2.2.Digitalization in construction industry

Globally, construction industry is lagging behind other manufacturing sectors in terms of applying digitalization into production and management. The overall picture in US and Europe is similar, construction is the least digitized sector. (Friedrich, Merle, Grone, & Koster, 2011; *Income Distribution Data Review*, 2012) Moldof (2015) argued that many constructions contracting and subcontracting firm owners are reluctant to jump on the bandwagon and spend money on the latest technology fads and trends. Despite the benefits that have been shown in other industries, construction companies have not managed to integrate innovative technologies to keep up with their counterparts from the automotive or mechanical engineering sector (Kraatz et al., 2014). Also, the maturity level of IT application varies along and within the construction's value chain."(Leviäkangas, Mok Paik, & Moon, 2017).

However, some of the researches have realized that the industry has started to grasp some of the technologies that construction companies are more concerned about developing technical platforms (Bygballe & Ingemansson, 2014). In their systematic literature review and case study analysis, Oesterreich and Teuteberg (2016) found out that several digitalization and automation technologies for construction have reached market maturity and are currently available. Based on the synthesis of their work and the work of Adwan and Al-Soufi (2016), we group the technologies according to their profound impacts and functions (***Table 1***).

- **BIM**: The most penetrating technology in the field is BIM, described as a digital environment that is used in the design and preconstruction stages of a building project and its components which retrieves information of a three-dimension (3D) entity model by multiple different project team members during the project (Davies & Harty, 2013). Major construction projects increasingly depend on BIM to be completed expeditiously, and many companies in the architecture,

engineering, and construction (AEC) industry have used BIM as a catalyst for IT-based change processes in their operations (Construction, 2012). BIM enables a new way of working by providing a common environment for all information defining a building, facility or asset, together with its common parts and activities (Pittard, 2013).

- **Web-based technologies**: Another powerful and widely used tools are web-based technologies, which provide a platform to manage and share construction information by getting rid of paper documents, improving access to data, allowing common documents between agents in different locations, eliminating discrepancy and misunderstanding in the versions of documents, and recording data in a multimedia format (Martinez-Rojas, Marín, & Vila, 2015). Some research, through their empirical findings, suggested web-based technologies that are widely used: intranet and extranet (Lam, Wong, & Tse, 2010); communication using email, mobile phones, internet (Hassan & McCaffer, 2002; Oladapo, 2007; Vachara & Derek, 2005) ; Cloud Computing (Jardim-Goncalves & Grilo, 2010).
- **CAD and 3D CAD technology**: CAD technology is used in the drafting and design of small and large types of buildings and may be used to design curves and figures in two-dimensional 2D or 3D space (Varady & R. Martin, 2002). Chien and Barthorpe (2010) revealed that CAD was one of the most useful technologies to improve the effectiveness of product design and drawing task.
- **Tracking technology**: A tracking system is used to observe the movement of persons or objects and provides a timely ordered sequence of respective location data to a model that depicts the motion on a display capability. Tracking technology included the usage of GIS, GPS, and RFID. GIS stores, edits, analyzes, shares and displays geographical referenced information. GPS which enables a GPS receiver to determine its location, speed, and direction while RFID is a sensing technology that uses radio signals to identify objects from small sensor devices composed of RFID tags or transponders and RFID readers (Seong Leem & Gun Kim, 2013).
- **Simulation and analysis**: As construction projects are unique and highly complex undertakings which are influenced by external factors like weather, worker performance and supply fluctuations, simulation can be applied to improve the design of construction operations (AbouRizk, Halpin, Mohamed, & Hermann, 2011). It has been showed that the application of Virtual Reality (VR),

Augmented Reality (AR) and Mixed Reality (MR) can create risk-free virtual learning and training environment, support defect management or improve communication, collaboration and customer relationship (Chan, Heng, & Martin, 2012; Park, Lee, Kwon, & Wang, 2013; Trimble, 2015). As data increases in volume, velocity and variety; and as it is aggregated and re-used, the implementation of big data solutions plays a vital role in project management. For instance, the analysis of historical big data (e.g. weather, traffic or business activities) makes it possible to identify patterns and probabilities of construction risks for performance improvements in future projects or enhanced decision-making (Burger, 2017)

- **Smart factory**: The vertical integration of various components inside a factory to implement a flexible and reconfigurable manufacturing system (Wang, Wan, Zhang, Li, & Zhang, 2016). One central technology in the concept is the *Internet of Things*, which enables the creation of virtual networks to support a smart factory environment. By using IoT in construction process to predict failure points, companies can save a huge amount of money by avoiding reactive maintenance, where machines and equipments run until failure before they get repaired (Manyika et al., 2015; B. Thompson, 2015). *Modularization* as another concept is technically known as prefabricated construction. It refers to the manufacturing of larger building components away from construction site which are mostly fabricated in a factory and then transported to the construction site, where they are assembled by using cranes (Hong, Shen, Mao, Li, & Li, 2016). *Robotics* are also a powerful tool that can make construction work easier, safer, more efficient and more attractive (Balaguer & Abderrahim, 2008). However, robotics has not been widely used in the industry, as the low level of standardization in the construction process and the harsh construction environment does not provide an ideal environment for robotics (Kajander, 2016). *Cyber-Physical-Systems (CPS)* facilitates bi-directional coordination between virtual models and physical construction, including the validation of the developed proof-of-concept prototype systems by industry practitioners.

Table 1 List of technologies

Technologies Group	Technologies
Web-based technologies	Intranet, Extranet
	Email, mobile phones, Internet communication
	Cloud Computing, Mobile Computing
BIM	
CAD and 3D CAD Technology	
Tracking Technology	GIS, GPS, RFID
Simulation and analysis	Big Data
	Augmented Reality (AR)/ Virtual Reality (VR)/ Mixed Reality (MR)
Smart Factory	Internet of Things
	Robotics
	Cyber-Physical Systems (CPS)/Embedded systems
	Modularization

Table 1 presents the list of technologies that have been received most attention from research and practice as well as have proved impact on the performance of the construction companies and communications with their counterparts (customers and suppliers). There are many other types of technology, but they are still new to or not widespread used in the construction industry (Adwan & Al-Soufi, 2016; Oesterreich & Teuteberg, 2016). Therefore, we assumed that they have trivial influence on the strategic buyer-supplier relationships.

2.3.Digitalization influence on business relationships within the industry

Construction industry has always been considered to be lagging behind other industrial industries in adopting innovative technologies (Kraatz et al., 2014; Moldof, 2015). Claimed by KPMG report (Busta, 2016), the industry is not taking full advantage of technologies such as advanced data and analytics, automation or robotics. The current stream of research has paid much attention to the link between IT and the improved performance (Kauppi, Brandon-Jones, Ronchi, & van Raaij, 2013) or the increased innovation (Zhou, Fang, Wang, & Yang, 2016). Some other authors studied the effects of IT on the links between the parties, i.e. the business relationships (Bocconcelli et al., 2017; Day & Bens, 2005). Basu and Muylle (2007); Muylle and Basu (2008) contributed to this stream by studying how IT support business process in inter-organizational relationships. As claimed by authors, “buyer-supplier dyads may go beyond passive information exchange and engage in proactive collaboration”. IT is also stated to facilitate information and

knowledge sharing with business partners (Ekman, 2006; H. Liu, Ke, Wei, & Hua, 2013) that had the power to strengthen business relationships.

Despite the increasing interest of research on the impact of digitalization on performance and business relationships, just few of them study in the inter-organizational setting in industrial markets. Pagani and Pardo (2017) started to touch upon the impact of digitalization adoption on B2B exchanges by building on the interaction model ARA (activity links, resource ties, and actor bonds). The paper also identified three types of "digitalization" that are in consistent with those three components of a relationship. Even though those types need to get clearer definition and characteristics, this method of distinguishing different kinds of information technology has paved the way for future research on all aspects of the digitalization journey. Lindh and Rovira Nordman (2017) researched on the link between IT and business relationships development and IT's impacts on performance in industrial contexts by studying more than 800 supplier firms in Sweden.

Our thesis continues this trend to see the linkage between IT and the business relationships among firms in the construction context, which is quite different from other industrial contexts. Even though, most of the researches focus on the influence of IT on business performance, we take a different angle to look closely to the business relationships influenced by IT. Would firms gain closer collaboration or the arm's length distance be more distant?

3. Theoretical framework

3.1. The INA approach

The above-mentioned works all contend the idea that digitalization is profoundly changing the way business is carried out between companies. One important underlying dimension of the digitalization movement as analyzed by scholars is that it clearly refocuses on co-ordination between companies.

There have been several other theories trying to explain the business relationships, but they are one-dimensional dyadic approaches, which include the purchasing portfolio management, supply chain management, transaction cost economizing (from the buyer side), the customer portfolio management and the

relationship portfolio mapping (from the supplier side). Overall fundamental problem with much of this one-dimensional literature is that, most of the thinking tends to prescribe the benefits of trust, transparency and collaboration, without ever fully specifying what this means in practice for either the buyer or the supplier.

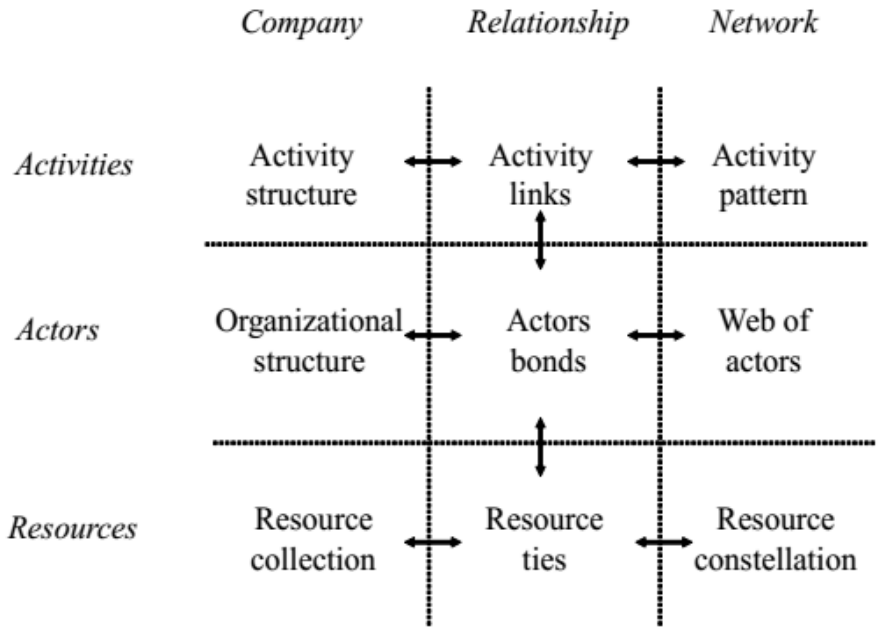
As "coordination between companies" is a central issue with digitalization, we want to use the framework that allows a detailed understanding of how companies get connected. The Industrial Network Approach developed by IMP scholars is chosen as our theoretical framework because it offers a rich set of concepts for business relationships (Håkansson & Snehota, 1995) and focuses particularly on inter-organizational issues in business-to-business situations (Bygballe & Ingemansson, 2014). IMP studies based on empirical evidence and observations from manufacturing and process type industries and emphasized on the interaction patterns between firms. According to the INA, companies do business with each other on a continuous basis in a series of transactions and develop business relationships that connect their operations (Håkansson & Snehota, 1995). The term "relationship" therefore refers to what is actually going on between business organizations, such as providers and sellers with users and buyers. Companies seldom have one or two transactions but repetitive transactions, then they could develop specific relationships with each other to increase efficiency, build trust, and decrease opportunity cost (Snehota & Håkansson, 2017). According to IMP empirical studies, "such long-term relationships have been shown to contain numerous adaptations and "heavy" economic investments (Håkansson & Waluszewski, 2002).

In this part, the INA approach is also applied through the use of the "ARA Model". The "ARA model" (Hakansson & Johanson, 1992) provides a conceptual framework of the process and outcomes of interaction and suggests that business relationships developed between buyer and seller could result in different ways. The model suggests that the outcomes of an interaction process can be described in terms of the three layers: Actor (bonds), Activity (links) and Resource (ties) between the counterparts (Håkansson & Snehota, 1995).

In general, the layers refer to how actors relate on a social level (bonds), how they combine technological and organizational solutions (ties), and how they are interrelated through the various activities they perform (links) (Ingemansson Havenvid, Håkansson, & Linné, 2016). In the construction setting, the application

of ARA model would help us to see the how interactions are influenced within and between the project level, and the firm level with the adoption of technology, when the "new combinations of activities, resources and actors are created and further integrated and utilized" (Bygballe & Ingemansson, 2014).

Figure 2 ARA model



(*Hakansson* & Johanson, 1992)

These three layers, however, are not independent but inter-connected that each layer affects each other by the constellation of resources, pattern of activities and web of actors in the wider network which presents the development of relationships (Håkansson & Ingemansson, 2013).

The Activity layer: A business relationship grows when certain of their different technical, administrative or commercial activities link together (Håkansson & Snehota, 1995). Hence, activity is present in all business relationships and relationships affect the way two companies perform their activities, or in other words, activity structure. The activity link establishment "permits novel structuring of activities that affects productivity" and is achieved by mutual adjustments of activities or in other words, by "adaptations" (Håkansson & Snehota, 1995). These adaptations could regard both the activities performed within the relationships such as information exchange, transportation and the activities performed by each company including rationalization or reallocation of production

process. Adaptations are entailed from activity links but are also a condition for the effects of those links.

Adaptations in the construction industry is featured to strongly rely on contracts and that, those adaptations are typically "collective and project specific rather than relationship specific" (Dubois & Gadde, 2000). Dubois & Gadde (2000) mentioned four reasons for this phenomenon including: (i) the government regulations that require certain principles and standards; (ii) the industry itself which established numerous forms of contract formulas; (iii) the tendering procedures that requires the similar offerings of different suppliers, both in terms of product features and price and (iv) the generic roles of actors are also standardized. Hence, the activities in construction industry are mostly integrated through standardized links (Dubois & Gadde, 2000), and the material suppliers do not usually develop products adapted to particular contractors or specific construction sites. (Dubois & Gadde, 2010).

Likewise, Stinchcombe (1959) observed the strong reliance on standardized products in the construction industry compared to other industry contexts. He concluded that the automobile industry and other mass-producing arrangements hinge on standardization of tasks, while construction utilizes standardization of parts. This practice combined with the project's uniqueness in terms of unique combination of input factors required (Eccles, 1981) indicates that the customization is conducted at the particular construction site. Therefore, even though there are limited interactions among firms in the long term, the actors intensively adjust their activities to cooperate with each other on site. Their joint efforts are mainly focused on developing solutions to problems in the particular project, as Hellgren and Stjernberg (1995) argued "activities are orientated towards responding to problems usually in ways that could be described as seeking the simplest and most straightforward solution." Beside components, the main contractors also use standardized types of contracts that limit the responsibility of the involved parties (Cox & Thompson, 1997). In their paper, Dubois and Gadde (2000) argued that reliance on standardization hampers the innovation and product development.

In the light of digital technology application, how activities linkages change or how companies adapt their activities when a new technology is introduced by either side. One really important factor that needs to keep in mind is that strong

activity links are only developed when the counterpart are deemed important or the activities of counterpart are visible enough to affect the desired outcome for the company (Håkansson & Snehota, 1995). Hence, digital technology may not necessarily have influence on the buyer- supplier relationship if the counterpart's activities could not help increasing the productivity of the company.

The way that suppliers are selected does not encourage long-term interaction over several projects and hence, does not support the development of long-term relationships but "fortifies the uniqueness of the con- stellation of actors and resources in each project" (Bygballe & Ingemansson, 2014). This finding has triggered us to see if there has been any attempt to improve this situation with technology and if yes, how that investment influences the activities linkages between buyer and supplier. Regarding the long-term relationship, it is important to recognize how procurement behavior alters under the development of technology, that if firms start to have closer collaboration or more arm-length relationship.

The Resource Layer: When two companies build up a relationship, they can decide to combine several resource elements to utilize those resources. Different resources include both tangible assets (land, equipment, plant) as well as intangible ones (talent pool, knowledge, culture). New resource combinations are likely to change when the interaction between two companies change when it requires more mutual specific adaptations. Resource ties arise as the two parties in a relationship confront and mutually adapt their resources over time (Håkansson & Snehota, 1995). However, how resources are determined to be valuable for the focal company depends on how they are combined with other resources. This requires a need of information exchange or learning different uses of resources to better implement the resources combination.

In this sense, we find digitalization could have double-faced feature. In one hand, digital technology may influence the resources control (both for tangible and intangible resources), and in other hand, it could be considered as a resource itself. If considered as the latter, it would be interesting for us to understand how digital resources possessed by an actor can be combined with that of another actor. For construction companies, the resources ties between firms are characterized to be weak in the design phase of each project (Dubois & Gadde, 2000).

The Actor Layer: Actors refer to companies, or organizations and/or individuals that individually control resources to execute certain activities (Ingemansson, Elsebeth, Åse, & Ann-Charlott, 2017). Even though companies are considered actors, they act through individuals; hence, the bonds between companies are constrained by "bounded rationality" of individuals. The bonds between two actors may alter their way of seeing and interpreting situations, what they can exchange and how they trust, appreciate and become mutually committed (Håkansson & Snehota, 1995). Hence, commitment and trust are the two critical factors of identities development in a business relationship between two companies. While commitment refers to the "tendency to persist with course of actions" (Håkansson & Snehota, 1995), trust is the necessary condition for commitment which takes time to develop. The actor dimension hence, plays an important role in relationships development because it can influence the input of activity and resource dimension. When the trust is weakened, it affects what the counterpart is willing to act or what resource they are willing to combine.

Embedded in the construction setting, the suppliers are chosen from the traditional competitive bidding process where the lowest price is prioritized (Lena E Bygballe & Ingemansson, 2014; Dubois & Gadde, 2002; Miozzo & Dewick, 2002). This process makes the constellation of actors different through different projects which hinders the possibility for building up trust and commitment and for utilizing experience and knowledge gained in previous projects (Dubois & Gadde, 2000). The actors are involved mostly at the construction site as "main characteristic of construction organization to be the co-ordination of specialized and differentiated tasks at the site level" (Shirazi et al., 1996), where the interactions are quite intense. However, their joint efforts are mostly spent on solving problems on site, which are, in some cases, even more costly than the savings from competitive tendering process (Dubois & Gadde, 2000).

In the digitalization context, it is interesting for our paper to find out the impact of ICT on the development of commitment and trust between two companies and if technology affects a pre-existing relationship. Obal and Lancioni (2013) said that "a pre-existing relationship with a given supplier can heavily influence the buyer's adoption decision, even when the new product is unrelated to previous products from that supplier. As buyers tend to trust firms they have worked with

before, incumbent suppliers have an inherent advantage over new entrants in the diffusion of new, disruptive technologies".

All in all, the Activity layer is concerned with the productivity, the Resource layer relates to innovation while the Actor layer is associated with trust, commitment and identity (Håkansson & Snehota, 1995). This argument also serves as the guide for us to construct the interviews. Håkansson and Ingemansson (2013) argued that any innovation that changes the activities or resources of any of the two actors would also alter the relationship or the "renewal" of the relationship. Hence, we expect that the application of any ICT tools would also alter one or any layer of business interactions. As these three layers are interdependent that when one layer is influenced, the other two would also be influenced. When actor bonds are developed over time, the mutual commitment and trust also increase which may pave the way for more resources ties or activity links development (Ingemansson Havenvid et al., 2016). New resources combinations may hinder or foster more activity co-ordination and activity links may limit or facilitate resource adaptations and may develop the bonds between two actors (Håkansson & Snehota, 1995).

In this paper, we apply the ARA model to investigate the interaction of a buyer – supplier relationship with the application of ICT at the corporate level. Even though we will only focus on a buyer – supplier relationship, the ARA model can be extended to understand broader context – the network that the companies are embedded in. An activity link is a link in a broader activity pattern over several companies, a resource tie is part of a resource constellation and an actor bond is a part of a web of actors.

3.2 Partnering

3.2.1 The concept of partnering in construction

There has not been an unified understanding of the concept (Lena E. Bygballe et al., 2010) which leads to different interpretations (Crespin-Mazet & Portier, 2010), but many of researchers refers to the definition by The Construction Industry Institute (CII) as:

> "A long-term commitment by two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant's resources. This requires changing traditional relationships to a shared culture without regard to organization boundaries. The relationship is

> based upon trust, dedication to common goals, and an understanding of each other's individual expectations and values. Expected benefits include improved efficiency and cost-effectiveness, increased opportunity for innovation, and the continuous improvement of quality products and services." (CII, 1991, p. iv)

Manley, Shaw, and Manley (2008) argued that partnership is not a legal but a relational contract which promotes mutual benefits, trust and commitment (Erik Eriksson, Nilsson, & Atkin, 2008). Crespin-Mazet and Portier (2010) claimed that partnering is based on several principles including (i) mutual objectives, (ii) early integration of key project actors, (iii) use of project management techniques, (iv) team building principles based on trust and (v) the development of well-structured but open and informal communication flows.

While the traditional view of partnership concerning the long-term relational exchanges and relationship continuity (Gadde, Håkansson, & Persson, 2010) which is justified by "the enduring desire to maintain a valued relationship" over a long period (Crespin-Mazet & Portier, 2010), partnering in construction industry seems to convey different meanings as the construction industry is characterized by the discontinuity of project exchanges (Cova, Ghauri, & Salle, 2002; Cox & Thompson, 1997). Bygballe, Jahre, & Swärd (2010) has conducted a systematic and extensive review of the construction literature on partnering and identified three key dimensions of partnering relationships – relationship duration, the relationship partners and how the relationship develop.

Regarding the relationship durations, researchers have usually distinguished between project partnering, which focuses on short-term efficiencies and benefits of individual project, and strategic partnering, which emphasizes the long-term relationships between firms across several projects (Bresnen & Marshall, 2000; E. W. L. Cheng & Li, 2001). Due to the project-based characteristics of the construction industry, the project partnering has received considerable attention. Larson's study (1995) on 289 projects was reviewed by Lena E. Bygballe et al. (2010), concluding that "partnering projects achieved results that were superior to those of projects that were managed in a traditional way". There have been not many papers concerning the strategic partnering or none of the papers deal with partnering in a "strategic, multi-actor and purely evolutionary sense" (Lena E. Bygballe et al., 2010). The reasons for this phenomenon are also stated which is due to the project-based feature of the industry that many projects focus on their

relationship with the main contractors rather than the involvement of sub-contractors and suppliers, hindering the possibility of strategic partnering. There were several exceptions, though, which are also reviewed. Gidado (1996) claimed the project quality improvement with help of a strategic partnering between a client, contractor, sub-contractors and suppliers. The studies by E. W. Cheng, Li, and Love (2000) and Lau and Rowlinson (2009) also touched upon the multi-actors' long-term agreement, the inter-personal trust in partnering; however, they did not cover the partnering process (Lena E. Bygballe et al., 2010).

3.2.2 Challenges of construction partnering

Bresnen and Marshall (2000) has identified several opportunities associated with partnering that make partnering "stands in contrast to the adversarial conditions" (see Gadde & Dubois, 2010):

- The potential net benefits that stem from increased productivity and reduced costs.
- Reduced project times owing to early supplier involvement and team integration.
- Improved quality through the focus on learning and continuous improvement.
- Improved client satisfaction and enhanced responsiveness to changing conditions.
- Greater stability that helps companies deploy their resources more effectively.

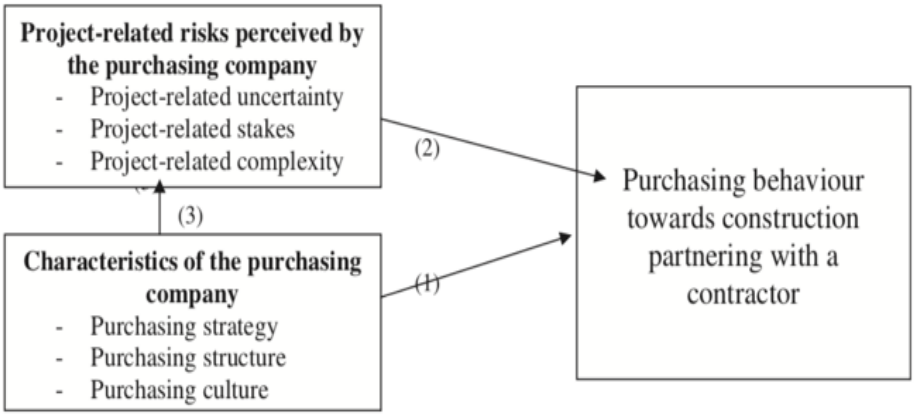
Crespin-Mazet & Portier (2010) also pointed out a number of benefits provided by partnering in construction industry, including increased efficiency, lower bidding prices and project costs and improved design and improved supply chain collaboration. Regarding those benefits, it is not surprising that partnering has gained much attention and even has to be referred to as "the most significant development today as a means of improving performance" (Wood & Ellis, 2005). Several researches have revealed the benefits of partnering in construction industry. For example, Larson (1995) concluded that improved performance in "partnered projects" by studying 280 construction projects; Wood et al. (2002) claimed the "trust-based partnering" to contributing to the improved ethical performance.

Despite great benefits and those identified improvements from partnering, it seems that the outcome of those efforts to implement partnering in the construction industry has not keep up with the expectations as in other industrial contexts (Winch, 2000). Even with researches claiming the improved performance in partnering, few empirical studies "analyze partnering consequences in sufficient empirical depth" (Gadde & Dubois, 2010), which results in the lack of consistent justification for claims made for partnering (Wood & Ellis, 2005). In consistent with that finding, Ng, Rose, Mak, and Chen (2002) also claimed that partnering is not always successful even with great potential impact. Several authors have identified problems associated with achieving the desired outcomes of partnering in construction. Gadde and Dubois (2010) reviewed various publications regarding this issue. Anvuur and Kumaraswamy (2007) claimed the problems to stem from the adversarial culture among firms in the industry. Bresnen and Marshall (2000) saw the difficulties in converting strategic decisions into practice at operations levels regarding the gaps between corporate level and project level where actual operations take place. Tang, Duffield, and Young (2006) observed the same situation that "considerable uncertainty as to how to translate general principles of partnering into any sort of concrete application".

Dainty, Briscoe, and Millett (2001) argued that the focus on dyadic relationships between clients and main contractors while neglecting the involvement of sub-contractors and suppliers is one of the reasons leading to this underperformance (Lena E. Bygballe et al., 2010). Some other researchers have focused on the factors influencing construction partnering. While project characteristics such as complexity and uncertainty, which influence the level of risks for the customer firm (Cova et al., 2002; Scott, 2001), have been proved to affect the adoption of partnering, customers characteristics and objectives also contribute to the contract strategy and procurement selection (Crespin-Mazet & Portier, 2010).

Crespin-Mazet & Portier (2010) formulated in their study a model of the purchasing behavior towards construction partnering with a contractor with the aim of understanding the rationale behind the reluctant of construction purchasers.

Figure 3 Purchasing model



(Crespin-Mazet & Portier, 2010)

The research found out that the characteristics of the purchasing companies helps explain the situation than the project characteristics.

Regarding that stream of research, Gadde and Dubois (2010) also studied the reasons explaining the difficulty to exploit the intended effects of partnering in construction industry by comparing the characteristics of high-involvement relationships in other contexts with the typical construction relationships. One of the features of high-involvement relationship is the longevity which is the result of continuous business transactions over long time periods (Ford et al., 1998). In the construction setting, the relationships seem to be more irregular intermittent that "the majority of construction projects are one-off, which often means that no long-term business relationships can be established" (Brown, Ashleigh, Riley, & Shaw, 2001). Furthermore, construction companies commonly attempt to avoid dependence on specific business partners, which features their relationship as "arm's length distance". To become independent from a business partner, firms are required to avoid adaptations, meaning that they simultaneously avoid certain benefits brought by such adaptations. Those elements of longevity, independence and adaptations "significantly affects the processes of interaction" (Gadde & Dubois, 2010). Intense interaction is claimed to happen on the construction site, which means at project level rather than at the corporate level. The lack of knowledge transfer across different projects prevents the experience to be exploited. The price-focus feature of the business interactions imposes the lack of trust and mutuality issue which is the major reason behind inefficiencies in construction projects (Shek-Pui Wong & Cheung, 2004). This also results in what Bresnen and

Marshall (2000) claimed in their paper "if some companies are willing to share their technical know-how, other may jealousy guard such proprietary knowledge". The cost-driven and adversarial relationship between contractor and subcontractor hinders the possibility of total cost approach that may even outweigh the savings from the bidding process (Wood and Ellis, 2005).

3.2.3. Differentiated partnering approach

As discussed above, partnering in construction industry mainly occurs at project level that the strategic partnering could hardly achieve. Green and McDermott (1996) also concluded that partnering "should be the result of natural evolution of long-term relationships between two parties who have realized the financial benefits of combining production processes". To exploit the potential benefits of partnering as in other industrial contexts, an extended partnering is required (Gadde & Dubois, 2010).

We found the paper by Gadde & Dubois (2010) suggesting a differentiated approach to partnering in construction industry very appropriate to serve as a guidance for us in this thesis. First, the paper mentioned several requirements for extension of partnering in construction, which include (i) enhanced knowledge transfer between projects, (ii) long-term opportunities instead of short-term efficiency. In their research, Eriksson et al. (2008) found that "two thirds of the construction clients regarded increasing cooperation as more important for achieving project success than exploitation of competitive forces". This once again emphasizes the need for long-term and closer collaboration. However, since high-involvement relationships requires a considerable budget and firms may not have enough resources to handle many of those relationships. Therefore, Gadde & Dubois (2010) suggest three levels of partnering which requires different managerial approaches by construction companies.

Local level partnering "departs from the benefits that have been attained in project partnering through intense interaction at the construction site." Even with project partnering, companies still need to take a different approach of selecting subcontractors and suppliers rather than tendering process. Collaborating with main contractors in local teams appears to be a possible alternative that could improve

efficiency and opportunities for knowledge transfer among projects over time, which in turn, results in long-term relationships.

Central level partnering "involves long-term agreements with specific suppliers for standardized products that are used across a wide range of projects and where adjustments are made at the construction site." Central level partnering relies on standardization to exploit the benefits of economies of scale in manufacturing activities, which means a supplier is selected for all projects. The objective of this level is to foster the relationships with selected suppliers as well as collaboration across projects. However, centralization means hampering local adjustments that force "strategic partnering" upon the local project level (Jones & Kaluarachchi, 2007).

Intermediate level partnering "regards agreements concerning supply of prefabricated and preassembled systems (…) that enhance interaction between firms in the "permanent" network through long-term and regular contacts with these suppliers". This approach balances the centralization and decentralization, which leaves some room for local adjustments but requires interactions overtime with a limited number of suppliers.

In order to cope with the complexity inherent in the industry, the companies involved just focus on the efficiency of a specific project, as Shirazi et al. (1996) (Ingemansson Havenvid et al., 2016; Ingemansson et al., 2017); Pagani and Pardo (2017)In order to cope with the complexity inherent in the industry, the companies involved just focus on the efficiency of a specific project, as Shirazi et al. (1996). In order to cope with the complexity inherent in the industry, the companies involved just focus on the efficiency of a specific project, as Shirazi et al. (1996) concluded that construction is mainly about coordination of specialized and differentiated tasks at the site level. Thus, the relationships among the actors within the project exist until the products are delivered. A buyer tends to switch suppliers for other project, as a result, even though buyers and suppliers have been involved in business with each

other for a long time, their transactions are irregular and intermittent (Gadde & Dubois, 2010).

4. Research methodology

4.1.Research strategy

According to Bryman and Bell (2011), the meaning of a research strategy is to generalize and orientate the business research. Qualitative research tends to be concerned with words rather than numbers, and its three noteworthy features are fitted to our purpose of research:

An inductive view of the relationship between theory and research: through analyzing the observations and positions of the experts within large companies in construction industry, we want to see how digitalization has changed the interaction of buyer - supplier relationship of construction companies.

- An epistemological position: in order to understand the influence of digitalization on the buyer - supplier relationships of construction companies, we scrutinize the interpretation of the industry's experts who has directly experienced and observed the change in their own interaction with other suppliers/buyers under the influence of digitalization.
- An ontological position: the properties of the buyer - supplier relationships after the intervention of digitalization are the consequences of continuous interactions among the participants over a period of time. Digitalization adoption is also an inevitable outcome of the needs of improving the industry's productivity.

4.2.Research design

We conduct the research by applying qualitative approach. Our first intention was to adopt the cross-sectional design, also called social survey design by studying the 10 largest construction companies in Norway. However, due to the limitation of data collection, we decide to narrow down the number of interviewed contractors to 03 companies and conduct following interviews with their subcontractors and suppliers. The 03 companies are chosen in a way that, to some extent, complement each other.

The research considers the perspective of the 03 biggest construction companies and of their main subcontractor as well as material supplier upon the impact of digitalization on their relationship with each other. The variation in the opinions of the observed companies due to the differences in companies' size, profit, specific position in the supply chain, and most importantly, the degree of IT adoption and realization is a fruitful source for us to derive the overall view of the influence of digitalization on the industry network through both suppliers and buyers' point of view. Among those 03 contractors, there is 01 contractors involved in a huge project that requires extensive technology usage.

We conduct the research at a single point in time. All the interviews are conducted in a short time (less than one month) to collect the data related to the understanding of the experts in the aimed companies about the effect of digitalization on the companies' relationships with the subcontractors and vice versa over long time. The construction industry is considered laggard in adopting innovations and the relationships also change slowly over time under the influence of any intervention, thus, it takes a long time for the companies to observe the clear trend in their relationships with others after applying digitalization. Therefore, the time of collecting data is considered a single point relative to the long-time of actual impact of digitalization being observed.

With the nature of qualitative research, semi-structured interview is chosen to gain more insights into the reformation of the construction companies' network via different perspectives of different buyers and suppliers. To establish variation in the personal view requires more flexible data collection methods rather than the standardized survey which can omit some important characteristics that cannot be included in any uniform questionnaires.

4.3.Data collection

The first intention was to collect the data about the top 10 biggest construction companies in Norway and their relationships development with the suppliers, which suits the intended cross-sectional research design. However, due to the time limitation resulted from both the research being conducted in the short time and the tight schedules of potential respondents, we were able to reach the three main contractors and their suppliers/ subcontractors. The 10 biggest

companies with their capabilities regarding finance, human resources and knowledge are the leaders in innovation within the industry. As IT development in the industry is still at the beginning phase with many obstacles and challenges, the observations on the practices of the leading organizations can yield better insights into the phenomenon than those on the practices of the small and medium enterprises (SME) which may not be able to reach the IT tools or have the limited capabilities to develop the tools to the extent that they can make an impact on the relationships between the SMEs and their counterparts. Suppliers/subcontractors respondents were selected based on 'snowballing' approach, where one interviewee would suggest someone else who would be appropriate for our study.

Data collected from the firms and their relationships combines pre-interview questionnaires and semi-structured interviews. Seven semi-structured interviews were conducted with the people in the management board of the firms. All interviewees are the ones who are in charge of managing the relationships with the companies' counterparts and have deep understanding about the digitalization process within their organizations: procurement managers in main contractor companies and sales managers or IT director/ equivalent position in the suppliers/subcontractors' companies. Focusing the interviews on the practice at central level allowed for developing a solid understanding how IT affects the interaction patterns between the companies in general which was considered sufficient for the purpose of our study. The interviews were conducted from April 2018 to June 2018. Five interviews took place at the firms' main offices, one was conducted via Skype and one took place at the respondent's construction site because of the special characteristics of the project. One main contractor (Main contractor 1) and its supplier (Material supplier 1M) were the chosen pilot cases to test the interview guide. All interviews were voice recorded, transcribed, and coded. In preparation for interviews, pre-interview questionnaires were sent out by email to the procurement managers of the main contractors only. These questionnaires asked for: job title; role in the company; length of time in construction industry and in the current company; degree of understanding about the digital tools within the organization; and opinion about the importance degree of some specific emerging IT suggested by the authors. In addition, interview guides were handed out to the interviewees in advance so that they can have preparation for the upcoming meetings. **Table *2*** provides an overview of the interviews conducted.

Table 2 Interviews conducted

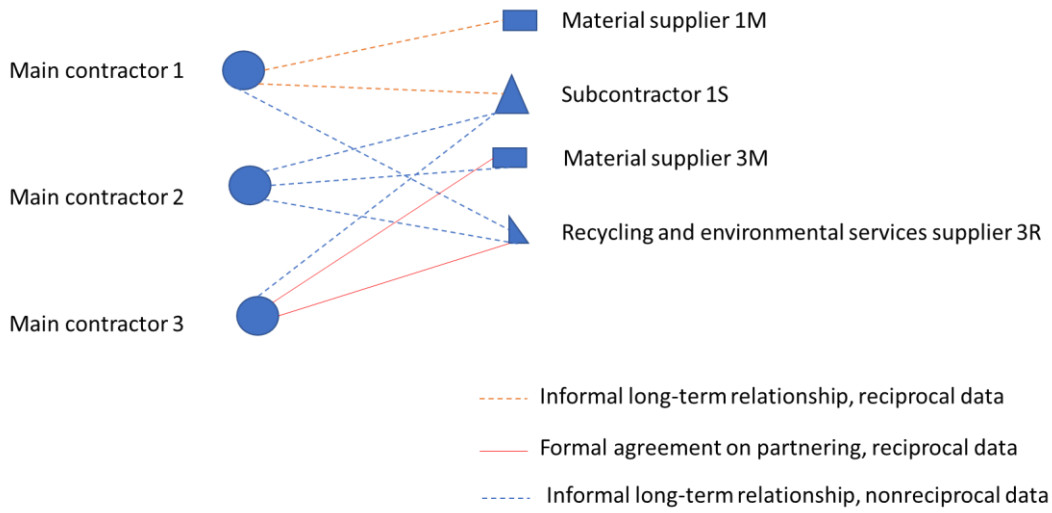
Company	Role of the respondent	Pre-interview questionnaire	Interview duration (extent of transcribed audio)	Interview mode
Main contractor 1	Chief Development Officer	Y	1 h 10 min (1:08:32)	Face-to-face
Main contractor 2	Manager project procurement building construction	Y	40 min (41:49)	Skype
Main contractor 3	Chief Ambition Officer/ Procurement manager	Y	2 h 15 min (2:15:48)	Face-to-face
Material supplier 1M	Business Developer		1 h (1:06:34)	Face-to-face
Subcontractor 1S	Digital director		1.5 h (1:26:07)	Face-to-face
Material supplier 3M	Sales director		1 h (58:13)	Face-to-face
Recycle and environmental service supplier 3R	Innovation manager		45 min (48:50)	Face-to-face

In the interviews with the procurement managers, we started by asking for clarification of the data collected in the pre-interview questionnaire to prompt the interviewee to narrate their interpretations of digitalization. After asking about the time when their companies started focusing on the IT development, we investigated into the change of the total number of suppliers the firms have connection with and their intention to the general supplier management after IT implementation. Then we tried to narrow down the scope of concerned suppliers to the ones who the companies have formal partnership agreement with or repetitive transactions across the project borders. Consequently, we discussed further how the main contractors value the pointed relationships and how the three layers of the relationship (Activity-Resource-Actor) have changed under the influence of each IT tool according to their importance ranks which were obtained from the pre-interview questionnaire. The questions were designed to avoid the abstract idea of the model and focused on the operational and practical perspective so that the respondents can answer with their best expertise. The interviews were closed with the questions about the interviewees' opinion about the opportunities and obstacles digitalization can bring to the organizations. The suggested suppliers/ subcontractors were revealed during the interview.

The interviews with suppliers/ subcontractors were to see how they perceive the relationships described by the main contractors and how they react to the change

from their counterparts under the influence of digitalization. Moreover, the industry is characterized of short-term orientation and adversarial nature where all the companies seek for standardized solutions and pursue arm-length relationships with each other, the approach of the main contractors to their subcontractors/ suppliers and vice versa is quite similar across the observations. Therefore, besides looking into the relationship between the suppliers/ subcontractors and the suggesting main contractor, we also discussed about those between the suppliers/ subcontractors and the other main contractors having the same size as the known one. In some cases, we could also acquire the reflective data related to the main contractors in the sample. **Figure *4*** presents the initial overview of the relationships characteristics among the observed parties which will be explained further in the next part of the paper. The relationships among the main contractors and among the suppliers/ subcontractors are out of the scope of this thesis, thus they are not showed in the figure. The red color indicates that the data about the relationship between a pair of companies was collected from both sides whereas the blue one indicates that the relationship connecting the two firms were only mentioned from only the supplier/ subcontractor side.

Figure 4 Overview of the relationships among the observed parties and characteristics of data collected



A semi-structured approach provides the respondents reflexibility to the answers (Bryman & Bell, 2011). This flexibility contributed to revealing the true perspective of the interviewee, which also made it possible to capture other important surfacing issues relevant to the topic. During the interviews, the researchers were able to customize the questions to fit the directions of the research

question and prompt the interviewees to elaborate their point of view. As a result, the interview questions in each meeting were slightly different in each meeting and did not follow the order in the interview guide. This kind of conducting the interviews guarantee the main objective in qualitative studies which is getting rich, detailed answers (Bryman and Bell, 2011, p. 469).

Moreover, a semi-structure method allowed the researchers to ask open questions and avoid questions that provide only yes/no answers. One main disadvantage of open questions is that it may be time consuming; in making the right questions, conducting the interviews and in coding the answers in a favorable way due to the large variation among the answers. Additionally, according to code of ethics, the interviewees were informed that the interviews would be recorded, and the interviewees were also made aware that the information will solely be used for the purpose of the thesis.

4.4.Data analysis

Getting familiar with the data to be able to generate insights is deemed important (Glaser & Strauss, 2017; Klag & Langley, 2013) that requires a process of constant comparison of going backwards and forwards between data and emerging theory and that data should not be forced to fit (Dubois & Gadde, 2002). We present our analysis in sequential steps:

Firstly, all the interviews are recorded and transcribed. Recordings are necessary as the researchers may miss something important while highly focusing on what was said. Furthermore, they made it possible to realize interesting points later on (Bryman & Bell, 2011). Thoroughly reading transcripts gives us an overview as well as some insights of the phenomenon. The interviewee's answers provided evidence on the project's activities, the communication process and operation with suppliers at project and corporate level. Secondary data could be provided due to the interest of the interviewees such as operation process, working models and internal reports.

Secondly, the data would be analyzed and coded according to the framework components (Miles & Huberman, 1994). Yin (1994) stated that "data analysis consist of examining, categorizing, tabulating, testing or otherwise recombining evidence to produce empirically based findings". We aim at breaking

down the data to identify the different parts and levels of the data, hence coding and categorizing the data before comparing to keep "close connection between data and conceptualization, so that the correspondence between concepts and categories with their indicators is not lost" (Bryman & Bell, 2011 p. 571).

Thirdly, the findings are reviewed according to the theoretical frameworks, that are the three layers of business interactions (activities, resources, and actors) and the three partnering categories.

4.5. Quality of research

4.5.1 Reliability

Reliability refers to whether a measure of a concept is stable or not (Bryman & Bell, 2011). It basically asks the researcher to make sure that if the study were to be repeated, it would yield the same results. In the survey, there are two important aspects to reliability; the use of a protocol and the development of a database (Ellram, 1996). Data collection steps, questions asked in the procedure, assumptions taken, limitations made, and challenges met, as well as detailed information about the sources used are all examples of information that will be provided. All of this will be presented in the thesis in a structured and detailed manner, in order for other researchers to be able to repeat the study.

The survey study protocol attached to our thesis will include an interview guide and the procedures that will be followed in this research. The study database will include completed interview guides, any additional notes taken outside the interview guide as well as a detailed summary write up. Furthermore, as a cross sectional design includes the use of multiple sources, all of the written documentation used as sources for the thesis will be included in the study database.

4.5.2 Validity

Mishler (1990) explains that "validity assessments are not assured by following procedures but by investigator's judgement". He has also pointed out that validation is often being applied to social science research in the same way as experimental research, with many studies being judged wrongly to lack academic rigor. He proposed that validation should be a theoretical rather than a technical problem. Therefore, in order to interpret the information gained from interviews objectively, we try to conduct intensive literature review on which we create the interview

guidelines and metrics to assess all the dimensions of the relationships regarding Actors-Resources-Activities.

External validity is concerned with the degree to which a study is generalizable to other situations. The selection of people chosen to participate in the study, becomes crucial in this context (Bryman and Bell, 2011), and will therefore be described in great detail in the thesis.

5. Empirical base and analysis

5.1.Empirical base

5.1.1. Companies background

Three companies among the 10 biggest construction companies according to Byggeindustrien's annual overview 2017 ("100 Største, 2017," 2017) are the representatives for the practices within the industry. They are the leaders in terms of innovation and development. Digitalization is on the main agenda of their strategies until 2020 and further. Aware of the opportunities brought by digitalization to productivity improvement, all three firms are focusing on developing and integrating digital interaction into every phase of operations not only within the organizations but also in the collaboration with their customers and suppliers. Within the scope of this paper, we just focus on the technologies that support the interaction between the main contractors and their suppliers. BIM, CAD technology, and cloud computing are now the center digital tools in all construction companies. In our discussion with the top managers in the companies, the first ever tool mentioned when they were asked about digitalization was BIM combined with CAD and its development. However, although BIM and its advantages were introduced more than a decade ago, the three companies just started to develop and implement for broad use across almost all projects 3-5 years ago. Therefore, BIM is just at its beginning phase of its development and there are still a lot of potential requiring the companies to explore. In communication with material suppliers or similar suppliers who do not participate directly in the work of erecting the buildings, the main contractors are now still mainly relied on phones and emails. Except Main contractor 2 has just developed the integrated ordering system with Material supplier 3M, the other 2 main contractors are planning to have one with their material suppliers.

The three main contractors (except the special project of Main contractor 3) pursue the traditional procurement practice where competitive bidding is the main tool to choose the suppliers. They almost do not have any formal agreements with the suppliers regarding partnering or long-term mutual development at company/ strategic level. Even though they have had relationships with some of the big suppliers and subcontractors in the market for many years and there are intense interactions among the personnel in the focal organizations, they still collaborate on project-basis and standardized contracts.

Subcontractor 1S is a leading technical contractor and service partner in Norway. It has technical expertise in the fields: ventilation, building automation, cold, pipes, electrical, etc. The relationships between 1S and the focal three main contractors were established long time ago but they are intermitten and reconnected by the projects where 1S wins the competitive bidding. 1S is also currently focusing on developing their competence in using BIM and CAD tools in order to compete in the market.

Recycling and environmental services supplier (RES supplier) 3R is a huge company which handles the 4th largest logistics volume in Norway (data from the respondent). Construction waste accounts for the biggest proportion of the total volumn it works on each year. 3R has relationships with almost all big construction companies in Norway including the three main contractors. Similar to the way 1S connects with their buyers, 3R also competes for the published projects and works with the main contractors based on standardized contracts.

Material supplier 1M and 3M are two of the biggest players in sales and distribution of construction products. Besides the main focus on providing building materials to the construction site, they also offer logistics services in construction and their future ambition is to cover the broader logistics work in each construction project they partake in . While 1M has developed relationship with only Main contractor 1, 3M has worked with both Main contractor 2 and 3 and even other big contractors in Norway. Transactions between material suppliers and Main contractors are repetitive across all projects with the delivery of standardized products, thus, the contracts are usually signed at company level and last for a specific longer period of time (few years) rather than those are signed at project level with other subcontractors/ suppliers. Whenever the main contractors need a customised product, they order by phone or email and sometimes a contract related

to the customization is established. Despite the long-term contracts between each other, material suppliers are still at the arm-length space with the main contractor, which means the two firms in the focal relationship do not have any organizational adjustments or adaptations.

1M, 3M, and 3R have quite advance digital system within their own firms which supports their complex logistics management. However, to collaborate with their customers, they are still using traditional tools to communicate and there are no synchronization between the two systems located in the buyer and supplier's organization. The coordination process relies on manual tasks and lacks efficiency. Besides the main communication tools such as email and phones, 1M, 3M and 3R are developing their own online ordering portals which contain all the products and services information they offer to the customers. Moreover, the online portals also help the main contractors to better manage their projects in terms of information related to products' type, volume and price, etc. Despite the provided advantages, the portals have not been able to automize the ordering processes because they are still separate from the digital system located in the main contractor company (except for the case between 3M and main contractor 2). The overview of the relationships among the observed parties is presented in **Figure *4*** in the previous section. **Table *3*** provides summary about the main contractors, type of contracts between them and their suppliers/subcontractors as well as the communication tools connect the parties besides email and phone.

Table 3 Overview of the main contractors and their relationships with the suppliers/subcontractors*

	Main contractor 1	Main contractor 2	Main contractor 3
2017 Turnover (million NOK)	4042.4	14500	13704
Number of employees	778	3800	3768
Contract with 1S	Y	Y	Y
Company/Project level	Project	Project	Project
Communication tools**	BIM and CAD	BIM and CAD	BIM and CAD
Contract with 1M	Y	N	N
Company/Project level	Both		
Communication tools**	Online portal		
Contract with 3M	N	Y	Y
Company/Project level		Both	Both
Communication tools		Online portal, integrated ordering system	Online portal
Contract with 3R	Y	Y	Y

Company/Project level	Project	Project	Project
Communication tools**	Online portal	Online portal	Online portal

*Not consider the special case of project B
**These are the emerging IT besides the common communication tools like email and phone

While the Main contractor 1 and 2 and the main part of Main contractor 3 try to avoid dependency and maintain their arm-lenghth relationships with the suppliers, in the pilot project B, Main contractor 3 promotes top management initiatives to manage long-term relationships in a more permanent way and thus strategically associate specific actors including 3M and 3R to its operations and various (sub)projects. In the next section, we would introduce about the project B and Main contractor 3's initiatives towards establishing the partnership with its suppliers/ subcontractors.

5.1.2. Introduction of project B, a different approach to collaboration in construction industry

Main contractor 3 is building a new project which utilizes the completely new procurement process of choosing suppliers based on the suppliers' capabilities and innovative mindset. The main project is planned to last 7 years with many sub-projects to be completed within the normal timespan of a typical project in the industry (18 – 24 months). The Main contractor 3 initiates the new partnering program where they try to create partnership with the key suppliers and subcontractors in order to fully digitalize the working process and achieve return to investment. These initiatives are taken on the firm level where a network of actors is formed as part of a strategic initiative to integrate different services and solutions across organizations to promote learning and adaptations as well as being able to offer a "package deal" to customers.

3M and 3R are among the participants who are collaborating to develop a better logistics system for the project. Their ambition is to develop the coordination plan so that the delivery trucks which carry the materials to the construction site do not return empty. Moreover, the project is testing the lean production principle in which the materials/products are delivered right at the time and place the buyer needs them. Lean production principle requires intensive and seamless coordination among the parties involved.

5.2.Analysis

In this section, we are going to analyse the change of the three layers of the relationships under the influence of the digital tools mentioned by the interviewees: BIM, CAD and web/ mobile portal. The partnerships between Main contractor 3 and 3M and 3R are at their beginning phase in which the parties' first pritority is trying to alter the traditional way of collaboration. The IT development is planned to be at the later phase of the project. We will investigate into the change in the relationships with the initiatives of promoting partnerships from the Main contractor 3 and the potential effects of the collaborating efforts on IT development.

5.2.1. Activity links

BIM and CAD technology have been proved to change the common way of collaboration in design and construction in many studies. Several companies have used BIM to change their operation processes (Construction, 2012) or to create a common environment for all information defining a building, facility or asset, together with its common parts and activities (Pittard, 2013). The three main contractors have been developing and currently use the BIM platform as the main tool to promote collaboration among actors in the design phase and at the construction site.

Instead of the traditional way of using 2D drawings on the paper, the main contractors, in most projects, use 3D model for designing and communicate with the subcontractors. At the pre-construction phase, the main contractors use 3D model (developed by themselves or provided by designers) to get an overview of the project. Subsequently, with the complementary digital calculation system, they can estimate the type, amount, quality of the materials, then export to excel files and give out the files to potential subcontractors for bidding. The subcontractors using the provided excel files and 3D model (not fully detailed at this phase) in return quote their products' quality and quantity as well as create the plan for their delivery and give an offer. The main contractors have used the 3D model and its complementary technologies to conduct the tendering process more efficiently. By giving more details, comparing to 2D drawings, about the project from overall view of design to information related to required products in terms of quality and quantity, the main contractors can better assess the subcontractors and avoid the risks in the construction phase regarding the subcontractors' inability of delivering the products because of lack of capacity. On the other side, the new technologies also facilitate

the subcontractors' planning process and help them to allocate capacity to their projects reasonably. After winning the project, the subcontractors use their own system to put their specialization-related variables into the BIM model given by main contractors and sometimes the models given by other subcontractors. In the case of the observed subcontractor who provides ventilation, plumbing, electricity, etc. installation services, it needs the concrete model with all the windows from the concrete subcontractor. The new developed models are resent to the main contractor who usually has the BIM coordinator to combine all the models into one integrated model for later use and update in the construction phase. The process described above is currently adopted in most of the projects conducted by all the three main contractors. The pilot project B is an exception where the subcontractors or suppliers in general are selected based on their solutions and ambitions which are aligned with the problems and ambitions presented by the main contractor in the project introduction meeting facilitated by 3D model about the project.

At the construction phase, the design and construction activities are carried out simultaneously and coordinated more efficiently with the support of BIM and 3D models. Regarding design activities, communication via traditional channels such as email, phones gradually shifts to using face-to-face or skype meetings with the presentation of the 3D models. The representatives from the involved parties meet each other every week to assess all the presented errors, discuss and test the solutions right on the model. The updated model is distributed to the assigned people at the construction site via cloud system and they can access all the digital drawings and models by using smart tablets or smart phones. Moreover, BIM also allows the people on site to report the errors directly on the model so that all the parties involved, especially the subcontractors who are in charge can figure out the problems and provide the solutions. All the communication during the detect-and-fix-error task can sometimes completely occur on BIM collaboration platform where the errors and solutions are uploaded. The communication via phone or even on-site between the workers/engineers at the construction site and the ones at the office can be reduced thanks to the new system.

Website and mobile app provide detailed information about the suppliers' products and services and help the main contractors to better control their projects. After having the list of needed products which is exported from the designed models

of the projects, the buyers get access to the online portal to order the products. Each project is assigned a unique ID number so that the suppliers can identify the buyers' location and the personnel at the supplier's office can take the order and send information to the internal system for delivery. With the traditional ordering process via email, the project manager can hardly check whether the products delivered onsite are according to his orders because of the complexity of the projects in which different places within the construction site may need the materials at the same time and the complex combined information can be overwhelmed to human. With the portal's ability of storing the information about a specific project, the project manager can know, calculate, and control the cost of the project's materials overtime with fewer errors. However, the portal still requires a lot of manual works from both sides. The project manager has to have the list of the products he needs and puch manually into the portal. The personnel who takes the order from the portal has to manually process the order and ask the warehouse for delivery. The integrated system between Main contractor 2 and 3M has helped to remove the manual work at the supplier's side. The procurement officer with the digital purchasing tool can directly go to the 3M's system to check the availability of the products, make the order and have the products delivered. However, there is no such similar system between Main contractor 1 and 1M or Main contractor 3 and 3M.

5.2.2. Resource ties

The current implementation of IT tools such as BIM and CAD, web portals has increased the awareness of the involved parties about the resources of each other. The use of BIM and CAD to provide the information about the project and its initial requirement of the quality and quantity of the products at the bidding phase helps the suppliers have a better picture about the demand of the buyers. As a result, they can have better plan and suitable adjustment of their resource capability to participate in the project. The same logic applied to the buyer side, the tender from the supplier based on the more detailed planning information given by the model is a good tool for the main contractor to capture more data about the supplier's capability and suitability for the projects. The frequent discussions around the models among the participants in the construction phase helps virtually visualize and test the combinations of resources. However, not all the suggested solutions are

more easily realized. The use of IT just facilitates solving the solutions that rely on the available resources on site or do not require the complex technical adaptations from the organizations. The web portals offered by material suppliers and RES supplier makes those suppliers' resources visible to the buyers. The information about thousands of products is made available and accessible regardless of time and place. Nevertheless, all of the products are standardized and customization still requires traditional process. The use of IT does improve the visibility of the information about the standardized resources of the parties but have not showed its ability in facilitating the process creating customization among the parties.

From other perspective, the digital tools and their systems are considered as one type of resource which require the companies to develop. There exists some initiatives to combine the digital platform in separate organizations into the integrated one but these efforts are not applied to all type of digital tools.
Regarding the use of BIM and CAD, the main contractor provide a digital collaboration platform in which the subcontractors can upload and combine their models. The subcontractor 1S develops their own model in its internal system, export the data into a standard format and subsequently send it to the main contractor's system for combination. This can be enabled only if all the models have the same format and can be read on the platform. The current open BIM model is now the solution for the industry. The main contractors can frequently switch the suppliers across projects as they do not have to rely on any specific suppliers who could deliver the specific solution format that could be read on the company's platform if the open BIM did not exist. Therefore, even though BIM creates the environment for the involved parties can better combine their expertise in the project, it does not require new or more intensive resource combination in the permanent relationships between the two companies.

Opposite to the effects of BIM, the integrated ordering system between main contractor and material suppliers require intensive adapatation from both sides. The integrating ordering system between Main contractor 2 and 3M took 1.5 years to be put into operations. During the process of developing the integrating system, the personnels in the two organizations had to frequently have meeting with each other to find the solutions for the two complex systems talk to each other. Currently the

digital developers in the two companies are still working closely with each other to do manual check and keep developing the system. Although integrating the system does not require much financial investment in developing the infrastructure, it requires intense human capital to sort out the difference between the two complex systems. The respondent in 1M explained further the problems it is facing when 1M and Main contractor 1 are planning to have the integrated system with each other. The digital platform of each company is the place for many systems located in the different departments can connect to each other. One change in the platform or in any single system can affects the whole ecology of systems. The problem is bigger when the organization structure is more complex. 1M and Main contractor 1 are both big companies with several interdependent departments and processes, which results in the bulky systems which are hard to adjust. Therefore, it will be a long way for the two companies to develop the mutual integrated system.

In project B, Main contractor 3 prompted its partners to have their small team on site. The representatives of the companies have the meeting once a week to make the plan for the next week. The aim is to deliver exactly "what they need when they need it" (3M). After creating the production and deliver plans for the next week with the people from the buyer, 3M starts to coordinate logistics which is facilitated by GPS technology. In terms of customized products, the people on site work closely together to develop the most innovative solutions and the products' specifications are stored on the collaborating platform provided by the main contractor. All the partners involved can log into the platform and retrieve the data for production at their manufacturing site. At the beginning phase of the partnerships, the parties are learning how to collaborate better. Therefore, all the coordinating activities are now still doing manually. The plans for material delivery are created by the 3M's people after they meet up with the people from maincontractor 3 and 3M's representatives will send the order to the sale office instead of using the web portal offered by 3M to other main contractors. The ultimate aim is to have the materials delivered automatically at the right place whenever they are needed. Therefore, after the 3M and the main contractor 3 acquire enough knowledge about lean production and its nature, the development of an integrated ordering system between the two parties is inevitable.

5.2.3. Actor bonds

BIM and CAD promote the collaboration among the personels partaking in the project. Through frequent meeting with each other to find out the solutions, the personal relationships have been developed. However, with the support of open BIM, the main contractors can switch suppliers across the projects, which does not foster the long-term relationship with the potential suppliers. Due to the short-term nature of the projects, it is hard for trust and commitment to be developed at the company level. The main contractors still remain the arm-length relationships with the subcontractors because with their power in the market, they expect the subcontractors to have enough expertise in using BIM and CAD to collaborate with them. Likewise, the subcontractor 1S did not see any opportunities for it to develop further relationships with the buyers. The main opportunity 1S saw is that BIM support the creation of more detailed contract with more specification and close collaboration within the projects. However, the main contractors did mention about their intention of focusing more one the big technical installation suppliers who have more advance capability and expertise about the digital tool than other type of subcontractors.

Separate web portal does not show any obvious effect on the way the companies see each other either even though it helps visualize the suppliers' resources. In contrast, integrating web portal to the ordering system of the buyer can result in positive effects. The integrated system first requires a certain level of trust between the two companies. Main contractor 3 and 3M have collaborated with each other for many years, and they are both one of the biggest players in the industry which means that they have the capabilities to develop together in the long time and the portal guarantee to bring the return to investment. The initiative being taken by the Main contractor 1 and 1M shares the same logic. 1M provides the largest volume of materials products to most of the Main contractor 1's projects and Main contractor 1 is the biggest customer to 1M. The integrated system development process has in turn increased the trust between the two parties. In order to understand the complex system of the counterpart, the material suppliers had to have several meetings with the management board of the customers' firms to understand the strategy and intention of the customer in the long future with the tight connection via the system.

In project B, the Main contractor 3 takes many initiatives to improve the trust and commitment of the participants on the projects. Besides the initiatives to involve all the top management in the projects by conducting weekly meeting, the main contractor also focused on developing personal relationships with the individuals in its partner firm to make sure that those people can achieve their own goals after finishing the project. Main contractor 3 also observed that there are the variation in the innovation mindset among its potential partners. The innovation mindset is very important in collaboration. When all the parties involved have the same innovation mindset level, they can have the same interpretation of the mentioned (usually complex) concepts, which reduces misunderstandings about the complicated terms and improves the collaboration process. Therefore, before signing the contracts with the potential partners, the main contractors also invested directly time and human resource (send its employee to the suppliers' site to give the training) or acted as a facilitator between its two suppliers which also have the buyer-supplier relationship so that the company with higher level of innovation mindset can help the one with lower level can develop to catch up with other players in the network. The improved trust and commitment have encouraged the firms to invest and try to adapt their resources for better innovation.

6. Discussion

6.1. Different digital tools have different effects on the relationship

From the analysis section, we can see that BIM and CAD has different effects on the buyer-supplier relationship from web portal does. BIM and CAD have promoted tighter collaboration among the parties involved in the project. The technology has created the environment where the actors can effectively communicate and coordinate with each other (activity links). The resource combinations in some cases can be enhanced thanks to the meetings among the participants in order to improve the design model. However, the tight interaction among the parties to find the new way of combining resources has the biggest effect when those adaptations can be conducted with the available resources on site or do not require much adjustment from the two companies. The actor bonds which are developed under the BIM implementation does not change much due to the practice of competitive tendering. Despite the advantages of BIM in collaboration, the interactions are tight in the project network and loose in the in the permanent company network. This is

aligned with the idea of Y. Liu et al. (2017) that “BIM projects are often tightly coupled technologically, but divided organizationally. This means that BIM is not fostering closer collaboration across different organizations though it makes connections among project members visible” (Dossick & Neff, 2009).

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Appendices

Appendix 1. Pre-interview short survey

Appendix 1.1 Short survey about the company's current application of digitalization

(The online survey can be accessed via this link: https://goo.gl/forms/NLZTfZly4TQ5BGtk2)

Dear participant,

We are two Master students from BI Norwegian Business School, Oslo, Norway. We are writing a thesis which studies on "The influence of digitalization on the buyer-supplier relationship in the construction industry".

In order to gain more insight about the effect of digitalization on the supplier-buyer relationship in the construction industry, we would like to get more information about the current state of digitalization application in your company. This short survey is complementary to the interview which we will conduct with you later. Your information will be used as crucial resources for our study and will only be shared among us (2 MSC students) and our only one supervisor, Lena Elisabeth Bygballe, Associate Professor - Department of Strategy and Entrepreneurship, BI Norwegian Business School, Oslo, Norway.

If you have any question regarding the research or the survey or if you have any recommendation for our study, please do not hesitate to contact us via email:

Hoa Thanh Hoang: hthoamm@gmail.com

Hanh Thi Hoa Pham: phamthihoahanh.mac@gmail.com

Thank you for your cooperation!

First of all, we would like to know more about your professional background in relation to your company.

1. Please state your name
2. How long have you been working with your company?
3. How many years of experience do you consider yourself working in construction industry?

4. How familiar do you consider yourself to the company's technology system?

	1	2	3	4	5	
Not at all	○	○	○	○	○	Very familiar

Current state of digitalization application in the company

1. Please choose the degree of importance in the scale 0-5 to give your opinion about the importance of each technology to the supplier relationship management or the way your company interact with the counterpart.

	0 - Your compa...	1 – the technol...	2 – the technol...	3 – the technol...	4 – the techno...	5 – the techno...
Extranet	○	○	○	○	○	○
Email, mobile p...	○	○	○	○	○	○
Cloud Computi...	○	○	○	○	○	○
BIM	○	○	○	○	○	○
CAD and 3D CA...	○	○	○	○	○	○
GIS, GPS, RFID	○	○	○	○	○	○
Big Data	○	○	○	○	○	○
Augmented Re...	○	○	○	○	○	○
Internet of Thin...	○	○	○	○	○	○
Robotics	○	○	○	○	○	○
Cyber-Physical ...	○	○	○	○	○	○
Modularisation	○	○	○	○	○	○

2. Other technologies that you think are important

Appendix 1.2 Survey results

	Main contractor 1	Main contractor 2	Main contractor 3
Extranet	5	2	0

Email, mobile phones, internet communication	5	5	5
Cloud Coputing, Mobile Computing	3	5	4
BIM	4	5	5
CAD and 3D CAD technology	5	5	5
GIS, GPS, RFID	1	4	4
Big Data	1	3	2
Augmented Reality (AR)/ Virtual Reality (VR)/ Mixed Reality (MR)	0	3	3
Internet of Things	0	4	3
Robotics	0	2	4
Cyber-Physical Systems (CPS)/Embedded systems	0	0	0
Modularisation	0	5	2

0 - Your company does not use the technology

1 – the technology is used but not important at all

2 – the technology is used and important to some extent

3 – the technology is used and fairly important

4 – the technology is used and important

5 – the technology is used and very important

Appendix 2. Interview guideline

Appendix 2.1 Interview guide for contractors

Thank you very much for your answers in the short survey. These questions below are the ones we are going to use in the upcoming interview. We hope that these questions can give you an overall view of our intention in the study and help you have a good preparation.

Questions for interview

1. Could you tell us briefly about your responsibility at the company?

2. What is "digitalization" from your perspective?

3. From when do you think your company has integrated digitalization into business?

4. Do you see any change in the total number of suppliers you work with?

5. Do you have any big suppliers that you have a partner agreement with? How much proportion do they make up in the total number of suppliers? Do you see any changes in this proportion after digitalization?

6. Are there any suppliers that you work with more frequently than with the others (more projects)? After digitalization, do you collaborate with them more often? Are there any new potential suppliers you want to meet again in several forthcoming projects?

Now, we would like to interview in more detail about the influence of digitalization on your long- term relationship with the supplier. If your company have a partnership agreement with the suppliers or your company has repetitive purchasing activities across projects with one specific supplier without any formal agreement, please look at the questions in ***Session A.*** Otherwise, you can move to ***Session B***.

Session A

First, please choose one typical supplier that you have the most digital interaction with.

1. Regarding the relationship with your chosen supplier, could you please list down the technologies you are using to cooperate and communicate with them?

2. Which one do you think is the most important to developing your relationship with the (chosen) supplier?

3. Regarding the chosen technology, does your company or your supplier own the technology platform?

4. How does it change the way you coordinate with that supplier towards efficiency and effectiveness in the long term? Could you please elaborate more your point of view by giving an example of using the technology in a project in which you worked with the supplier?

5. Did you face any obstacles when applying the technology to the operation? How have your company prepared itself in terms of human resources as well as infrastructure to integrate the technology into the operation?

6. How important is your partner to your company now compared to when there was the absence of digitalization? Do you trust each other more?

7. Have you ever cooperated with the supplier to improve the technology platform?

Session B

This session is for companies having no partnership agreement with any suppliers or in the case that there is no specific technology facilitating the repetitive purchasing activities with one specific supplier across projects

Go through each technology in the order according to their important degree (based on the answer to the survey)

1. How do you use the technology to coordinate with the suppliers? Could you please elaborate more your point of view by giving an example of using the technology in a project in which you worked with the supplier?

2. Did your company develop the (specifically pointed out) technology by itself/ receive from your supplier/ or buy from another third party company?

3. How have your company prepared itself in terms of human resources as well as infrastructure to integrate the technology into the operation?

4. Does (the mentioned technology) improve the suppliers' commitment to the project? Does it increase your trust with the suppliers?

Finally, we would like to know more about your opinion about the opportunities and challenges of digitalization to your future supplier relationships:

1. What are the opportunities towards using digitalization in your relationships within the supply base?

2. What are the obstacles towards using digitalization in your relationships within the supply base?

Thank you very much for your cooperation. We are looking forward to our meeting! If you have any questions regarding the interview questions above, please do not hesitate to contact us. We are grateful to have any recommendations to make our study better.

Appendix 2.2 Interview guide for subcontractors

These questions below are the ones we are going to use in the upcoming interview. We hope that these questions can give you an overall view of our intention in the study and help you have a good preparation.

General information

1. Can you let us know your position and your responsibility in your company?

2. How long have you been working at the company?

3. Who are the targeted customers of your company?

4. What is "digitalization" from your perspective?

5. From when do you think your company has integrated digitalization into business?

For general customers

1. Which kind of technology do you use to work with the customers? (Email, Cloud, BIM…)

2. Could you share with us more detail about the process that you are coordinating with them?

3. Does your company or your customers own the technologies?

4. Do you have long-term formal agreements with the customers or are the contracts created for each specific project?

5. Are there any differences in the coordinating process with companies of different sizes? Do you develop tailored digital coordinating platform for some specific important buyers?

6. Did you face any obstacles when applying the technology to the operation? How have your company prepared itself in terms of human resources as well as infrastructure to integrate the technology into the operation?

7. Do you think the technology helps to improve the transparency of the relationships with most customers?

Regarding the specific relationship with one specific company

1. When did you start working with (company)? (From when did you have frequent contact with them?)

2. Do you have any formal agreement with (company)?

3. What kind of technology do you use to interact with (company)? (Email, Cloud, BIM…)

4. Does your company or (company) own the tehnology?

5. Could you share with us more detail about the process that you are coordinating with (company)?

6. Did you face any obstacles when applying the technology to the operation? How have your company prepared itself in terms of human resources as well as infrastructure to integrate the technology into the operation?

7. Are you satisfied with the current process? Do you see any need for development?

8. Do you have any plan to develop a mutual system with (company) for better efficiency?

9. Do you think the technology helps to improve the transparency of the working process (information exchange, quality control) between the two companies?

10. Have you ever had any conflict while working with each other? If yes, does technology help you to figure out problems faster?

11. Do you regularly meet each other to review the problems or find way to improve the technology scheme?

Finally, we would like to know more about your opinion about the opportunities and challenges of digitalization to your future customer relationships:

1. What are the opportunities towards using digitalization in your relationships within your customer network?

2. What are the obstacles towards using digitalization in your relationships within your customer network?

Thank you very much for your cooperation. We are looking forward to our meeting! If you have any questions regarding the interview questions above, please do not hesitate to contact us. We are grateful to have any recommendations to make our study better.

Appendix 2.3 Interview guide for material supplier

General information

1. Can you let us know your position and your responsibility in your company?
2. How long have you been working at the company?
3. Who are the targeted customers of your company?
4. What is "digitalization" from your perspective?

Regarding the specific relationship with (company)?

1. When did you start working with (company)?

(From when did you have frequent contact with them?)

2. Do you have any formal agreement with (company)?
3. What kind of technology do you use to interact with (company)? (Email, Cloud, BIM…)

   (When did you start utilizing this technology to work with them?)

4. Could you share with us more detail about the process how you are coordinating with (company)? Do you work with them based on a specific project or on the orders you receive from (company) every day?
5. Do you get any access to (company)'s technology platform in order to see the demand in each project? (If yes, do you find it difficult to follow up with the system?)
6. Have you ever developed any technology to keep track of the order patterns from (company)?
7. Are you satisfied with the current process? Do you see any need for development?
8. Do you have any plan to develop a mutual system with (company) for better efficiency?

   (Do you think this development will raise the need for formal agreement with (company) in the future? Ask if they have not had any formal agreement)

9. Do you think the technology helps to improve the transparency of the relationship between the two companies?
10. Have you ever had any conflict while working with each other? If yes, does technology help you to figure out problems faster?
11. Do you regularly meet each other to review the problems or find way to improve technology scheme?

For other customers

1. Besides (company), do you have any similar size customers?
2. Do you have formal agreement with other companies or you work by orders like (company)?
3. Do you apply the same technology that are being used to interact with (the above-mentioned company) to work with other companies? For the smaller companies, how do you interact with them?

If no, which technology are you using?

4. Do you use the same process to work with other buyers? Are there any differences in the process with companies of different sizes?
5. How have your company prepared itself in terms of human resources as well as infrastructure to integrate the technology into the operation?
6. Do you think the technology helps to improve the transparency of the relationships with most customers?

Future expectation:

1. What are the opportunities towards using digitalization in your relationships within your customer network?
2. What are the obstacles towards using digitalization in your relationships within your customer network?