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School of Business and Management

Supply Management

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**Assessing the Leanness of construction organizations: A case  
study**

*Master's thesis 2019*

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## **ABSTRACT**

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The purpose of this thesis was to evaluate the current state of Lean in the case organization and identify the success factors and obstacles present in Lean implementations. Further, the aim was to recognize the factors that contribute to successful supply chain performance in Lean and the construction industry, and to give the case company suggestions for future Lean initiatives. Finally, a Leanness assessment framework was created based on the reviewed literature, as such frameworks are absent in the construction industry.

The study started with a comprehensive literature review on Lean, the construction industry and Lean construction. Following, secondary data was presented to support the results from the primary data. The two primary data collection methods were qualitative interviews and a survey questionnaire. The results from the empirical section and the literature review were used to evaluate the current state of Lean in the case company. The study identified multiple critical development areas for the case organization. Improvement suggestions were given for the company to establish a solid basis for possible future Lean initiatives.

## TIIVISTELMÄ

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Tämän tutkielman tavoitteena oli arvioida case-yrityksen Leanin laaja-alaisuutta ja tunnistaa ne menestystekijät ja esteet, jotka ovat läsnä Leanin implementoinnissa. Lisäksi tarkoituksena oli tunnistaa ne tekijät, jotka vaikuttavat hankintaketjun menestykseen sekä Leanin implementoinnissa, että rakennusalalla, ja antaa case-yritykselle ehdotukset, kuinka edetä tulevien Lean-aloitteiden kanssa. Lopuksi tutkimuksessa luotiin viitekehys arvioimaan, kuinka laaja-alaista Lean on rakennusyrytyksessä, koska tällaista viitekehystä ei ole olemassa rakennusalalle.

Tutkielma alkoi laajalla kirjallisuuskatsauksella Leanista, rakennusalasta ja Lean constructionista. Tämän jälkeen toissijainen data esiteltiin ensisijaisen datan tueksi. Ensisijaista dataa kerättiin laadullisten haastattelujen ja kyselylomakkeen avulla. Empiirisen osion ja kirjallisuuskatsauksen tuloksia käytettiin yrityksen Leanin nykytilan arviointiin. Tutkielmassa tunnistettiin monta kriittistä kehitysaluetta case-yritystä koskien. Yritykselle annettiin kehitysehdotukset, jotta tulevia Lean aloitteita varten saataisiin luotua vankka pohja minkä päälle rakentaa.

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I have enjoyed some of my time in Lappeenranta. I have met pretty decent people throughout my time there. Some of them have helped me a lot to write this thesis, but others could not answer the simplest of questions and I thank the ones who actually contributed. On a more serious note, I want to thank my instructor for helping me to write this thesis and giving me advice along this journey. I also want to thank my grandmother and grandfather for hosting me for lunch every other Sunday in Lappeenranta – the food was amazing each time.

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Tikkurila, April 2019

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## 1. INTRODUCTION

Lean thinking was first introduced by Taiichi Ohno in the form of Toyota Production System (TPS) and was brought to awareness of the general audience by Womack and Jones (1990; 1996). The goal of the TPS was to improve the quality and productivity of the traditional mass production used in manufacturing (Liker 1998, xiv). Womack and Jones' (1990) publication generated increased research into the adoption of Lean practices and soon Lean spread to other manufacturing and service industries (Holweg 2007). Lean aims to identify the value-added and non-value-added process steps and to eliminate waste so that ultimately every step adds value to the process (Miller 2005). This is best achieved through the continuous improvement process *kaizen* (Hines and Rich 1997), which is fundamental in Lean thinking. Krafcik (1988) first introduced Lean in a production system context (Shetty et al. 2010) and concluded that the operating performance was highly affected by production management practices and utilizing the Lean methodology in management practices and moving the corporate culture towards the Lean model made companies more competitive and efficient in terms of productivity and quality.

The construction industry is one of the major industries in every country and it comprises several manufacturing and service sectors and building systems (Horvath 2004). Construction can be summarized as “the design and assembly of objects fixed-in-place, and consequently possesses, more or less, the characteristics of site production, unique product and temporary teams” (Ballard and Howell 1998). Construction differs greatly from manufacturing since the end products cannot be moved, compared to manufacturing where the products are moved to retailers or straight to end customers. (Salem et al. 2006) The construction environment is highly dynamic, complex and unpredictable, and there are multiple activities in place simultaneously, which makes the successful planning and coordination of tasks hard to accomplish. (Fearne and Fowler 2006) Delays are common in construction and are caused by late design and design documents, poor site management, late delivery of materials, delays in progress payments and by insufficient project planning and scheduling (Assaf and Al-Hejji 2006; Gebrehiwet and Luo 2017).

The construction industry has been criticized for forming ineffective project teams and having a fragmented approach to project delivery (e.g. Love et al. 1998; Baiden et al. 2006), which has resulted in subpar performance in communication, collaboration and costs (Evbuomwan and Anumba 1998). Procurement practices used in construction have dwarfed the incentive to create collaboration and integration among the participants, and the absence of trust between clients, main contractors and subcontractors is significant. (Fearne and Fowler 2006) This has created separation between functions (e.g. the design and the construction process) and led to a situation where communication processes and cooperation between the functions are ineffective (Love et al. 1998).

Business and competition between companies is continuously more relied on complex relational networks rather than the strengths of individual supply chains (Martin and Towill 2000), and various industries have proven that supply chain integration is important (Cheng et al. 2010) and supply chain collaboration can be used to achieve competitive advantage (Akintoye et al. 2000). While other industrial sectors like retail distribution have already moved towards more integrated and effective supply chains (Briscoe and Dainty 2005), the construction industry is the least integrated large industrial sector (Fearne and Fowler 2006). Construction industry requires a significant paradigm shift to be able to integrate the construction projects' every key participant together through management practices (Evbuomwan and Anumba 1998).

Lean construction (LC) has been used to manage the inherent problems related to the construction industry. Lean construction was first introduced by Koskela (1992), calling it "the new production philosophy". The paper emphasized flow processes, variability and continuous improvements in waste, value and efficiency as the key aspects of LC. Although Koskela (1992) drew attention to the subject, LC became a more discussed topic between practitioners when the Department of Environment, Transport and the Regions published a work called "Rethinking Construction" in 1998. While debate exists regarding the definition and use of Lean construction, it has been utilized in organizations with differing methodologies and results. (Green

and May 2005) Some claimed benefits of LC are productivity gains, more satisfied clients, shorter lead times, reduced costs and improved quality (Mossman 2009).

### 1.1. Research questions and objectives

Lean methodology has been applied to the construction industry through Lean construction and its tools in numerous case studies (e.g. Choo et al. 1999; Salem et al. 2005; song et al. 2008; Kalsaas 2012; Khaba and Bhar 2017) and the use of Lean construction is growing in the construction industry (Tezel et al. 2018). For example, multiple LC initiatives have been conducted in the Finnish construction industry (LCI 2018). Despite the increased research regarding LC, there seems to be no comprehensive framework to assess how widespread Lean or Lean construction is in a construction organization. Much of the Lean construction literature focuses on its singular aspects like tools (Kalsaas 2012) or barriers of implementation (Khaba and Bhar 2017), and while authors such as Kim and Park (2006) have assessed the implementation of Lean construction in construction projects, the literature lacks assessment methods that evaluate the organizations holistically. As Narayanamurthy and Gurusurthy (2016) summarized in their literature review regarding Leanness assessment frameworks; “hardly any study has developed an assessment methodology that captures the systemic nature of Lean practice implementation at a firm level.” Therefore, the purpose of this thesis is to assess the Leanness of the case organization in company level, and to create a framework to assess the Leanness of a construction company. Following, the main research question for this study is:

**RQ1:** How comprehensive is Lean thinking in the case company?

Further, Narayanamurthy and Gurusurthy (2016) observed that none of the Lean assessment frameworks consider behavioral aspects in the implementation and do not capture the whole Lean journey of the company. For example, failures are presented based on the initial stage of Lean implementation without considering how future developments would affect them. To be able to evaluate the former, current, and future state of the companies thoroughly it is seen necessary to identify

the success factors and obstacles present in Lean implementations. Therefore, the second research question is:

**RQ2:** What are the success factors and obstacles in Lean implementations?

Lastly, Narayanamurthy and Gurumurthy (2016) noted that leanness assessment at supply chain level is at its very nascent stage, as only few studies have tried to assess how Lean implementations impact the other companies in the supply chain. This study does not directly aim to evaluate the impacts of Lean implementations thorough the supply chain, but rather aims to identify the factors that contribute to successful supply chain performance in both Lean implementations and the construction industry. Consequently the third research question is:

**RQ3:** Which factors contribute to successful supply chain performance in Lean thinking and the construction industry?

After assessing the Leanness of the case organization and answering these research questions the researcher aims to give suggestions to the case company on how to move forward with Lean. The goal is to give the case company concrete examples to follow to improve its existing Lean activities. Finally, the Leanness assessment framework will be presented.

## 1.2. Research methodology

An explanatory approach was chosen for this study, since there is no clear consensus on the nature or extensiveness of Lean in the case company. Explanatory studies aim to establish causal relationships between variables and this can be achieved through quantitative and qualitative methods. (Saunders et al. 2009, 140-141) Single case study methodology is applied in this thesis. Case studies aim to get a holistic understanding about the studied phenomenon, which can be achieved by triangulating several sources of data. Triangulation means that the data gathered through various techniques (e.g. qualitative interviews and a

questionnaire) are used to confirm the reliability of the results. (Saunders et al. 2009, 145-146) This study pursues triangulation by comparing the results from the literature review, qualitative interviews, survey questionnaire and secondary data.

The study will begin with an extensive literature review on Lean, the construction industry and Lean construction. The purpose of the literature reviews is to have a comprehensive understanding of Lean and what are the success factors and obstacles in its implementation. Further, the literature review aims to give insight of the construction industry's unique qualities like fragmentation to understand the existing idiosyncrasies to be able to analyze them. Lastly, Lean construction literature is reviewed to understand how Lean has been applied to the construction industry. The Lean and Lean construction literature will be used as the basis to evaluate the Leanness of the case company. Moreover, the relevant topics identified in the literature review are used as a basis for the qualitative interviews and the questionnaire.

The literature review is followed by qualitative interviews, which can be either unstructured or semi-structured. *Unstructured interviews* (i.e. in-depth interviews) are used to get an in-depth understanding of the topic by having a free discussion with a participant. Unstructured interviews are the most flexible, hard to analyze and require the most time for analysis. (Patton 2002, 341-343) *Semi-structured interviews* have pre-defined questions and themes, but the researcher is free to add or omit questions as the interview progresses, aiming to get the most relevant information about the discussed topic. (Saunders et al. 2009, 320-321) The interviews conducted in this study are somewhere between unstructured and semi-structured interviews. While the intention was to use unstructured interviews to get as in-depth information as possible, due to the researcher's inexperience regarding qualitative interviews it was seen necessary to have some pre-planned topics to keep the interviews focused on the topic and to avoid sidetracking, guiding the interviews towards a mixture of the two types. For coherence, the interviews will be called qualitative throughout this study.

Lastly, the qualitative interviews are used to develop a survey questionnaire, which aims to provide generalizability and reliability for some of the interviews' results. The results from the literature review, qualitative interviews and the questionnaire will be combined to answer the research questions. The Leanness assessment framework will mainly be based on the extensive literature review. Further, secondary data are collected to understand the case company's past, current and future Lean-related initiatives to be able to better give suggestions on moving forward.

### 1.3. Structure

The theoretical structure of the thesis is shown in figure 1. The main purpose of each process step was explained in the previous section. First, in chapters two and three the literature review on Lean, the construction industry and Lean construction is carried out. The literature review is followed by the used research methodology explaining the reasoning for each data-gathering method and how the data gathering process was carried out in practice. Following, a short introduction for the case company is given and the secondary data presented.

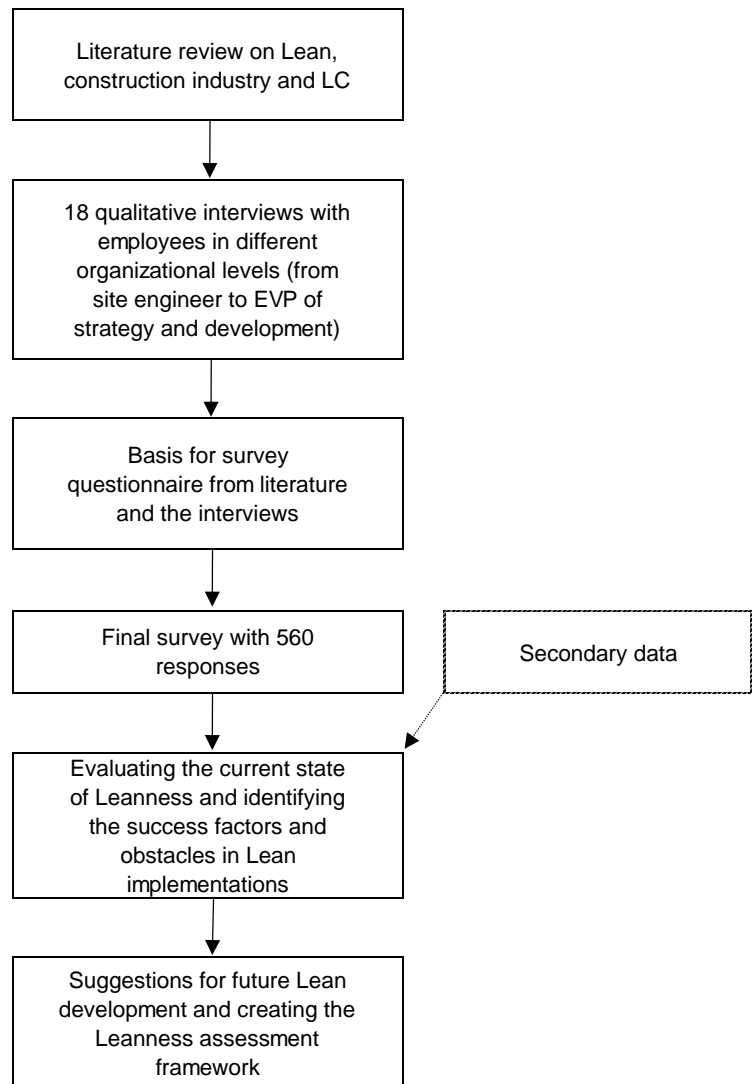


Figure 1. Theoretical structure of the thesis.

The fifth chapter presents results for the qualitative interviews and the survey questionnaire. The goal is to give in-depth information about the case company based on the quantitative and qualitative data. Next, the sixth chapter combines the qualitative and quantitative data with the literature review to answer the research questions. Lastly, the Leanness assessment framework is created and the case company is provided with suggestions on how to move forward with its Lean activities.

## 1.4. Limitations

Some limitations are present in this case study. First, this thesis is single-case study and therefore the empirical results cannot be generalized to industry-level and will not likely directly translate to other companies in the construction industry. This means that the suggestions moving forward will be based on the distinct qualities of the case organization. However, the identified success factors and obstacles and the Leanness assessment framework will be heavily based on the extensive literature review and should be applicable on industry-level.

Secondly, since Lean and Lean construction definitions are ambiguous and there is no shared agreement on their meaning, the researcher's bias will influence the interpretation of the collected data and ultimately the results of this thesis. Many activities were performed during the study to minimize bias and guarantee the objectivity of the interpretations and therefore the quality of the results. These activities will be further discussed in the methodology section. Lastly, while the case company is a multinational firm, this study is limited to its operations in Finland, because the Lean initiatives have been limited to the operations in Finland almost without exception. It is therefore likely that adding a multinational view would bring no extra value in this study. Further, time and resource constraints would make it impractical to broaden the scope of the thesis to a multinational approach.

## 2. LEAN

The TPS is considered as the origin of Lean thinking (Fullerton et al. 2014). Lean thinking is based on five principles: (1) Specify value from the perspective of the customer, (2) Identify the value stream, (3) Make the value creating steps flow, (4) At the pull of the customer, and (5) Strive for perfection. These principles are critical in the elimination of *muda* (i.e. waste), and waste identification and elimination are fundamental to a Lean organization (Hines et al 2008). Liker (1998, 8) defines waste as anything that "impedes the flow of product as it is being transformed in the value

chain.” In simpler terms, Hines et al. (2008) define waste as “anything that does not add value to the customer.”

Being Lean means doing more with less, i.e. using less resources (human, time, equipment) to have a higher output (Pettersen 2009; Shetty et al. 2010). This is achieved through waste elimination and concentrating on continuous improvement (Fullerton et al. 2014). Waste elimination plays a critical role in Lean since it is impossible to implement a Lean value stream and sustain it while having excess resources in use (Womack and Jones 1994). For example, minimizing lead times can be considered important as by definition excess time is waste (Martin and Towill 2000). The seven generally accepted types of waste are presented in table 1 below.

Table 1. The seven wastes. Adapted from Hines and Rich (1997) and Hines et al. (2008).

Waste	Definition
1 Overproduction	Producing too much or too soon, leading to poor information flow and excess inventory
2 Waiting	Long periods of unnecessary inactivity for people, goods or information, resulting in lacking flow and long lead times
3 Transport	Excessive movement of people, goods or information, resulting in wasted effort, time and costs
4 Inappropriate processing	Using the wrong set of tools, procedures or systems, usually when a more straightforward approach may be sufficient
5 Unnecessary inventory	Excessive storage and delay of information or products, resulting in extra costs and lacking customer service
6 Unnecessary motion	Lacking workplace organization, resulting in poor ergonomics
7 Defects	Constant errors in paperwork, poor delivery performance or product quality problems

Hines and Rich (1997) suggest that most of the improvements that come from waste identification are small but incremental. They emphasize the importance of using the seven wastes for a continuous and iterative analysis of system improvements. Hines and Taylor (2000, 10) continue by arguing that employees should be given “waste glasses”, and to achieve this a company should ask their employees to recognize and rank the wastes in their work area. The idea is that once you are

aware of the existing sources of waste they are easier to recognize and therefore easier to eliminate. However, Hines et al. (2008) note that waste identification and elimination is rarely enough on its own. Achieving Leaner operations through improved customer focus and productivity gains should further help to expose waste and quality problems. They argue that a methodical attack on waste should help to fix the factors underlying fundamental management problems and poor quality in the organization.

Three types of activities can be identified in a company: (1) non-value adding (NVA) activities, (2) necessary but non-value adding (NNVA) activities, and (3) value-adding (VA) activities. (Hines and Rich 1997) Value is defined by the end-use customer alone in Lean production, and value-adding activities are the ones that create value in the eyes of the final customer (Hines and Taylor 2000). The customer scarcely cares about the functions and processes that are used to deliver the value to the customer. However, many companies define the value themselves instead of listening to the customers' needs, which results in long-term waste. (Emiliani 1999) In a traditional supply chain, VA activities range from forging raw materials to sub-assembling parts, which include the use of manual labor to process the raw materials or semi-finished products. NVA activities (e.g. waiting time or double handling) should be eliminated completely since they bring no extra value to the company or the customer. NNVA (e.g. walking long distances or unpacking deliveries) comprises needed, but possibly wasteful activities. To eliminate the NNVA activities the company needs to make significant changes, for example plan a new layout for the factory to reduce the walking distances. (Hines and Rich, 1997) Due to their complex nature, companies should aim to eliminate the NNVA activities in the long-term rather than the short-term (Hines and Taylor 2000).

Hines and Taylor (2000, 14-15) argue that a realistic long-term timescale for a lean transformation program is 3 to 5 years. Within this period the company should set short-term targets for every 6 or 12 months. For a system to be Lean, it needs to address the specific operationalization of supplier and customer relationships and aim to reduce variability (Shah and Ward 2007). Successful Lean implementation enables continuous improvement, operational superiority, improved productivity and

the elimination of NVA activities (Conti et al. 2006; Dal Forno et al. 2014). Being a holistic business system, Lean thinking has always been difficult to introduce as it calls for collaboration from both the people and the independent organizations. (Liker 1998, xv) Miller (2005) emphasized that rather than being a manufacturing tactic or a cost-reduction program, Lean is a management strategy applicable to all organizations as it aims to improve processes, and all organizations are made up of a series of processes. Similarly, Shah and Ward (2007) argue that Lean is not a distinct concept but rather conceptually multifaceted, meaning that Lean is not solely waste elimination, continuous improvement, JIT, Kanban or TQM. While these are its guiding principles and fundamental components, only collectively they act as a complete system. Machado and Leitner (2010) further establish that Lean is not only a toolkit and its successful implementation requires an overall transformation plan.

## 2.1. Value stream mapping

Womack and Jones (1994) presented the idea that creating a continuous value stream in a company can vastly improve its quality, responsiveness and flexibility, but this continuous improvement calls for a new organizational model called “Lean enterprise”. Lean enterprise can be defined as “a group of individuals, functions, and legally separate but operationally synchronized companies. - - The group’s mission is collectively to analyze and focus a value stream so that it does everything involved in supplying a good or service (from development and production to sales and maintenance) in a way that provides maximum value to the customer.”

Value stream mapping (VSM) was created to take a cross-functional approach to recognize supply chain wastes after diagnostic tools usually failed to perform in a more holistic setting (Hines et al. 1998). Successful adaptation for Lean instruments like the VSM requires participation from all organizational levels (Hines et al. 1998; Hines et al. 1999; Dal Forno et al. 2014) and instead of focusing on the individual functions and people, managers should focus on the performance of the company. Having managers understand the value stream and using this understanding in practice is a crucial first step when striving for a Lean enterprise. (Womack and Jones 1994).

Rother et al. (2003, 3) define VSM as “all the actions (both value added and non-value added) currently required to bring a product through the main flows essential to every product: (1) The production flow from raw material into the arms of the customer, and (2) The design flow from concept to launch.” A VSM effort should comprehend the entire company, but it should be started on a smaller scale. VSM can be used to visualize and comprehend how material and information flows move through the value stream. (Rother et al. 2003, 4) Additionally, VSM provides a basis to institute, analyze and maintain the Lean approach in an organization (Dal Forno et al. 2014). Successful implementation of VSM requires the company to recognize the different wastes that exist in the company and the significance of their effect. Further, the company needs to analyze the results based on the seven value stream mapping tools. (Hines et al. 1998) Table 2 describes the seven VSM tools and how they are interrelated with the seven wastes.

Table 2. The seven value stream mapping tools and their interrelation with the seven wastes. (Hines and Rich, 1997)

Wastes/structure	Mapping tool						
	Process activity mapping	Supply chain response matrix	Production variety funnel	Quality filter mapping	Demand amplification mapping	Decision point analysis	Physical structure (a) volume (b) value
Overproduction	L	M		L	M	M	
Waiting	H	H	L		M	M	
Transport	H						L
Inappropriate processing	H		M	L		L	
Unnecessary inventory	M	H	M		H	M	L
Unnecessary motion	H	L					
Defects	L			H			
Overall structure	L	L	M	L	H	M	H

Notes: H =High correlation and usefulness  
M = Medium correlation and usefulness  
L = Low correlation and usefulness

Usually organizations select 3 to 6 tools to understand the existing wastes and how to reduce them (Hines et al. 1998). To date, VSM is used to develop processes by

identifying the existing wastes in them. VSM aims to visualize the observed process flow in real time by using symbols to illustrate the process clearly. There are three basic steps in VSM: (1) Creating a current state map, (2) Creating a future state map and (3) Developing an action plan. (Dal Forno et al. 2014)

Time is a critical aspect of VSM and therefore time can act as a blockade against successful implementation. A company can overcome this obstacle by enabling continuous data flow to create an environment where VSM can be applied frequently, thus complementing the kaizen-principle of continuous improvement. In addition, since the data from VSM can be used to create substantial changes within an organization's cross-functional or cross-company processes (Hines et al. 1998), having continuous data flows allows the company to utilize statistical methods to oversee its process flows and the stage of its future state maps. However, the more complex the process is, the more difficult it is to gather data for VSM. (Dal Forno et al. 2014)

## 2.2. Supply chains

Suppliers and partnerships play a central role in Lean thinking (Pettersen 2009) and the efforts to become Lean might turn void if intrafirm and interfirm cooperation cannot be achieved (Womack and Jones 1994). Cross-functional and interfirm collaboration is therefore essential for a successful Lean implementation (Womack and Jones 1994; Dombrowski and Mielke 2013). The strategic focus of an integrated Lean supply chain (LSC) is to increase the market share and profits for all supply chain participants, as it is important to share profits and losses in a Lean organization (Womack and Jones 1994). The goal is to work together to reduce overall costs rather than have the individual supply chain participants aim to increase their own profits on the cost of others. Long-term commitment to a successful supply chain is achieved through continuous collaborative efforts to improve quality, costs and delivery. (Taylor 2006) However, aligning organizational subsystems (e.g. goals and values) is necessary to create an integrated Lean supply chain and to generate successful operational improvements (Simons and Taylor 2007).

Most companies focus on short-term improvements and financial goals at the cost of long-term success. This leads to extra costs and might cloak the supply chain's quality issues. (Wee and Wu 2009) Taylor (2006) argued that value chain analysis (VCA) is the first step to accomplish a more collaborative approach to Lean, and that a competent value chain is impossible to create without the full cooperation of all supply chain partners. Wee and Wu (2009) noted that LSC aims to continuous waste elimination which can be achieved through the utilization of VSM. While a lot of companies have tried to seize the benefits of the LSC-concept, the complexity of supply chains has hindered the process. VSM can be used as a tool to improve Lean mechanics and to create a basis for continuous improvement in the supply chain. Vitasek et al. (2005) provided six key attributes for a Lean supply chain:

- **Demand management capability.** The product should be pulled by customer demand rather than pushed to the market, and all the supply chain tiers should work together. Eventually forecasting is unnecessary as the supply chain responds to actual demand.
- **Waste and cost reduction.** Waste elimination is essential in a Lean supply chain. Collecting digital waste (i.e. data) that serves no purpose is particularly detrimental. There should be joint goals and collaborative efforts between the supply chain partners to reduce waste.
- **Process and product standardization.** Process standardization enables continuous flow and therefore developing standardization across products and processes is important. Value stream perspective should be considered together with the continuous flow to determine how value is created for the customer.
- **Industry standards adoption.** Standardization should extend beyond the company and to the industry, as it benefits all companies by reducing the complexity of product variations.
- **Cultural change competency.** Resistance to change is a reoccurring obstacle to successfully implement LSC concepts, thus cultural challenges play a critical part in a Lean transformation. A clear roadmap is therefore needed for a successful cultural change. The roadmap needs thorough

support from top management and it should clearly communicate the objectives and benefits of going Lean.

- **Cross-enterprise collaboration.** The value stream to customer should be maximized through collaborative practices and processes. Identifying how customer value is created is crucial to be able to deliver it. Cross-enterprise teams can be used to enable supply chain collaboration.

Even if there is a chance of improving both operational and strategic efficiency of a supply chain, it might require the business to make fundamental shifts regarding its way of working. (Womack and Jones 1994; Taylor 2006) The existing business philosophy might be a barrier when trying to utilize a value stream-based model, and a mistakenly applied VSM can lead to undesirable financial and technical decisions which overshadow the expected benefits. (Dal Forno et al. 2014) To fully realize the benefits of value chain management, a company should not play the market or exploit its power, but instead strive for cooperation. While larger companies can use power to suppress its suppliers to increase their profits, this approach might backfire severely (Taylor 2006) as today's competition is increasingly between supply chains rather than individual companies and requires close collaboration between the supply chain participants. (Christopher 2011, 10-11)

Recent Lean supply chain management (LSCM) and LSC literature has recognized some critical aspects that should be considered in companies' Lean implementations. Tortorella et al. (2017) found that shop floor improvements have been done disconnectedly from supply chain context. They continue that many managers have a narrow perspective on waste elimination and focus their continuous improvement efforts on internal issues rather than having an extended value stream approach. Further, Tortorella et al. (2018) summarized that the concurrent implementation of some of the LSC practices will likely result in conflicts between these practices. They established that planning a successful LSC implementation requires considering the level of onshore suppliers and the company's experience in Lean manufacturing implementations and their relation to the LSC practices. However, should companies wish to utilize an existing LSCM

framework in their implementation effort, they should acknowledge that the LSCM frameworks have incoherent theory building and many of the frameworks lack practical evidence (Jasti and Kodali 2015). It is therefore necessary to carefully assess which framework to use and how to adjust it to fit the organization's characteristics.

### 2.3. Management of change

Change is a permanent element that affects all organizations, and successful management of change is a key skill in the all-evolving business environment (Rune 2005). The necessary actors in change management are dependent on the scale of the wanted change. The company CEO is the key factor when it comes to company-wide change. When it comes to minor alterations, a middle manager might be enough. Kotter (1995) has presented eight steps to transform an organization through change management:

1. Establishing a sense of urgency,
2. Forming a powerful guiding coalition,
3. Creating a vision,
4. Communicating the vision,
5. Empowering others to act on the vision,
6. Planning for and creating short-term wins,
7. Consolidating improvements and producing still more change, and
8. Institutionalizing new approaches.

Without appropriate urgency the transformation process is unable to succeed while simultaneously compromising the organization's long-term future. (Kotter 1995) Also, major changes have a minuscule chance of succeeding and the change will not be sustainable if there is no active employee engagement. Further, change is very dependent on the capabilities of the leader of the change, who must have a clear long-term perspective, inspire trust and concentrate on people. Most companies fail to engage employees, recognize success and monitor and evaluate outcomes of change, which leads to undesirable outcomes. (Lucey et al. 2005) A

successful organizational change can be improved by (1) Analyzing the organization and identifying existing problems and the significance of each of these problems, (2) Analyzing which parties and factors in the organization are essential for the change, (3) Using the previous analysis to formulate an internally consistent change strategy that defines prerequisites for individuals and the necessary amount of preparation, and (4) Monitoring the implementation process to identify and react to deviations. (Kotter and Schlesinger 2008)

Accordingly, since the organizational context has a considerable effect on the success of the Lean implementation (Shah and Ward 2003), successful Lean transformation requires change management that focuses on long-term commitment of the workforce and proactive development of the supply base (Liker 1998, xv). Mann (2009) argue that considering Lean as a one-time implemented cost reduction system is inaccurate and most Lean transformations fail because of this. Continuous managerial efforts are required for permanent improvements and to organize a successful Lean transformation. Grove et al. (2010) further emphasize that a thorough Lean transformation requires support from all stakeholders, understanding Lean and its principles, adequate support from management and a strategic plan to communicate the goals to everyone involved. Some Lean implementation frameworks have been developed to help companies execute successful change management (see AIManei et al. 2018), but only few companies have managed to achieve successful and sustainable results (AIManei et al. 2018).

Some criticism towards change management practices has been presented. Rune (2005) argued that the current organizational change literature is ambiguous and lacks empirical evidence and is often based on “unchallenged hypotheses regarding the nature of contemporary organizational change management.” The study continues that organizational change management is usually reactive and discontinuous and has a high failure rate, which might imply lack of understanding regarding change management or lack of a valid framework. Similarly, Jaros (2010) agrees that most organizational change efforts fail to fulfill their promise and usually prove to be problematic. A key challenge is to get the employees and managers committed to change and overcoming the resistance to change. Should the

organization decide to pursue an organizational change, appropriate change management is therefore crucial to guarantee its success.

## 2.4. Lean management

Lean leadership can be considered as a systematical way to give organizations readiness to sustainable and continuous development of Lean production (Dombrowski and Mielke 2013). The leadership's role is critical when creating a Lean initiative (Comm and Mathaisel 2005) as successful Lean implementations require committed leadership and extensive change management in the whole organization. Consequently, a company-wide Lean implementation should be led by the top management, as the CEO is a key factor when it comes to company-wide transformation (Kotter 1995). The CEO must lead with example by being vocal, visible and creating a suitable environment for Lean. Further, it is critical that senior management understands Lean to establish a basis for a successful Lean transformation. (Miller 2005)

Usually knowledge is not the problem when trying to apply lean thinking in a company. Most companies' senior management fail to have an adequate amount of forethought which leads to the Lean initiatives to be killed. (Hines and Taylor 2000, 13) Implementing Lean tools account for only 20 percent of the effort in a Lean transition, while senior management's efforts to create conditions for a successful Lean transition account for 80 percent. (Mann 2009) To ensure desirable financial and non-financial results, top managers must understand kaizen and other activities aimed to improve processes (Emiliani 2006). Managerial discipline is the main driver to sustain Lean performance on the long-term and managers should understand and improve the Lean process continuously. Sustained Lean success starts from the management's changed thinking and behavior, reaching through the organization step by step. (Mann 2009) Employing management practices such as using devoted teams in the implementation, creating performance reporting processes around Lean and introducing non-financial rewards have a positive influence in the Lean implementation (Netland et al. 2015).

In addition to top management participation, collaboration between the management and the employees, and the managers' respect for the employees are critical success factors in a Lean implementation. (Emiliani 2006; Dombrowski and Mielke 2013) If the employees are not addressed properly they are less open towards the results of the Lean implementation (Dombrowski et al. 2012). Further, employee engagement is essential to guarantee a sustainable lean implementation and to fully realize its benefits (Lucey et al. 2005). The employees must understand Lean philosophy and participate in its implementation, leaving managers in charge of creating a two-way information flow between them and the employees. (Dombrowski and Mielke 2013) However, employee involvement has its disadvantages such as slower decision-making and higher costs, which are caused by the need to communicate the information and extra time requirements. It is therefore important to balance the benefits and critical points of participation. (Dombrowski et al. 2012)

Puvasvaran et al. (2008) presented three integration elements (table 3) for utilizing a Lean concept in a company. The study emphasizes the importance of integrating all three elements within a people development system. The system should aim to help people with problem solving in their respected work areas and to create collaboration between top, middle and bottom management.

Table 3. The three integration elements for utilizing Lean, adapted from Puvasvaran et al. (2008)

Integration element	Description
Lean Process Management System	A cornerstone to eliminate or reduce wasteful practices. Aims to create standardized methods to remove opportunities for waste.
People management System	Activities, procedures and practices that empower people and help to implement the company's business plan. Also focuses on educating and developing the employee's skills and knowledge.
Business Management System	Includes the company's practices, policies and procedures. These systems control resource flows to satisfy customer requirements by planning and controlling the organization's employees' activities.

Puvasvaran et al. (2008) argue that to eliminate waste properly, an employee needs to have the required skills and knowledge in Lean process management.

Problem solving, waste identification and waste elimination will not succeed without the needed attributes. Accordingly, Emiliani (1999) establish that the organization should aim to minimize “fat” behaviors (e.g. negativity and gossip) and to maximize Lean behaviors (e.g. patience and trust) to promote waste elimination and to minimize unnecessary waste. Further, Stansfield and Longenecker (2006) suggest that goal setting and having a feedback system can be used to eliminate waste and promote productivity in a company. Promoting feedback and goal setting through an information system increases the performance of individuals, and incorporating goal setting with graphical feedback is more effective than with verbal feedback. While companies should put high importance on the manager and employee participation, they must acknowledge that developing sustained Lean behaviors is a five to ten-year challenge (Emiliani 1999).

## 2.5. Measuring Leanness

Measuring “Leanness” means developing a relative measure of Lean by assessing the manufacturing performance of an organization (Bayou and Korvin 2008). Shah and Ward (2007) developed an early framework to measure Leanness in manufacturing environment. The aim was to develop a framework to assess the state of Lean implementations in manufacturing companies. However, since the framework was tailored for the manufacturing industry, some of its features cannot be applied to other industries and therefore it needs to be modified to fit other industries’ (e.g. the service industry) characteristics (Overboom et al. 2010). More recent Leanness frameworks (see Singh et al. 2010; Vinodh and Balaji 2011; Vinodh and Vimal 2012) have utilized fuzzy technique to overcome the weaknesses of the Leanness frameworks, such as uncertainty, vagueness and ambiguity (Vinodh and Vimal 2012).

Narayanamurthy and Gurumurthy’s (2016) literature review suggested that the wide amount of various Leanness measurement approaches has created confusion and complexities when trying to choose a suitable assessment method. The study utilized content analysis methodology to create an assessment method to help companies successfully implement Lean practices by continuously observing their

implementation statuses. The Leanness assessment was divided into two major categories: manufacturing Leanness assessment and service Leanness assessment, and both categories have their own subcategories. Further, the Leanness assessment process was divided into three stages: (1) Pre-implementation assessment, (2) Practices implementation assessment and (3) Outcomes assessment, and these stages are connected by continuous improvement assessment. Leanness assessment will be further discussed when creating the framework to assess the Leanness of a construction organization.

## 2.6. Criticism

Lean has been criticized over time by different authors, but the target of criticism has changed through time as Lean has evolved (Hines et al. 2004). A major criticism towards Lean is the notion that there is no universally agreed meaning for it and it is difficult to create an all-encompassing definition (Pettersen 2009). Hines et al. (2004) recognized lack of contingency and attention to human aspects, capability to manage variability and limited operational focus on the shop floor as the key drivers in Lean criticism. Many companies still have the shop floor in the center of their Lean implementations, while misunderstanding the “contingent nature” needed to employ Lean thinking and disregarding the need for more integrative approaches. Lean has also been criticized over the notion that the tools and techniques have played a leading role over strategic level thinking and the inability to manage variability.

Williams et al. (1992) argued that “the difference between lean production and mass production is not empirically sustainable” while pointing out the validity of Womack and Jones’ (1990) research. They note that Womack and Jones’ (1990) work is based on standard secondary sources, which had their own deficiencies (Williams et al. 1993), and not in original historical research. They similarly argued that Krafcik’s (1988) methodology was far from robust and the results were questionable due to failure in control. Lewis (2000) follows this by maintaining that in any complicated system it is difficult to prove causal linkages between inputs and outcomes, pointing out that the assumptions made of the superior productivity of the

Japanese vehicle assemblers in 1980s' and 1990s' are ambiguous and should be filtered carefully.

While Lewis' (2000) study is limited to only one industry sector, it suggests that Lean does not necessarily lead to improved financial performance. A critical point seen to be the company's ability to generate value through cost savings. In addition, Lean implementations seem to inevitably reduce innovative activity, forcing the company choose a balance between Lean production and innovation. Gall (2007) went as far as calling Lean a method of worker suppression, claiming that its goal is to make work simplistic, narrow and as cheap as possible. However, the unbiasedness of these claims should be taken with skepticism, considering that Gall's (2007) whole work is aimed to help people "fight" against Lean.

While Gall's (2007) work should be taken with skepticism, Pettersen (2009) established that one meaningful criticism towards Lean is that the approach does not consider usually employees' perspective and the employees are not seen as creators of success, but rather as components in the production system. Pettersen (2009) notes that "the extensive discussion about jidoka and poka yoke in the Lean literature suggests that employees cannot be trusted to produce good quality, thus creating a necessity for removing the possibility of human error from the system." However, multiple authors have highlighted the importance of employees and managers in a Lean implementation (Emiliani 1999; Comm and Mathaisel 2005; Lucey et al. 2005; Emiliani 2006; Puvanasvaran et al. 2008; Dombrowski et al. 2010, 2012; Dombrowski and Mielke 2013). The two are not necessarily mutually exclusive. Managers and employees could be considered as requirements for success, but also as components in the production system. Much like a component in a machine – if it is not working it should be replaced.

Lewchuk and Robertson's (1996) survey in North America supports Pettersen's (2009) conclusions to some extent. They concluded that workers in companies that used Lean production instead of the traditional "Ford-style" way of working reported their workload to be heavier and faster. The workers also did not feel that they could influence the things they disliked in their job. On the contrary, Seppälä and Klemola

(2004) concluded that workers perceived Lean activities mostly positive, since they felt like they had higher control over their work and more opportunities for participation. However, similarly to Lewchuk and Robertson (1996), the study identified the amount of work, mental load, and stress as negative Lean-related factors. Conti et al. (2004; 2006) continue that while Lean implementations might lead to more work-related stress, the stressful practices are not inherent in Lean nor are they a necessity or a requirement for a successful Lean implementation. Rather, management choices related to production practices and designing and operating Lean systems are the determining factors of success. Seppälä and Klemola (2004) similarly recognized bad management of change as a contributor in the success of Lean implementation.

The need of modifying Lean practices to fit an industry's characteristics has been noted by multiple authors (e.g. James-Moore and Gibbons 1997; Lewis 2000; Cooney 2002; Lee and Jo 2007; Seddon and Caulkin 2007) and sometimes a fundamentally different approach is required (James-Moore and Gibbons 1997). Mehta and Shah (2005) noted that Lean production fits a production environment characterized by low technical uncertainty, where the tasks can be executed in a standardized manner. Consequently, Cooney's (2002) study disputes Lean's universal applicability. Buyer-supplier relations, general market conditions and the structure of institutions (social, political) all have an impact in Lean's applicability, but are usually disregarded in the literature. In addition, while JIT flow is a fundamental practice in Lean and implementing JIT might lead to significant performance improvements (Nakamura et al. 1996), multiple conditions must be met for it to be suitable. Lee and Jo (2007) further contest TPS's universal transferability by arguing that "the adoption of TPS involves a complex evolutionary process of organizational learning and interpretation", emphasizing that TPS is not easily transferred and the strategic choices of a company and their complex interactions with internal and external factors might lead to a differentiated version of TPS that suits the company better. Lastly, Pettersen (2009) maintains that if the Lean principles were applicable to every industry, the Japanese should have distributed their knowledge across industries. This however does not seem to be the case as

the Japanese are performing in the same or worse level in other than the automobile industry compared to their western competitors.

## 2.7. Scaled Agile

Scaled Agile (SAFe) is an integral part of the case organization's development activities and it is heavily related to Lean. It was therefore seen necessary to include a short description of SAFe in the theoretical framework and it will be further discussed in the empirical part of the thesis. Scaled Agile is a methodology created by Dean Leffingwell in 2011, originally to "help software development bring better products to market faster" (Norville 2018). SAFe is based on a mixture of Lean product development, systems thinking and Agile development (Scaled Agile 2018a). There are four core values in SAFe: (1) Quality, (2) Program execution, (3) Alignment and (4) Transparency. SAFe consists of 8 to 12-week development circles called "Program Increments" which are further divided into 2-week development periods called "Iterations". The purpose is to plan the next 8 to 12-week development circle and divide it to 2-week development periods where the required actions are closely described for each iteration. (Hayes et al. 2016) The agile methodology has been used for project planning and execution as traditional planning processes have failed to deliver the wanted results. Using the Agile methodology in project management has produced successful results. (Serrador and Pinto 2015) The challenges and success factors of SAFe are shown in table 4 below.

Table 4. Challenges and success factors for SAFe.

<b>Challenges</b>	Kalenda et al. 2017	VersionOne 2017	VersionOne 2016	Dikert et al. 2016
<i>Case study</i>		Organizational culture at odds with agile values	Company philosophy or culture at odds with core agile values	Agile difficult to implement
Resistance to change		General organizational resistance to change	Lack of experience with agile methods	Integrating non-development functions
Quality assurance issues		Inadequate management support and sponsorship	Lack of management support	Change resistance
Integrating with non-Agile parts of organization		Lack of skills/experience with agile methods	General organization resistance to change	Requirements engineering challenges
Too fast roll-out		Insufficient training and education	Lack of business/customer/product owner	
<i>Literature review</i>				
Resistance to change				
Distributed environment				
Quality assurance issues				
Integration with non-Agile parts of organization				
Lack of commitment and teamwork				
Too much pressure and workload				
Lack of knowledge, coaching and training				
Requirements for management hierarchy				
Measuring progress				
<b>Success factors</b>				
<i>Case study</i>		Internal agile coaches	Internal agile coaches	Choosing and customizing the agile approach
Unification of views and values		Consistent process and practices across teams	Executive sponsorship	Management support
Executive sponsorship		Implementation of a common tool across teams	Consistent process and practices	Mindset and Alignment
Company culture		External agile consultants or trainees	Implementation of a common tool across teams	Training and Coaching
Prior Agile and Lean experience		Executive sponsorship	External agile consultants or trainees	
<i>Literature review</i>				
Acquire knowledge				
United view on values				
Tools and infrastructure				
Solid engineering practices				
Careful transformation				
Teamwork support				
Executive sponsorship				

Most of the major challenges regarding SAFe are related to general organizational qualities such as management and culture. Resistance to change, lack of management support and mismatches with the organizational culture are main challenges in a SAFe implementation. In addition, lack of knowledge regarding Agile methods seems to be a critical challenge to overcome. Overcoming these challenges can be achieved by recognizing and utilizing the success factors, such as managerial support, training and aligning and unifying the views and values. Ebert and Paasivaara (2017) noted that SAFe is highly complex and costly and its scaling targets large companies and it is also perceived to be heavy to operate. They continue that having a strong leadership, active internal change agents, external consultants and customizing the framework are essential for success, supporting the findings of Dikert et al. (2016) and Kalenda et al. (2017). The study further argues that SAFe requires a cultural change, long-term commitment and appropriate investments to be successful.

### **3. CONSTRUCTION INDUSTRY**

Compared to other industries, the construction industry is unique by having a product that is immovable after completion, rather than one that is supplied to end customers (Salem et al. 2006). In addition to the stationary nature of the industry, the largest difference between manufacturing and construction is that the manufacturing industry comprises continuous process flow and relationships, whereas the construction industry is inherently discontinuous and project-based. (Segerstedt and Olofsson 2010) The wide fragmentation of the construction industry has been noted by multiple authors (e.g. Koskela 1993; Love et al. 1998; Briscoe and Dainty 2005; Baiden et al. 2006; Fulford and Standing 2014; Jelodar et al. 2016), and partially responsible for the fragmentation are the volatility of market demand and the high complexity of the industry (Segerstedt and Olofsson 2010). The discontinuity of demand, high complexity and the uniqueness of each project contribute to the lack of collaboration in project-based industries (Skaates et al. 2002), and the construction industry is severely behind other industries when it comes to the scale and depth of collaborative efforts (Fearne and Fowler 2006).

Traditionally, clients in the construction industry have relied on competitive bidding, where the lowest total price has been the primary selection criterion. Such procurement methodology has lately been criticized for creating conflicting relationships that lead to more costs, worse quality and worse customer satisfaction. (Pesämaa et al. 2009) Correspondingly, the poor project quality in public projects has been contributed to the competitive bidding process (Lo et al. 2007). Despite its deficiencies, competitive bidding is extensively used in construction. Competitive bidding prohibits having contractors and subcontractors in the design process while also decreasing incentives for collaboration and achieving shared goals. The cost of aforesaid seem to surpass any potential savings using competitive bidding. (Elfving et al. 2005)

Cooperation and effectiveness in construction processes and between clients and contractors can be increased by limiting the number of bidders (Pesämaa et al. 2009). Alternatively, the amount of competitive bidding can be reduced to facilitate improved partnership performance (Gadde and Dubois 2010), as expanding the selection criteria beyond price can produce significant tangible returns (Bresnen and Marshall 2000b). Further, since project cost overruns are frequently created by project scope and cost estimation problems in the contractor-subcontractor relationships, using lifecycle costing and value engineering by substituting the competitive bidding process with stakeholder led design would decrease costs and improve productivity. (Fulford and Standing 2014)

The construction industry has also been identified to be stagnant regarding productivity improvements. In addition to the fragmentation and complexity of the industry, scarce (or therefore lack of) standardization in project management practices and insufficient IT investments combined with subpar information standards threaten the collaboration and productivity improvements in the industry. (Fulford and Standing 2014) The inherent nature of construction projects being temporary usually prevents forming trust between the participants, which in turn leads to unwillingness to share information. Also, complex external relations and adversarial relationships affect supply chain collaboration in the industry. (Humphreys et al. 2003) Thus, a comprehensive information sharing system is seen

as a necessity for the industry (Cheng et al. 2010), and such a system should enable all project participants to access and utilize information in an efficient fashion (Froese 2010).

While the construction industry hasn't exploited the progression of IT practices to their fullest, some suggestions to realize the benefits of IT have been presented. Fulford and Standing (2014) concluded that evaluating the alignment of the current business strategy and IT can create substantial productivity gains. In addition, IT can be used to improve communication in supply chains to decrease errors and cost and time overruns in projects by improving horizontal and vertical information flows. Froese (2010) suggested that ICT tools can improve the efficiency and performance of designing and managing a construction project, but this requires corresponding modifications to the project participants' work tasks and skill sets. Somewhat contradictory to previous, Kang et al. (2013) argued that IT does not directly have an impact on project performance, but rather an indirect impact through best practices. While failing to identify how the performance improvements were achieved in the interaction between IT use and best practices, the study summarized that IT improves the use of best practices which consecutively improves construction project performance.

In construction, knowledge management and information sharing can be improved through intrafirm intranets, where best practices and feedback can be collected. However, having useful information in the intranet has proven to be difficult for construction companies. (Gann 2001) For example, although Smyth (2010) agrees that knowledge transfer could happen inside a company from one project to others by a trickle-down basis using intrafirm reporting and the knowledge of the people involved, the knowledge transfer was perceived to be limited to general descriptions of improvements, and while this could have inspired others to pilot similar initiatives, the lacking information regarding what was done in the demonstration projects and how it was done prevented extensive transfer of knowledge.

### 3.1. Supply chains

London and Kenley (2001) summarized in the early 2000s' that the supply chains (SC) in construction industry lack theoretical and empirical research that considers the industry's idiosyncrasies. They also argued that there are deficiencies in knowledge regarding the supply chains' types, complexity and behavior. Similarly, Cox and Ireland (2002) summarized that "companies (in construction) are some considerable way from understanding what constitutes effective supply chain management (SCM) and how superior performance can be achieved." There have since been multiple studies assessing the different aspects of construction supply chains, for example using limited competition (Humphreys et al. 2003), developing and evaluating supply chain relationships (Meng 2010), developing a model for collaborative network approach (Fulford and Standing 2014) and exploring the relationship quality in construction projects (Jelodar et al. 2016). However, despite the increased research towards construction supply chains, there still seems to exist a lack of successful cooperative, especially long-term, efforts in the industry. The nonexistent productivity gains in construction will continue until the many organizations in the supply chains view their processes comprehensively across organizations (Fulford and Standing 2014).

Due to the pervasive fragmentation, supply chain integration is highly challenging in the construction industry. Participants in the supply chain have differing capabilities and information is loosely distributed among them. (Cheng et al. 2010) Further, Dubois and Gadde (2002) argued that since each project are thought to be separate from each other a "strong project focus makes coordination in other dimensions difficult or even pointless." The performance criteria are bound to the unique project, which supports short term productivity and makes interfirm cooperation difficult. In addition, while subcontracting has been used for risk mitigation (Segerstedt and Olofsson 2010), Briscoe and Dainty (2005) have noted that the continuous dependence on a fragmented and mostly subcontracted workforce has amplified supply network complexity in construction thus limiting the chances for process integration. Briscoe et al. (2001) continue that supply chains in construction usually suffer from the dominance of an adversarial culture amongst the project team

parties, and many critical determinants for successful partnerships, such as trust and openness, are often missing. These attitudes can block efficient cooperation in supply chains, and to realize successful partnerships, overcoming these attitudes should be considered a must.

According to Bankvall et al. (2010), a differing logic applies to construction supply chains compared to typical supply chains. While typical supply chains have sequentially interdependent activities, reciprocal interdependence is prevalent in the activities of construction projects. Reciprocal interdependence is a situation where “the outputs of each become inputs for the others” (Thompson 1967, 54-55). The complexity that arises from aforesaid explains the need for higher buffers and the difficulties of coordinating even the extremely simple product deliveries. It is problematic to apply SCM models made for different industrial contexts (e.g. automotive) to construction industry, since the “pattern of interdependence” is highly different in construction. Due to the reciprocal interdependencies, construction projects require more extensive and better planning of activities, and only coordinating the sequential interdependence is not enough. (Bankvall et al. 2010)

Since competent supply chains require better communication and information exchange (Briscoe et al. 2004), there is an inherent need for the industry to address its shortcomings in support structures, absence of senior management commitment, and ignorance towards supply chain philosophy (Humphreys et al. 2003). Effective communication positively contributes to project success by harmonizing team behavior, improving information transparency and trust, and by increasing the teams’ understanding of work content and rules and regulations. (Wu et al. 2017) Having successful supply chain relationships in construction and managing them adequately requires the buyers and suppliers to understand the existing power relations and the requirements to manage the dyadic relationship. (Cox and Ireland 2002) Construction should move away from the project-based approach towards initiations like JIT and customization, which both require interfirm collaboration (Dubois and Gadde 2002). Developing stonger ties with suppliers and subcontractors should increase the quality of work and project results (Fulford and Standing 2014).

Lastly, client's role (Briscoe et al. 2004) and their systems play a major part in successful supply chain integrations. Supply chain participants must understand the client's processes and be able to align the client's systems with their own. Unsuccessful system and process integration creates suboptimal conditions where quality is compromised and innovation is thwarted, leading to missed opportunities in adding value and better quality. (Briscoe and Dainty 2005) Further, the benefits of integration cannot be realized without the client's willingness to develop SC relationships, making the client the most important success factor in SC integration (Briscoe et al. 2004). Accordingly, Mesa et al. (2016) concluded that the "owner's decisions about the project delivery system directly affect, or even define, supply chain relationships." They further emphasize that this eventually affects project performance, arguing that complex projects require a more comprehensive project delivery system that considers the factors that define the supply chain relationship (i.e. trust, communication, profit sharing). To have successful supply chain collaboration, it is necessary for the main contractors to manage their supply chains more effectively and beyond the initial tiers to improve their performance (Smyth 2010), but it is also essential to establish collaborative relationships with the clients.

### 3.1.1. Partnering

Bresnen and Marshall (2000a) describe partnering as an "imprecise and inclusive concept capturing within it a wide range of behavior, attitudes, values, practices, tools and techniques." Developing a competent partnering approach requires more than numerous tools and techniques, and there is no single strategy for successful partnering. Rather, it is a result of complex and dynamic processes where formal mechanisms and informal processes are equally important. (Bresnen and Marshall 2002) Partnering is a phase in a long-term relationship that requires adaptations and results in deeper interactions than those in traditional project cooperation (Crespin-Mazet et al. 2015). Usually partnering initiatives are tested when problems arise during collaborative projects (Humphreys et al. 2003). Although high business challenge supports partnering by acting as a risk mitigation tool (Crespin-Mazet and Ghauri 2007), previous adversarial experiences of attempted partnering initiations

create lack of trust (Briscoe and Dainty 2005), which can further act as a blockade for partnering. However, previous partnering initiatives between two parties (with no adversarial experiences) will most likely generate higher trust and facilitate learning in the dyadic relationship (Crespin-Mazet et al. 2015).

Carefully selecting a partner can be used to reduce the risk and uncertainty in a project (Pesämaa et al. 2009). Since short-term collaboration can be generated through incentives (Bresnen and Marshall 2000b), risk can be mitigated by linking reimbursement methods to the complexity and scope of the construction work done by a subcontractor (Cox and Thompson 1997). In addition, a lot of research suggests that cooperative procurement practices have a clear positive effect on project performance, thus facilitating a collaborative climate through cooperative procurement practices enables project success. The positive relationship between cooperative procurement procedures and project performance increases as the collaborative climate grows stronger. (Eriksson and Westerberg 2011) In intrafirm collaboration, procurement should collaborate with production to get the right resource on the right time to the worksite to reduce space requirements and on-hand inventory (Ballard 1993).

Based on Gadde and Dubois' (2010) literature review, research regarding collaborative efforts between companies is lacking in strategic partnerships in construction, since most of the research focuses on project partnering. Further, Bygballe et al. (2010) note that previous project partnering literature in the construction industry has mainly focused on the relationships between clients and contractors, leaving subcontractors and suppliers to lesser attention. Also, a lot of emphasis is put on formal means and the benefits of critical success factors in partnering, while the informal means play only a minor role in the literature. It would be necessary to understand the indirect factors more comprehensively, as the possible benefits of partnering might be caused by indirect factors such as the contractors' willingness to absorb extra costs (Bresnen and Marshall 2000b).

While partnering has been perceived to have a positive impact in project performance, several authors (e.g. Bresnen and Marshall 2000b; Bresnen and

Marshall 2002; Humphreys et al. 2003; Laan et al. 2011; Meng 2012) have noted that partnering is not a panacea for solving problems in supply chain collaboration. Venselaar et al. (2015) recognized that mismatches in strategic needs act as a barrier in supply chain partnering. Meng (2012) further argues that a major reason for poor supply chain performance is the degradation of supply chain relationships. Although partnering can reduce poor supply chain performance, project partnering will not guarantee improved performance over the traditional approach. Understanding the strengths and limitations of partnering is essential, as problems like lack of contractor input into design and coordination problems still exist in partnering initiatives (Bresnen and Marshall 2002). Further, partnering might even worsen the arising problems due to higher demand for improved time and cost performance (Bresnen and Marshall 2000b). Meng (2012) suggests long-term strategic partnering to solve most of the partnering-related problems and to gain permanent improvements to project performance. However, not all project partnerships should automatically transform to strategic partnerships due to cost and resource limitations, thus it is necessary to assess who to pursue strategic partnerships with. (Lu and Yan 2007; Gadde and Dubois 2010)

Even though partnering does not guarantee success, it has a positive effect in time, cost, quality and developing collaborative approaches (Bresnen and Marshall 2000b). Collaboration facilitates the development of more capable strategic partnerships (Fulford and Standing 2014) and can significantly decrease time delay occurrences (Meng 2012). Correspondingly, good partnering relations promote collaboration and might help with fragmentation problems (Jelodar et al. 2016). Forming strategic partnerships can be used to realize the benefits of supply chain management. Such integrative approaches require trust among the participants, effective IT support throughout the value chain, centralized communication and decentralized liability for operational processes. (Lönngren et al. 2010) Improved knowledge transfer between projects is necessary for extended partnering (Gadde and Dubois 2010), and effective communication can significantly decrease cost overruns (Meng 2012). However, Gadde and Dubois (2010) concluded that transforming rapidly towards strategic partnerships is unrealistic as it would require considerable adjustments to the fundamentals of the construction industry.

### 3.1.2. Project management

Project management is a core function that has a critical role in the construction industry. Project management can be defined as “the process of ensuring that projects are completed within a predetermined budget and duration and with the specified quality” (Wong and Ahmed 2018). Project management activities include establishing practices for temporary project teams to coordinate and solve complex tasks. The teams usually have cross-functional participants from multiple organizations with various interests and purposes. (Pesämaa et al. 2009) Project management literature focuses on cooperation, communication and efficiency to identify and choose a project collaborator. The relationships between participants can be considered indispensable for controlling project networks (Jelodar et al. 2016) and project coordination has a significant effect in the project’s outcome (Arashpour et al. 2017). Hence, choosing the project partner is highly interrelated with project risks like uncertainty and technical complexity (Crespin-Mazet et al. 2015) as these risks can be mitigated through co-development. Moreover, since lacking relational harmonization in project network might impair co-development (Crespin-Mazet and Ghauri 2007), managers in construction organizations should clearly outline how project management is used for and how it creates value (Fulford and Standing 2014).

The traditional way production management works in construction is illustrated in figure 1. First, the project is divided into segments i.e. design and construction. These segments are put in a logical sequence and then evaluating the time and resources needed to finalize every activity ergo the project. The activities are further disintegrated until they are assigned to a foreman or a task leader (“sub”-activities). Every activity is monitored through its schedule and budget projections. Project level reports are made from these projections. Schedule modifications and cost reductions are used to mitigate the negative impacts if there is a problem in the process. However, the waste that is created by the unpredictability (e.g. release of

work) amongst the continuing activities is often hidden by the activity-focused approach. (Howell 1999)

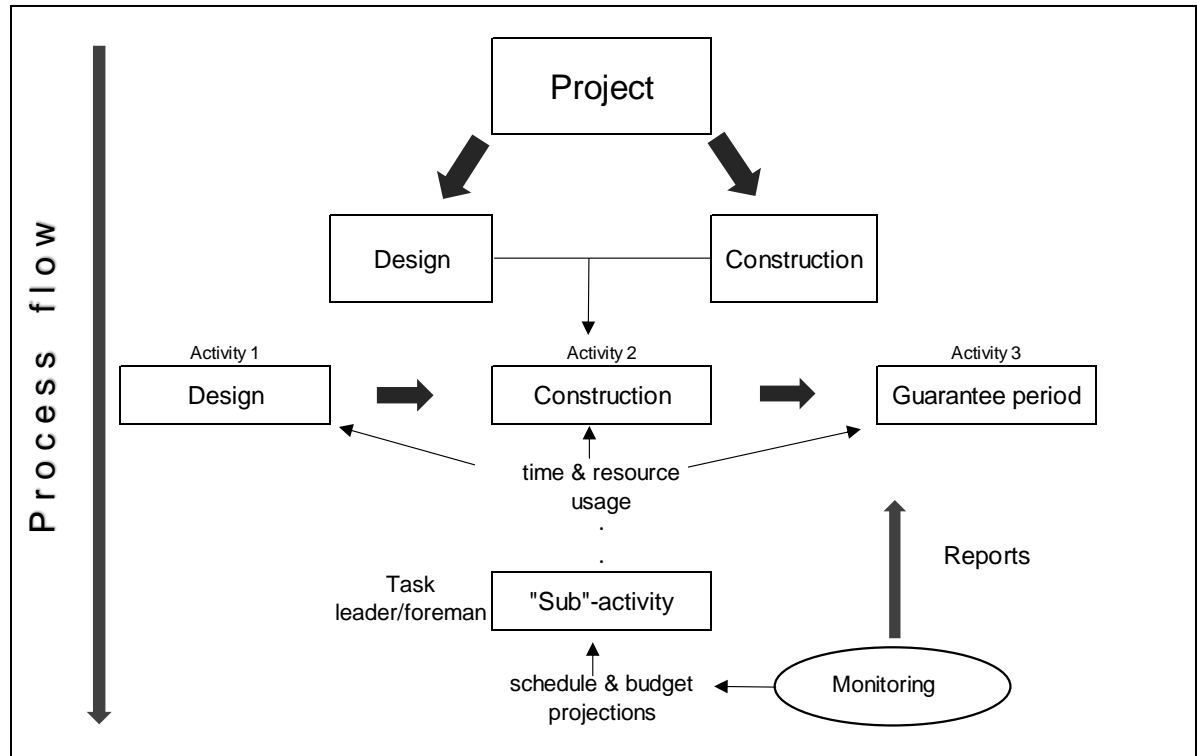


Figure 2. Traditional production management in construction, adapted from Howell (1999).

Dainty et al. (2003) argue that traditional success indicators like time, cost and quality are too simplistic metrics to measure managers' performance in construction projects. They recognize building, developing and maintaining the project team as the main challenge for project managers. The study stresses this improvement process as the main goal for project managers instead of the performance targets. Baiden et al. (2006) correspondingly suggest using different performance drivers to reap full benefits of the project teams. The research indicates that behavioral changes are necessary, and the project drivers should be shifted away from the traditional success indicators to endorse cultural and behavioral improvement. It should be noted that this transition does not mean that major organizational or behavioral barriers need to be overcome to realize the benefits of integration.

### 3.1.3 Trust

According to Briscoe and Dainty (2005), collaboration can be achieved through loose long-term alliances, hence it does not necessarily need specific contractual agreements. Similarly, Baiden et al. (2006) emphasize that fully integrated teams are not a necessity to have high-performance collaboration in the industry. However, while clients might understand the need to host collaboration among the supply chain, their understanding of the supply chain and the efforts to create cooperation are usually substandard. The arising problems have been attributed to construction industry's slow adaptation to SCM practices, unique organizational structure and the unique nature of construction processes (Akintoye et al. 2000). These qualities have led to main contractors having to build their own relational networks which in turn usually fail due to lack of trust between participants (Briscoe and Dainty 2005), as trust and leadership play a critical part in supply chain success (Venselaar et al. 2015).

Successful collaborative and managerial efforts require trust between the participants (Akintoye et al. 2000; Humphreys et al. 2003; Crespín-Mazet and Ghauri 2007). Trust takes time to develop, and collaboration with contractors is advocated by long-term strategic goals (Lu and Yan 2007). Since trust cannot be enforced, collaboration can only be supported by incentivizing suppliers or through unequal power-relationships (Cox and Thompson 1997). Laan et al. (2001) concluded that trust develops through risk and profit sharing, and increased trust leads to better problem solving and project outcomes. Shared goals, commitment and transparent communication flow also facilitate trust growth (Crespín-Mazet and Ghauri 2007). Further, using "open books" can create a basis for cost reductions and joint risk management by producing improved transparency, commitment and trust in the dyadic relationship (Crespín-Mazet et al. 2015). Still, while partnering arrangements such as project alliances enhance interorganizational trust through incentive alignment, such arrangements are not a problem-free solution for bad relationships between clients and contractors and require effort to be successful. (Laan et al. 2001) In intrafirm trust development, positive prior ties create a better basis for the project and intrafirm integration. (Buvik and Rolfsen 2015)

### 3.2. Lean Construction

Lean construction (LC) aims to solve the traditional problems of the construction industry, such as fragmentation, delays, errors and inefficiencies. Lean construction is one of the project management approaches that emerged to improve efficiency in the construction industry (Al-Aomar 2012). Implementing Lean in construction means that the tools and techniques are applied throughout the project stages (Johansen and Walter 2007). Howell (1999) recognizes four reasons why construction management is different under Lean than in typical contemporary practice: (1) There exists a distinct set of goals for the delivery process, (2) It aims to maximize customer satisfaction at the project level, (3) Products and processes are designed concurrently, and (4) The project's lifecycle is managed through production control. Some LC definitions are presented in table 5 below.

Table 5. Lean construction definitions.

Author(s)	Key focus	Definition
Koskela (1992)	Conversions and flows; improvement of activities	The new production philosophy is realized by increasing value and decreasing waste through the improvement of flow processes and more efficient conversion activities
Howell (1999)	Customer satisfaction; decreasing variation	Lean construction is a new form of production management that aims to maximize customer satisfaction and to manage a product's lifecycle through distinct objectives for the delivery process
Bertelsen (2004)	Adaptation of TPS	Lean construction is a modified version of the Toyota production system (TPS), where the TPS principles are implemented to the construction process, and construction is assumed to be a unique kind of production.
Green & May (2005)	What is "leanness"; problems in lean construction definitions	Lean construction definitions are vague, and its applicability and comprehension depend on localized contexts.
Miletsky (2010)	Lean construction conference: ACG	A companywide process to eliminate waste
Jamil & Fathi (2017)	Lean construction, sustainable construction	Lean construction achieves project goals and manages the construction process through the elimination of waste

Many of the definitions emphasize waste reduction as the main goal of Lean construction (e.g. Miletsky 2010; Jamil and Fathi 2017). Ballard and Howell (2003) suggest that construction projects become Lean when they aim to minimize waste and maximize value. Moreover, according to Huovila and Koskela (1998), waste elimination is critical in Lean production. Fearne and Fowler (2006) further stress

that minimizing waste and maximizing value, to be Lean in a construction project, means to reduce the significant existing variation, to streamline capacity and to manage the production process, which are all related to the activities of the project. However, the study mentions that many of the identified “wasteful” or inefficient practices were logical and allowed effective project delivery in an uncertain project environment. This possibly implies that the amount of NNVA activities is high in the construction industry, making the identification of de facto wasteful (i.e. NVA) activities difficult.

To make construction Lean, Ballard and Howell (1998) underline two critical steps: (1) Minimizing construction’s idiosyncrasies and defining what contemporary product manufacturing encompasses to utilize the Lean techniques created in manufacturing and (2) Developing appropriate Lean techniques for dynamic construction. The challenge is to develop “standard procedures for planning and managing the design and installation of unique facilities.” Moreover, achieving a more integrated and customized Lean adoption to deliver projects faster and to improve profitability for all participants requires significant changes in relationships and management practices (Fearne and Fowler 2006), as increased supply chain collaboration is a prerequisite for developing Lean in construction (Eriksson 2010). Johansen and Walter (2007) further emphasize that traditional structures regarding both organization and behavior need fundamental changes to allow the implementation of Lean concepts in construction.

### 3.2.1. Tools

Lean construction comprises various tools like the Last Planner System (LPS), concurrent engineering (CE) and Visual Management. The tools presented in this section will be focusing on the ones that the case company has been utilized, as it is not seen practical to discuss the multitude of the different existing LC tools and techniques.

**Last Planner System** (LPS) is a key attribute in Lean construction. The LPS is a practical approach where “construction managers and team leaders collaborate to

prepare work plans that can be implemented with a high degree of reliability, thus improving work stability and predictability” (Kalsaas 2012). According to Salem et al. (2005), Lean construction tools, like the LPS, can be successfully implemented into construction projects, but the successful implementation requires training to allow the workers to use the LPS effectively. While the training increases short-term costs, it will be beneficial for the company in the long-term. Moreover, LPS can be utilized by planners to discard assignments that do not fulfill quality criteria, which leads to better work flow reliability and construction performance. (Ballard 1999)

Last Planner will also improve subcontractor communication and coordination by creating a visualized schedule, where look ahead scheduling and linear scheduling are combined. (Song et al. 2008) The LPS produces a continuous learning cycle when implemented correctly, but it requires active failure identification and knowledge sharing in the project. (Kalsaas 2012) Koskela et al. (2010) presented five integrated elements in the LPS: (1) Master Plan (general plan), (2) Phase planning (master plan divided into phases with more detail), (3) Look ahead Planning (focusing management attention), (4) Weekly Work Plan (weekly meetings to increase collaboration) and (5) Percent Plan Completed and analysis of reasons for non-completed tasks (continuous assessment to improve processes). However, companies should acknowledge that authors such as Leigard and Pesonen (2010) have emphasized that the implementation of the LPS cannot be isolated from the implementation of Lean philosophy and practices.

**Constraint log** is a “list of constraints with identification of an individual promising to resolve the item by an agreed date.” The constraint log is usually developed during a review of look-ahead plan when the activities are identified to have constraints. (LCI 2017) The constraint log is a critical part of a successful LPS implementation as it is used to delegate the responsibility to solve the different identified constraints in the project. It is essential to continuously review the constraint log to see the progress and whether the constraint will be solved before it has an impact on the project schedule. For example, the constraint log can be a simple spreadsheet for easy access and distribution. (Coln 2019)

**Concurrent engineering** (CE) can be used to reduce project duration in construction (Ballard 1993). Concurrent engineering primarily manages information processes where value view is critical (Huovila and Koskela 1998). According to Love et al. (2000), the purpose of CE is to shorten cycle times in product development and the production process and improve the quality of the final product. They continue that CE can be used to integrate and coordinate interdependent tasks, integrate the design, production and manufacturing processes, minimize NVA activities and to implement continuous process improvement.

### 3.2.2. Barriers of implementation

A wide scale of barriers for the implementation of LC have been identified in several studies (e.g. Bashir et al. 2010; Marhani et al. 2013; Khaba and Bhar 2017; Tezel et al. 2018). Jørgensen and Emmitt (2009) argued that the absence of general theory of production obstructs using Lean as a basis in construction design and integration. This notion is reinforced by Johansen and Walter's (2007) research, where most of the respondents were critical regarding Lean's transferability and applicability in the construction industry. A key issue in the transferability of Lean is the need of re-interpreting its basic ideas to fit the needs of the different context such as construction, since Lean implementations and their outcomes cannot be generalized across business sectors (Jørgensen 2006).

Cano et al. (2015) suggested that LC implementations are more successful when the barriers are known beforehand, and appropriate action is taken to mitigate them. A more comprehensive list of Lean construction barriers is presented in table 6. However, it must be noted that the list is not all-encompassing and only describes the barriers that have been identified as the most important ones. It is possible that the organizational context might turn a weaker barrier into a more prevalent one. For example, Johansen and Walter (2007) recognized a mental change process as the most difficult barrier to overcome, while Khaba and Bhar (2017) identified the employees' resistance to change as the least significant barrier in an LC implementation. It is therefore suggested to also consider the less significant

barriers when implementing Lean in construction companies, as they similarly influence the success of the implementation.

Table 6. Barriers in Lean construction implementations.

Author(s)	Type of study	Key focus	Identified key barriers
Bashir et al. (2010)	Literature review	Barriers in sustainable LC implementation	Managerial issues Financial issues Educational issues Governmental issues Technical issues Human attitudinal issues
Ayarkwa et al. (2011)	Structured questionnaire	Barriers in sustainable LC implementation	Difficulties in understanding Lean concepts Incomplete designs Lack of top management support Lack of standardization Lack of long-term supplier relations Lack of client and supplier involvement Extensive use of subcontractors
Marhani et al. (2013)	Literature review	Barriers in sustainable LC implementation	Managerial aspects Technical aspects Human attitude aspects Aspects of process of LC Educational aspects Governmental aspects Financial aspects
Sarhan and Fox (2013)	Literature review; Questionnaire survey	Barriers in LC implementation	Lack of adequate lean awareness and understanding Lack of top management commitment Cultural and human attitudinal issues
Cano et al. (2015)	Literature review; Pilot project	Barriers and success factors in LC implementation	Difficulty in having appropriate people for LC's application Lack of identification and control of waste The results are not fast, and often only partially visible Poverty and social problems The own informality of local industry Lack of self-esteem and initiative on the part of individuals
Khaba and Bhar (2017)	Literature review; Expert opinions	Barriers in LC implementation	Project subcontracting Inconsistent government support Lack of understanding of customer needs Cultural differences Lack of awareness and understanding Lean
Sarhan et al. (2018)	Literature review; Structured questionnaire	Barriers in LC implementation	Influence of traditional management practices Unfavourable organizational culture Lack of technical skills, training and understanding of Lean techniques Lack of knowledge of the Lean construction approaches

Many of the authors emphasize top management support (Bashir et al. 2010; Ayarkwa et al. 2011; Sarhan and Fox 2013; Khaba and Bhar 2017) and organizational culture (Sarhan and Fox 2013; Khaba and Bhar 2017; Sarhan et al. 2018) as the decisive barriers in the LC implementation. Knowledge and understanding regarding Lean and its concepts also play a major part in the literature. Accordingly, Li et al. (2017) recognized culture and organization as the

key factors in an LC implementation, while highlighting the importance of the comprehension of LC. Further, Khaba and Bhar (2017) concluded that cultural differences (where management plays a critical part) is the most significant barrier for LC implementations. Wandahl (2014) argues that the main issue in insufficient Lean construction initiatives seem to be the lack of education, knowledge and communication.

Lastly, Fearne and Fowler (2006) found that operational Lean thinking might lead to project performance being overvalued over effective project delivery. Improvements in project performance does not necessarily translate to project effectiveness, meaning that the operational focus might cause difficulties in the project delivery by shifting the attention away from the project objectives, such as budget, planning and quality, to singular tasks that are only a fraction of the entirety. Thus, focusing on the performance of different distinct functions can hinder the ability to deliver the project effectively.

### 3.2.3. Successful implementation

There are multiple aspects that construction organizations should consider to guarantee that their Lean implementation will be successful. It cannot be stressed enough that even while multiple authors have emphasized the necessity to adapt Lean to fit the industry's characteristics, many of the success factors and necessary activities for successful Lean implementations in other industries also apply to the construction industry. For example, similarly to "traditional" Lean management literature, authors such as Sarhan et al. (2018) and Ayarkwa et al. (2011) have underlined the importance of top management participation in the Lean construction implementations. The barriers of Lean construction presented in the previous section support this notion as multiple authors identified the lack of top management support to be a major barrier blocking Lean construction implementations. Ayarkwa et al. (2011) further establish that it is highly important that construction managers are committed to changes to have success in the LC implementations.

Following, employee training is critical also in Lean construction implementations (Ayarkwa et al. 2011; Khaba and Bhar 2017). Creating a culture of continuous improvement and training employees should help to successfully implement Lean in construction (Khaba and Bhar 2017). In addition, an effective LC implementation improves human relationships in organizations as the roles and responsibilities are defined thorough all organizational levels (Kim and Park 2006).

Finally, the importance of subcontractors in LC implementations has been emphasized by several authors (e.g. Kim and Park 2006; Johansen and Walter 2007; Ayarkwa et al. 2011). Due to the extensive use of subcontractors in construction, the subcontractors should be included in the design process (Khaba and Bhar 2017). Also, it is important to improve the communication between participants in construction projects (Ayarkwa et al. 2011) and LC has a major impact on improved communication between project participants (Kim and Park 2006). Similarly to employee training, Kim and Park (2006) highlighted the need to have Lean training programs for the subcontractors, where the focus should be on the “how-to” rather than theoretical concepts. Further, Lean consultants can be used to help the main contractor and subcontractors to understand Lean better and consequently to have more successful LC implementations.

### 3.2.2. Criticism

Some considerable criticism towards Lean construction has been provided by multiple authors. While the research on LC has been increasing lately (Eriksson 2010), research on Lean construction’s key concepts is scarce (Marhani et al. 2013). Early LC criticism was given by Green (1999), London and Kenley (2001) and Green and May (2003). Green (1999) argued that the debate on LC is “based on an extremely one-sided interpretation of the available literature” and has mostly ignored the human cost in Lean production. Green and May (2003) further established the disregard for human aspect in re-engineering construction, where people are treated as passive objects and the short-term focus completely ignores the employee intransigence created by the existing management practices in construction. London and Kenley (2001) established that the LC literature lacks contextualization

in their Lean implementations, for example missing the comprehensive empirical analysis of market structures that support the construction environment, asserting that practitioners have forgotten to organize and control the market in an extensive and elaborate scale, which is essential in Lean implementations.

Green and May (2005) concluded that Lean construction definitions are vague and subject to various interpretations but are still accepted as a necessary part of best practice. They point out the inherent need of consultants having to sell their services and managers to act as “improvement champions” is one reason for the increased Leanness in construction. Consequently, while LC is advertised as a unique socio-technical innovation, its use is highly context dependent and relied on localized contexts. It has been argued that construction can utilize at best a scarce amount and at worst none of the Lean principles developed in the manufacturing industry (Johansen and Walter 2007). Although Green and May (2005) agree that LC could possibly act as a catalyst for workplace transformation, the most likely result is that managers maintain the existing practices and routines while giving lip-service to Lean. They further establish that the construction industry has had structural changes towards leaner ways of working since mid-1970s, which is a long time before Lean terminology came to the industry.

Jørgensen and Emmitt (2008;2009) have conducted two extensive literature reviews on Lean construction and its applicability to the construction industry. The earlier study (Jørgensen and Emmitt 2008) supports Green and May’s (2005) argument of Lean construction lacking a unified definition and having diverse interpretations, underlining that no meaningful philosophy for LC currently exists. They also note that Lean manufacturing literature is perceived to be significantly more advanced than the one of LC. The study further argues that the LC literature lacks peer-reviewed empirical research and has failed to recognize (or chosen to ignore) Lean’s limitations, arguing that it is therefore necessary to address these shortcomings by assessing the preconditions and limitations of Lean in the construction industry. In the latter study, Jørgensen and Emmitt (2009), surveyed Lean methods’ applicability in integrating design and construction. While Lean was perceived to be applicable for integrating purposes, there was some limitations.

First, the “Ambiguity, vagueness and uncertainty over value aspects define the limit to which the lean philosophy can be applied in an integrated construction project system.” Second, the practical limitations are also affected by social, cultural and structural aspects, and define the extent to which Lean philosophy can be applied to. They emphasize the need for comprehending the fundamental contextual conditions that define value to guarantee effective decision-making for projects.

## **4. METHODOLOGY**

Three distinct data gathering methods were used in this study. First, secondary data were collected to support the evidence from the primary data by aiming understand what kind of Lean-related activities have been and are being engaged in the case organization. Second, qualitative interviews were utilized to gain in-depth information regarding Lean initiatives and their extent in the case company. Lastly, a survey questionnaire was used to gather data that were generalizable in company-level to improve the reliability and validity of the overall results. The topics discussed in the literature review acted as a basis for the interviews. The interview guide mentioned in the introduction can be found in appendix 1.

### **4.1. Qualitative interviews**

Qualitative interviews can be either unstructured or semi-structured. Unstructured interviews are best fit for studies that use language-oriented or experience-based data (Saaranen-Kauppinen and Puusniekka 2006) and the basis for unstructured interviews is the assumption that the interviewee has valuable insight in the matter (Patton 2002, 341) The interviewees’ experience and insights were determined crucial to assess the current state of Lean in the case company, which is why qualitative interviews were chosen for the study. The interviewer’s role in terms of influence is immense in a qualitative research (Fontana and Frey 2005, 140) and the quality of data acquired through interviewing is highly reliant on the interviewer’s skills (Patton 2002, 343). The author was an inexperienced interviewer, but the steps to guarantee better quality for the collected data are explained next.

Qualitative interviews can have data quality issues related to reliability, types of bias, validity and generalizability. Reliability refers to whether other researchers would get the same results analyzing the same data. Interviewer bias occurs when the interviewer interprets the answers through his own beliefs or when the interviewer's bias is reflected to the interview questions. Interviewee bias occurs when the interviewee cannot or will not give in-depth information regarding the discussed topic. Validity refers to "the extent to which the researcher gains access to their participants' knowledge and experience and is able to infer a meaning that the participant intended from the language that was used by this person." (Saunders et al. 2009, 326-237)

The interviews' reliability was increased through careful planning, note-taking and by recording the interviews. Notes were taken as a back-up for the audio recordings, but they also provided a basis for better analysis and future questions. Each of the interview recordings were transcribed to a summary, since ensuring the functionality of the audio tape and that the interview went as planned are critical to guarantee the validity and reliability of the results (Patton 2002, 383). The interview summaries were afterwards sent to the interviewees for comments and corrections to guarantee that the interviewer understood the interviewees correctly and that all the necessary information was acquired.

Multiple authors have noted the importance of trust between the interviewer and the interviewee (e.g. Fontana and Frey 2005, 132; Saaranen-Kauppinen and Puusniekka 2006; Saunders et al. 2009, 326) and it plays a major role in interviewer and interviewee bias (Saunders et al. 2009, 326-327). Trust between the interviewer and the interviewees is expected to be relatively high in this case study, since the researcher is an employee in the case company. Further, the data is collected anonymously i.e. the answers cannot be directly linked to any specific interviewee, and for internal use rather than for external stakeholders. However, while trust is assumed to be higher than if the interviewer was an external researcher, some amount of reserve is expected to exist in the answers as the interviewer had no previous ties with most of the interviewees.

Fontana and Frey (2005, 140) argued that many studies utilizing unstructured interview focus on data analysis, cleansing and reporting while seeing the researcher as neutral and unbiased. They further establish that the studies are not reflexive enough when it comes to the interpreting process – no contradictory data or reasons why data was excluded are presented. Correspondingly, Saaranen-Kauppinen and Puusniekka (2006) warn that considering interviews as representations of reality while disregarding the flaws related to the interviewer and interviewee is problematic, emphasizing the need to list the advantages and disadvantages of an interview. The aforesaid have been noted while conducting the interview process. First, the data in its collected form shouldn't contain contradictions since the study is explanatory in nature. The contradictions should therefore be limited to the researcher's own bias and data quality issues. The steps to negate both the researcher (interviewer) bias and the data quality issues have been discussed previously in this section. Secondly, the attributes and limitations (i.e. data quality issues) of qualitative interviews have been shortly discussed to give the readers a comprehensive understanding regarding the qualitative interviews and how they were conducted in practice. Lastly, no information was directly left out of the interpreting process. Summarizing the interviews inherently forced prioritizing certain parts of the interviews thus reflecting the interviewer bias, but the interviewee commenting process was intended to minimize this bias by having the interviewees add any relevant missing information not included in the summaries, and to correct the interviewer regarding any misinterpretations.

## 4.2. Survey questionnaire

Questionnaires can be used for both explanatory and descriptive studies and they work best with standardized questions (Saunders et al. 2009, 362). A survey questionnaire was utilized to complement the literature review and the data from the qualitative interviews. To maximize the questionnaire's response rate, reliability and validity, one must thoughtfully plan and design the individual questions, have a clear and satisfying layout, articulate the purpose of the questionnaire and have a pilot test. Especially pilot testing is important to increase the validity and reliability of the

questionnaire's results for example to clear any misunderstandings that might arise during the questionnaire. (Saunders et al. 2009, 362, 394)

Designing the individual questions was a continuous process based on the literature review, interviews and pilot testing. The pilot testing was carried out in this study through three steps. First, the researcher had discussions with the other employees of the case company to clear any misconceptions regarding the questions. Second, the survey questionnaire was discussed with the thesis' instructor to ask for an expert opinion as suggested by Saunders et al. (2009, 394). Lastly, the pilot survey was sent to a small group (n=10) inside the company to guarantee that the questions were easy to understand, and that the structure was coherent. The questionnaire was improved based on the feedback from these steps.

An internet-based questionnaire was used for this case study. The survey questionnaire can be found in appendix 2. While internet-based questionnaires are not traditionally used for explorative studies (Saunders et al. 2009, 362), it was considered a necessity due to the survey's scale of distribution and the easiness to access it. The purpose of the questionnaire was explained in the cover letter. The questionnaire was separated into four sections: Demographic qualities, Intrafirm strengths, Development initiatives and Lean. The respondents were asked not to answer the last section regarding Lean, if they hadn't heard of it before the survey (see question 2.11.). The survey was carried out using Google Forms due to its clear layout and easy accessibility. The answers were transferred to Excel and analyzed with Excel and the add-ons XLSTAT and Real Statistics.

### 4.3. Correlation

Correlation analysis was performed to identify any underlying relationships in the questionnaire. The dependency between two variables can be generally named as correlation. Correlation is bounded to a  $(-1, 1)$  interval, where a correlation of 1 indicates a perfect positive association between the series and  $-1$  a perfect negative association. When there exists a strong correlation between two variables, the other variable can be used to determine the values of the other variable relatively

accurately (KvantiMOTV 2004). Pearson's product moment correlation is used in most studies. The correlation coefficient for Pearson's product moment correlation is calculated as

$$P_{x,y} = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{(N-1)\sigma_x\sigma_y} = \frac{\sigma_{x,y}}{\sigma_x\sigma_y} \quad (1)$$

where  $\sigma_x$  and  $\sigma_y$  are the standard deviations of x and y respectively. (Brooks 2014, 69) While Pearson's correlation coefficient is used for most studies, Spearman's rank-order correlation was used in this study due to the nature of the data collected with the questionnaire. Spearman's correlation determines the strength and direction of the monotonic relationships between two variables, meaning it is less restrictive than that of a linear relationship. Spearman's correlation coefficients for tied ranked data is calculated as

$$p = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}} \quad (2)$$

where i = paired score. (Laerd 2018) The correlation coefficients were used to determine which variables were selected for the correlation and the linear regression analysis. Taylor's (1990) correlation scale was used as the basis for the selection process. Taylor's (1990) scale for correlation coefficients is:  $\leq 0,35$  for low or weak correlation, 0,36-0,67 for modest or moderate correlation and 0,68-1,0 for strong or high correlation, where r coefficients with the value of  $\geq 0,9$  are considered very high correlations. All the questionnaire's questions were plotted against each other in a correlation matrix. If the correlation between two variables was at least moderate ( $>0,36$ ), the variables were included in the analysis.

#### 4.4. Linear regression

Correlation measures the degree of linear association between two variables i.e. correlation does not imply that changes in x causes changes in y or vice versa, but rather that there is evidence of a linear relationships between the two variables.

Regression is a more powerful and flexible tool than correlation. In simplistic regressions, it is assumed that the dependent variable  $y$  depends on only one independent variable  $x$ . The  $y$  variable is assumed to be random (or stochastic) and the  $x$  variable to have fixed (non-stochastic) values. (Brooks 2014, 76) The classical linear regression model (CLRM) and the related ordinary least squares (OLS) method were used in this thesis. Moreover, only simplistic two-variable regression models were utilized, where the regression analyses had only one dependent variable and only one independent variable. The purpose of the regression analysis was to confirm or invalidate the significance of the dyadic relationships found in the correlation matrix.

There are five assumptions in the CLRM and OLS (Brooks 2014, 180):

- $E(u_t) = 0$  (3)
- $\text{var}(u_t) = \sigma^2 < \infty$  (4)
- $\text{cov}(u_i, u_j) = 0$  (5)
- $\text{cov}(u_t, x_t) = 0$  (6)
- $u_t \sim N(0, \sigma^2)$  (7)

The basis for the first assumption,  $E(u_t) = 0$ , is that the average value of the errors is zero. This assumption will never be violated if a constant term is included in the regression equation. The second assumption is known as the assumption of homoscedasticity, meaning that the variance of the errors is constant,  $\sigma^2$ . (Brooks 2014, 181) White's test and Breusch-Pagan test can be used to detect whether the data are heteroscedastic. All the dependent variables in this thesis were tested for heteroscedasticity with both White's test and Breusch-Pagan test. Null hypothesis ( $H_0$ ) for the tests were "the data are homoscedastic" and the alternative hypothesis ( $H_a$ ) were "the data are heteroscedastic". All the dependent variables passed both tests, so it was concluded that the data were homoscedastic, and the second assumption was satisfied.

The third assumption of CLRM is that the covariance between the error term over time is zero i.e. the errors are uncorrelated with each other. If the errors are not uncorrelated, they are autocorrelated. Autocorrelation can be detected for example through graphical tests or the Breusch-Godfrey test. In graphical tests for autocorrelation, the current value of the residual  $\hat{u}_t$  is plotted against the immediately previous value  $\hat{u}_{t-1}$ , and  $\hat{u}_t$  is plotted over time, to investigate if a relationship exists between the current value of  $\hat{u}_t$  and any of its previous values,  $\hat{u}_{t-1}$ ,  $\hat{u}_{t-2}$ . (Brooks 2014, 188, 190, 193-194, 197) Autocorrelation was not very relevant in this study as no time series data were used. However, the residuals ( $\hat{u}_t$ ) were plotted against their previous values ( $\hat{u}_{t-1}$ ) to see if any autocorrelation was present in the data. The residual plots implied that there was no autocorrelation present in the data, thus the third assumption was satisfied.

The fourth assumption is that the  $x_1$  are non-stochastic. However, the OLS estimator is unbiased even if the regressors are stochastic (Brooks 2014, 209), which is the case in this thesis. The fifth assumption is that the disturbances are normally distributed. The normality distribution in this study was tested with Shapiro-Wilk test and Kolmogorov-Smirnov test of normal distribution. All the variables failed both tests, meaning that the data used in the regression analysis was not normally distributed, which could have an influence in the results.

#### 4.5. Secondary data

Secondary data refers to data that have been collected for some other purpose than the research being conducted (Saunders et al. 2009, 256-259). Secondary data are used to understand the most relevant past, current and future Lean-related initiatives and other relevant data regarding the case company. The main purpose for the secondary data is to support the primary data. Also, it is important to understand what the company is currently doing to improve its processes to holistically assess its current capabilities and future direction. The case company is shortly introduced in the next section and following the secondary data are presented.

## 4.6. Case-company introduction

The case company is a multinational construction company and its operational headquarters together with most of its activities are in Finland. It is one of the largest construction companies in Finland. In 2018 the case company merged with another large-scale Finnish construction company, where it acted as the absorbing party. To date, the company has almost 10 000 employees in total and comprises various segments such as infrastructure, business premises, housing and paving. The company's revenue in 2018 increased by 85% due to the merger and was around 3,7 billion euros, but its net income dropped 31% to only 39,2 million euros.

### 4.6.1. Performance Leap

Performance Leap (i.e. productivity leap) was one of the three key development initiatives in the organization's 2016 strategy. The purpose of Performance Leap was to "increase competitiveness through development, not through (cost) cutting." The initiative aimed to increase people's interaction skills and remove waste from working habits, decrease building costs in the housing segment by at least 15 percent and to find at least a 10 percent competitive advantage in business premises and infrastructure segments. What is meant with the "10% competitive advantage" goal and how it translates to practice is not explained. Performance Leap was divided into three sub-programs: (1) Securing know-how – developing collaboration and people's interaction skills, (2) Design management – creating a design management model for the whole company to use, and (3) Partnerships and prefabrications – securing profitable growth by increasing productivity and efficiency. These three sub-programs were highly interrelated. Performance Leap will be further discussed in the following chapters.

### 4.6.2. Yearly survey questionnaire

An annual survey questionnaire is used in the case company to map the development progress of several different topics in each country. A total of 83% of the employees (n=8282) answered the 2018 questionnaire that was sent out in

September 2018. In the housing and business premises segments the respective answer % of the Finnish division was 78 % and in infrastructure segment it was 76 %. There were five main themes in the questionnaire: My own work, My superior, My work community, Responsible practices and The case company as an employer. The results for the questionnaire were released in October. The results were coded in a 1 to 5 scale, and the reported percentages (see below) comprise the answers with values 4 (e.g. somewhat agree) and 5 (e.g. fully agree). The five questions that got the best grades in absolute values were:

- 1) I react when I see unethical or dangerous activities (91%),
- 2) My superior puts safety first (86%),
- 3) My colleagues work together to get the work done (85%),
- 4) I enjoy coming to work (82%), and
- 5) My superior is fair and righteous (81%).

The five questions that got the worst grades in absolute values were:

- 1) We continuously go through what we have learned (49%),
- 2) My performance appraisal was useful for my work and personal development (55%),
- 3) My future in the case company seems promising (58%),
- 4) The case company shares best practices (58%), and
- 5) I get relevant and useful feedback (59%).

Some other relevant information was also presented in the questionnaire's results. People are skeptic regarding the leadership and the company's development activities, as 65 % believe that the company is doing the right things to succeed in the future and 66 % trusts the case company's top management. Interestingly, people seem to believe in the future of the company more than they believe in their own future in the company. The merger has probably affected this dimension by creating some uncertainty in the organization, for example in terms of overlapping work positions.

Many (78%) respondents think that the communication in their respective teams is honest and open, there are clear priorities (68%) and that the company utilizes up-to-date tools and working methods (68%). There are some disagreements in developing the activities through customer feedback (63%) and encouraging cross-division collaboration (62%). Lastly, the theme “Responsible practices” got the best values out of all the five themes i.e. people are happy with how things are managed safety-wise within the case company. The lowest valued theme was “The case company as an employer”, as people are cautious towards the case company’s current and future state and its leadership.

#### 4.6.3. New management system GRIP

The new management system GRIP defines how performance is evaluated, managed and continuously improved. The term “management system” might be somewhat misleading, as the main purpose of GRIP is to bring the harmonized process charts and function-specific documents easily available. The system is cloud-based and it was deployed 1.1.2019 to be used by all starting projects and cost estimations. There are several main sections in GRIP, such as Management, Procurement, People, Finance, IT, etc., but the access is limited for most users. GRIP has different instructions for different sectors and processes. For example, change leadership exists under Management and has a clearly defined purpose, scope, inputs and outputs, records and procedure. The procedure sub-section is divided into eight subsequent activities that have detailed instructions explaining how the change management should be executed in practice. GRIP comprises different process charts and relevant documents for each section, and different process models for seven types of projects, such as Life cycle projects, Traditional contracting and Project management contracting.

#### 4.6.4. PI Planning

The case organization has started its SAFe journey around three years ago in the “Customer Journey” function, and PI Planning is a fundamental part of the SAFe initiative. PI Planning is a two-day event that is held once every 10 weeks and the

purpose is to plan the upcoming development initiatives for the next four 10-week periods, where higher emphasis is put on the upcoming quarter. The development initiatives are put on a timeline, where the upcoming quarter has the 2-week iterations set on the timeline and the following three quarters comprise the whole 10 weeks inside them (see figure 2). The green development initiatives only consider the individual functions, while the red development initiatives are intercorrelated with other functions.

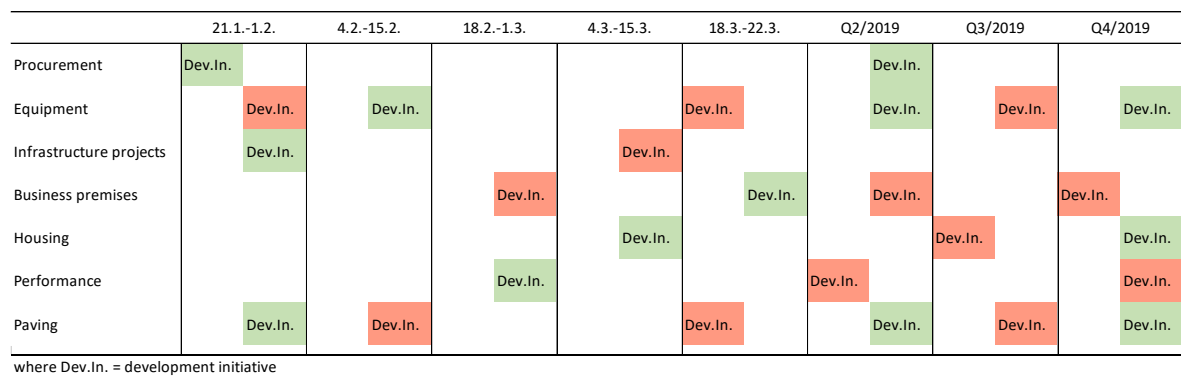


Figure 3. PI Planning schedule.

The researcher spent one day in the PI Planning event. The purpose was to understand how the SAFe model works in practice. A few key members involved with the SAFe development were asked why SAFe has been chosen for all development activities in the case company. The reasoning was success in the Customer Journey-function, where “its (SAFe’s) functionality has been proven through empirical evidence.” It is not surprising that SAFe is working in a function that is relatively close to what SAFe was originally developed for. For example, in the center of Customer Journey is a B2C platform. However, starting a full-scale development initiative without fully assessing the applicability of SAFe seems dangerous and could endanger the organization’s development activities, should the method not work as intended. Further, the literature regarding SAFe and Agile in the construction industry is very scarce, and the reference companies for SAFe are almost without exception IT-based (Scaled Agile 2018b), meaning that there is little to no knowledge on how to successfully apply these methods in construction. The researcher therefore believes that there are insufficient justifications to apply SAFe to all the development activities without more in-depth understanding and

planning. However, SAFe has been chosen as the method to develop the case company's functions.

#### 4.6.5. Quintet 4.0

Quintet 4.0 is a new project management system that is being developed for the case company. The development of the first version of Quintet was started in 2014, but the new Quintet 4.0 is practically a completely new program. The purpose of Quintet 4.0 is to have better project control by having the cost estimation, production and the procurement function implemented in the same system. The development however has been delayed considerably due to turnover and other factors. Nonetheless, it seems that the case company will be moving forward with Quintet 4.0 and the purpose is to pilot it in procurement by the end of 2019 and in production during 2020. The program should, in its ideal state, bring the functions together and make communication, collaboration and information processing considerably better between them.

## 5. EMPIRICAL RESULTS

This chapter presents the empirical results from the qualitative interviews and the survey questionnaire. First, the interview results are presented and analyzed. The aim is to holistically portray the discussed topics while keeping the focus on Lean. Second, the survey questionnaire's results will be discussed and analyzed. There will first be general discussion regarding the results of the questionnaire and following will be the correlation and regression analysis, where the focus will be on the dyadic relationships between the questions.

### 5.1. Interviews

Originally seventeen interviews were conducted. Sixteen of the interviewees were from the case company and one interviewee was from a consulting company. The consulting company has been involved with the Lean implementations within the case company and it was therefore seen necessary to get insight from this external

perspective. Additionally, some interviewees mentioned the use of SAFe in the company's development activities. One additional interview was therefore conducted with the person who had the most experience regarding SAFe in the case company to understand the topic better and what role SAFe plays in the organization.

Table 7 shows the basic information regarding the interviews. To get a comprehensive picture of the case company's current Lean initiatives and their scope, the interviewees ranged from different segment representatives (e.g. from infra segment to IT services) and from site engineer to EVP of strategy and development. As mentioned before, the interviews were transcribed and sent to the interviewees for corrections and to add any relevant information. While some literature suggests littering the interviews word to word (e.g. Patton 2002, 440), it was deemed unnecessary in this research due to time constraints with both the interviewer and the interviewees. Only the summaries were therefore created.

Table 7. Interviewee characteristics.

No	Title	Interview length	Comments (Yes/No)	Experience in construction	Lean experience (years)
1	Process Development Manager	39 min 51s	Yes	> 1 years	>10
2	Director, Head of Business Development	49 min 19s	Yes	> 30 years	>5, <10
3	VP, Project and Support Productivity	57 min 53s	Yes	> 30 years	>5, <10
4	Project Manager	81 min 01s	No	> 15 years	>1, <5
5	Site Engineer	66 min 34s	Yes	> 1 years	>1, <5
6	Planning Engineer	33 min 05s	Yes	> 1 years	>1, <5
7	Enterprise Architect	61 min 05s	Yes	> 5 years	>1, <5
8	Development Manager	35 min 32s	No	> 15 years	>5, <10
9	Development Manager	41 min 07s	Yes	> 30 years	>1, <5
10	EVP, Strategy and Development	42 min 37s	No	> 20 years	<1
11	SVP, Structural Engineering	36 min 04s	No	> 20 years	>1, <5
12	Site Manager	35 min 43s	No	> 5 years	>1, <5
13	Head of Performance Leap	45 min 55s	No	> 25 years	>5, <10
14	Development Manager, Sales and Operations	32 min 32s	No	> 1 years	<1
15	Marketing Manager	39 min 59s	No	> 15 years	>5, <10
16	Procurement Manager	46 min 53s	Yes	> 15 years	>1, <5
17	Lean professional, consulting company	83 min 21s	No	-	>10
18	Development manager	67 min 10s	No	-	<1

The average interview time was 50 minutes and the individual transcripts varied from 2 to 5 pages in length. Almost half of the interviewees added comments and/or corrections to the summaries. The interviewees' experience from the construction industry ranged from 1-5 years to 30+ years, and their Lean experience from 0-1

years to 10+ years. Most of the interviewees had over 15 years of experience from construction industry, while the median Lean experience was only 1-5 years. Around a third of the interviewees had over 5 years of Lean experience. However, it should be noted that amongst the people who had over 5 years of Lean experience there was high variation in their skills and knowledge related to Lean. While some had been applying Lean only occasionally, others had been continuously educating themselves in the matter. This pattern was present in every experience sub-group making the “Lean experience (years)” a somewhat imprecise measurement of the person’s actual Lean proficiency.

Eight categories were derived from the interviews. The categories were developed based on the interviews and the literature review. Saunders (2009, 492) have noted that categorizing data allows one to quantitatively analyze and draw conclusions from the data. While the categories have some overlapping due to their interrelations, it was deemed necessary to present each of them separately to fully assess the different aspects that emerged during the interviews. To guarantee the anonymity of the interviewees, the quotes used in this chapter will not be associated with any specific interviewee.

#### 5.1.1. Understanding Lean

Based on the interviews, no consensus of what “Lean” means exists in the case company. There seems to be somewhat substantial differences on the perceived nature of Lean amongst the interviewees. Some of the respondents see Lean as a method to lead people or as a philosophy and a way of thinking:

*“Lean is not tied to one industry, but rather a way of management.”*

*“Learn to learn.”*

*“It (Lean) is a philosophy for the most part, but its nature is mostly tool-related in our company. Lean is also a way of thinking – a frame, people talk about Lean and eliminating waste.”*

However, while some see Lean as something more abstract, many of the interviewees saw Lean through being efficient – minimizing lead times and doing things more rationally than before:

*“Lean means making activities more efficient through rationalization – rationalizing activities so that the result is more efficient. People will have more time to focus on what they need to be focused on by eliminating unnecessary things.”*

*“Eliminating everything unnecessary, to produce more, faster and with a higher quality.”*

*“Lean means shortening lead times and doing only smart things – avoiding waste, making things efficiently and in the right time.”*

There were also perceptions that included dimensions from both previous groups:

*“I think that Lean is a way of thinking, and when we are talking about thinking it is also a cultural point of view. According to some people (including me), Lean is also a manufacturing strategy. It is a manufacturing strategy that aims to produce value for the customer as smoothly as possible, using as less as possible (i.e. eliminating/minimizing everything that does not add to customer value).”*

Due to Lean’s ambiguous nature and the wide literature related to it, it is not surprising that there exists no unified meaning for Lean in the case company. While the definitions themselves differ from each other, some general themes for Lean were found in the interviews: (9) being more efficient, (6) a way of thinking/ a philosophy, (5) minimizing lead times, (5) eliminating waste and (4) doing things smarter (where the numbers represent the no. of respondents). However, it was surprising that creating customer value and continuous improvement were only mentioned once. There seems to exist a rather activity-focused atmosphere in the case company, where the aim is to minimize waste to decrease lead times to produce things more efficiently, while the focus on the customer and continuous improvement are left for lesser attention. Whether this originates from the fact that interviewees did not think of these dimensions on the spot, or if they see them less important than the things they mentioned, is out of the scope of this study. It should

be noted that the interviewees have most likely at least heard how customer focus and continuous improvement are related to Lean and know of their importance to a certain extent.

Despite the seemingly activity-based focus, the interviewees emphasized that Lean is not and shouldn't be thought of as a tool. It was noted that the continuous reports from Lean initiatives might distort people's view of Lean, since many of the stories are heavily tool-related. Instead, Lean should be people driven and value should be created through management of people, but this process has been hindered due to the merger. The following sections will discuss this in a more in-depth manner.

#### 5.1.2. Lean initiatives and their successes

Multiple Lean initiatives and tools have been used in the case company. Their success has been measured for example through NPS (Net Promoter Score) and time and cost savings. The most frequently mentioned tools were Last Planner and concurrent engineering. Other tools mentioned were SKAT analysis, schedule planning, value stream mapping, constraint log, visualization, Big room and 5 Whys. The tools and their use in different projects are presented below in table 8. Several interviewees mentioned that the best successes have been achieved when people start to think differently and evaluate their own actions, and when people find successes by applying Lean thinking to practice. However, according to one interviewee the risk is that people "*Think that they are thinking things through Lean, while they regress back to resource-efficient thinking*", which might lead to future problems. Having insufficient understanding of Lean can compromise the purpose of its use if people start "running faster" instead of doing things more smartly. Further, it was mentioned that some of the tools haven't had a systematic implementation methodology but have rather been used to fix specific problems.

Table 8. Lean initiatives in the case company.

Project name	Used Lean tools	Purpose of use	Successes
Suomenlinnan tunnelihanke	Last Planner	Visualization; holistic view	Visualizing and phasing work activities
	Concurrent engineering	Shorter lead times	Smoother work transitions; shorter lead times
	SKAT analysis	Root cause analysis	Identified the root cause of an employee injury
	Target planning	Adapt to budget constraints	Solutions to budget constraints set by client
	Constraint log	Identifying key obstacles	Identified key priorities through obstacles
	Big room	Visualization; holistic view	Identifying the most important topics and how to
Töölön pysäköintilaitos	Last Planner	Visualization; holistic view	<i>not identified</i>
	Concurrent engineering	Shorter lead times	Shorter lead times (theoretical examination after
	Big room	Visualization; holistic view	<i>not identified</i>
RU22 Kittilä	Last Planner	Visualization; holistic view	<i>not identified</i>
	Concurrent engineering	Shorter lead times	<i>not identified</i>
	Weekly planning	Improved management	<i>not identified</i>
Pääkonttorin peruskorjaus	Concurrent engineering	Shorter lead times	Shorter lead times
	Prefabrications	Shorter lead times	No specific values - the benefits of
General / other projects	Last Planner	Visualization; holistic view	<i>not identified</i>
	Big rooms	Visualization; holistic view	<i>not identified</i>
	Value Stream Mapping	Eliminating waste	<i>not identified</i>
<b>Lean initiatives:</b>			
Performance Leap	Multiple tools	Lean implementation	Collaboration between segments; Lean projects
New schedule planning system*	-	To help to control schedule	<i>not identified</i>
Collaboration	-	Better results	Varying
RAIN**	-	Improving collaboration in construction industry	<i>not identified</i>
Visio 2030**	-	Technology and productivity development in construction industry	<i>not identified</i>
*Not yet completed			
**Project with external parties			

Many interviewees noted that the implementation of Last Planner has been successful in multiple occasions. Implementing the Last Planner has helped to make activities more distinct, visualize the processes and to combine value streams. Especially the visualization has been noted useful in many projects. While many interviewees found the Last Planner as a good tool which has had successful implementations, some problems were also mentioned. For example, there have been failures to implement the Last Planner, which have been caused by the people's lack of understanding Lean and the lack of a culture that would enable the use of Last Planner. Also, even though the Last Planner was concluded to be good to determine whether project plans are correct and executable, the system has been too heavy maintain in some projects. In a certain project a change in a process (e.g. rock material delivery) took around 30 minutes to adapt on the Last Planner board. There was also confusion regarding the changes as there is no means to see how

the board has been modified. The project quit using Last Planner due to its heavily time-consuming nature.

It was implied during the interviews that Performance Leap has been the only corporate-level Lean effort to change cultural habits in the case organization. While the idea was to increase cooperation between segments and to optimize costs and time savings, it was argued that the initiative suffered heavily from the merger and did not advance much further after a good start. In addition, according to one interviewee, the people from the Performance Leap teams have scattered to new assignments and cannot be used for the same development purposes. There is a new initiative called "Performance" that is related to Performance Leap, but the specifics related to it are not currently available. However, it was mentioned that the word "Lean" is being avoided when talking about Performance, although some of its qualities are heavily related to Lean. The company apparently wants to avoid Lean terminology while still utilizing Lean-related methods to its benefits.

The researcher tried to find the material related to the Performance Leap initiative by contacting the key personnel in every segment, as it has played a major part in the organization's overall Lean activities. It turns out that no specific material regarding the initiative exist, and there are only some generic materials that concern topics such as LC seminars, concurrent engineering literature, the purpose of Performance Leap, etc. No information is available regarding the projects and how the claimed productivity or other benefits have been achieved. The concurrent engineering section below further discloses the methodology used in Performance Leap.

Concurrent engineering is a tool that has been utilized in multiple projects and at least one project has had CE training provided by a consulting company. CE in the case company is heavily related to the Performance Leap initiative, where most of the CE success stories were operated. Decreases in lead times have been attributed to the CE implementations and it has helped to control the projects' schedules through priority identification and planning the monthly and weekly schedules. While the decreases in lead times have been contributed to CE, the

researcher is somewhat sceptic about these conclusions and thus the validity of the results. As an example, in the project “Pääkonttorin peruskorjaus” the four-month improvement in lead times was calculated by first doing a traditional waterfall-type time schedule for the project and then creating a new schedule using CE. A similar methodology has been used in the other success stories in Performance Leap. Although it is possible that CE contributed to the decrease of lead times, there has been no control over any other variables except for the time schedules i.e. the utilization of CE has been deemed successful when the project has been completed faster than the original schedule. While there has been some control over the subcontractors and logistics, there is no way to know whether the original schedules have been planned loosely (in terms of time) or what other factors have contributed to the total decreases. Since almost no standardization exists in the industry or the company, there are no reference projects where these results could be compared to. Even if there were some similar projects, the dynamic nature of the construction industry forces one to question whether the improvements can be contributed to CE if there is no control for any other variable than the time schedules, and when there is no standardization in the individual work phases which would allow one to calculate deviation from the average process time. Thus, while CE could have been a major contributor in the previously presented lead time improvements, its role in them should be faced with healthy skepticism before having better data available.

Other successful Lean initiatives are related to Value Stream Mapping, prefabrications, Big Rooms and constraint log. VSM has been used to combine value streams and eliminate waste in infrastructure projects, although only in one of the divisions inside the segment. The company has focused on mapping singular processes or systems with the help of a consulting company. This has helped people to recognize how value is created and how to eliminate waste that obstructs value creation. The VSM has been mainly limited to the rock engineering division, and it was argued that the organization is not ready to do in-depth value stream mapping. While prefabrications have been used in different projects, there seems to be no data available to evaluate their success. An interviewee mentioned that *“There are no exact numbers and prefabrications are a more expensive solution, but their benefit has been recognized in the planning phase.”* Like with CE, the

benefits of prefabrications are questionable without any data to prove their usefulness.

Many of the interviewees noted Big Rooms as a good way to manage meetings, communicate inside the project, and to visualize things. Big Rooms have been used for example to discuss and identify which processes have high importance and what needs to be done next. Almost no critique for Big Rooms were given. Correspondingly, the constraint log has also been useful to identify the obstacles that prevent achieving goals and to prioritize the upcoming process steps. However, the use of the constraint log has been found problematic when a problem that needs immediate action emerges, as such instances require instant reaction to the problem. In such cases the constraint log is seen as more of a hindrance than a solution, since the problem must be written down to the logbook after it is already solved.

The interviewees were also asked whether construction industry's idiosyncrasies have been taken into consideration in Lean implementations. While a few interviewees believed that there is no need to consider this because "*Lean's basic principles apply to every industry*", most of the interviewees were adamant that Lean should and is modified to fit the company's and therefore the industry's needs. A lot of emphasis was put on the need to translate the philosophical contexts to practice i.e. to modify Lean in a way that fits the case company's processes and daily activities. This means that every project needs to consider how Lean can be applied to this specific context and understand the differences and limitations between different project types. Regarding Lean training it was mentioned that the educator should preferably understand the construction processes to some level, so that they could guide the participants in a more thorough way instead of repeating the general buzzwords. Overall, most interviewees thought that Lean can be applied to any industry, but the philosophy needs to be properly adapted to fit the industry's characteristics.

### 5.1.3. Obstacles for implementation

Many of the interviewees believed that there were no definite barriers for implementing Lean, rather only challenges that could be overcome. Due to the nature of the language used in the interviews, the difference between the words challenge (fin. Haaste) and barrier (fin. Este) could be considered wavering, and the interpretation was left to the interviewee's subjective understanding. Thus, after carefully reviewing how the *barriers* were described, the interviewer believes that none of them are meant as definitive. For clarity the word "obstacle" is therefore used as a synonym for both challenge and barrier.

A total of 29 individual obstacles were identified based on the interviews. They were categorized in three categories: managerial, people and practical. The identified obstacles and their definitions can be found in table 9. It should be noted that there exists high intercorrelation between some of the obstacles (e.g. Short-sightedness and Short-term planning) and between the three categories, but the most overlapping obstacles were combined to singular ones.

Table 9. The identified obstacles for Lean implementations.

Type	Obstacle	Definition
Managerial	Bad instructions	Specific indicators for success are set, but the means to achieve said success is absent
	Bad communication	No follow-up after initial contact, leaving project personnel unable to commit to Lean
	Cherry-picking	Singular aspects of Lean are cherry-picked rather than focusing on the big picture
	Cost focus	Focusing on costs but not understanding how they are formed
	Customer value	Not recognizing how creating better customer value creates profits
	Objectives	Not having clear objectives
	People	Having the right people available at the right time
	Short-sightedness	Not looking far enough in the future
	Short-term planning	Focusing on quarterly benefits instead of long-term success
	Turnover	Either in the company or inside projects
People	Attitude	Waiting another project to fail to avoid learning Lean
	Changing opinions	Difficulties to change existing opinions
	Commitment	Failure/unwillingness to commit to Lean
	Prejudices	Believing that you need to run to be more efficient
	Sub contractors	Unsatisfactory Lean understanding
	Suspicion	People are used to doing things based on their own cumulative learning
	Understanding Lean	Not understanding Lean and developing its way of thinking
Practical	Adaptability	Being able to connect the general Lean principles to practice
	Best practices	Sharing best practices is problematic
	Cultural	The machine isn't moving therefore its use is ineffective
	Haste	No time to learn or implement new
	Incentives	Clients, contractors, sub-contractors and even the intrafirm segments all have differing targets
	Lack of skills	Not enough people with adequate Lean knowledge for a larger scale implementation in the company
	Late implementation	Projects have gone too far before concurrent engineering (CE) implementation
	Post-it notes	Impossible to duplicate or share in their current form
	Practical knowledge	Information about long lead times is required to realize efficiency benefits
	Standardization	Almost non-existent in the case company
	Tenders	Creating tenders in a certain way leads to certain types of answers → innovations are non-existent
	Transferring knowledge	Difficulties in spreading information to other projects and people

A lot of emphasis was put on the need for people to understand Lean and management being the one to create the basis for this. As an interviewee noted: *“Last Planner is not a complicated thing, but it requires complicated people skills and a new way of thinking.”* Without proper knowledge it becomes impossible for people to implement Lean to their work and further guides them towards more tool-heavy thinking or in worst case scenario towards the traditional resource-intensive thinking. Resistance to change and cultural behavior were also perceived to be major obstacles blocking Lean’s implementation. It is important to note that the resistance to change is perceived to exist within both groups, the employees and the management. People in the organization were seen resistant to learn new things and wanting to stick to their old habits, as change always creates uncertainty. There have even been cases where the people have been waiting for a failure (in a Lean implementation), to avoid learning new. It was argued that people need to be open to learn new things and that it is the management’s responsibility to guide them through the transformation. Guiding people towards a more pro-flow thinking requires time and effort and most of all managerial support. However, if the people in the case company are unwilling to change, a successful transformation is at best hindered and at worst completely barred. Appropriate management of change therefore plays a critical role should the organization aim for a holistic Lean transformation.

Some interviewees see Lean as something that needs to be timed right and at the right level, but to succeed in this, people need to have appropriate Lean knowledge and how to apply it in practice. In this context, having the right timing means that things are not done too early or too late, and proper planning allows timing the procurement of materials and working in a way that on-site warehousing and waiting times are minimized. Using Lean at the right level means that depending on the project’s nature, Lean should be used differently. Since some project types are more adaptable to Lean than others, the nature of a project can act as an obstacle.

Short-term focus was also identified as a significant obstacle in the current Lean implementation. Focusing on quarterly profits instead of long-term success is seen to prohibit a wider scale Lean implementation. This combined with the heavy cost-

focus could possibly lead to neglecting customer value or failing to understand how value is created in the first place. In addition, setting up unclear goals and not clarifying the means to achieve them creates further vagueness in the organization. It could be argued that the overall management of people is problematic. People moving from project to project (or away from the case company) can leave a Lean-focused project in trouble if the key person(s) becomes unavailable. This problem could prove to be critical since the case company only has a few Lean professionals. It also makes the planning of future Lean-related projects harder, as there might simply not be enough people with adequate knowledge to guarantee that Lean could be utilized project-wide.

The fundamentals of incentives are also perceived to be an obstacle. There are mismatches between intrafirm incentives as well as in the triad relationship between a client, contractor and subcontractor. Since every participant has a different goal, everyone aims to guarantee their own success instead of working towards a unified goal. This kind of “silo mentality” is present inside the case company and between the segments. The way bonuses are rewarded in a multi-year project is vague. A segment (e.g. infrastructure) might do most of the work in the beginning of the project, but as time goes by its contribution might be forgotten. The organization should rapidly fix these mismatches in their intrafirm incentives, or collaborative efforts will continue to be lacking and true collaboration cannot be achieved when everyone is focused on their differing goals. The compensation system should be the same for everyone rather than based on the individual results of the segments to enhance intrafirm cooperation. If the case company cannot even fix its intrafirm incentives, how does it expect to establish successful external cooperation where the relations are far more complicated and out of its control.

Currently, almost no standardization is present in the organization. Without standardized methods that are reproduceable there cannot be systematical development as the variation between projects and processes is too high. There is a critical need for the case company to start standardizing the work processes to be able to facilitate learning and continuous development. Post-it notes (see e.g. Last Planner) are an example of the unreproducible methods. It is, if not impossible, at

the minimum heavily time-consuming to transfer the information collected in post-it notes to another project (or to a collective information system), and likely the information in the notes is forgotten after the project is over. There are however major differences in standardization between the organization's segments. For example, standardization is far more advanced in housing segment than in business premises segment or infrastructure segment, because the volumes in housing are known beforehand, and the projects have a lot of similarities in terms of the process steps. It could be argued that the housing segment is relatively standardized, or at least the cost and time each process takes is fairly known. Therefore, it would be easiest and likely most beneficial to create a basis for standardization and develop collaboration in the housing segment. Lastly, transferring best practices or information inside the company, and the scalability of the Lean methods were thought to be problematic. Information sharing in general is discussed more in the following section.

#### 5.1.4. Information sharing

Sharing information is a continuous challenge in most companies. The interviewees argued that sharing information in the case company is severely lacking. Having various information systems to store information and no clear consensus of what kind of information is stored where, it is no surprise that the people feel overwhelmed by the amount of information coming in. The information sharing was divided into three categories: best practices, information flow and feedback.

*Best practices.* Sharing best practices was unanimously perceived problematic by the interviewees. In the past the organization has produced news about singular success stories related to single Lean tools (e.g. concurrent engineering or Last Planner), but nothing more around them. Best practices are only shared mouth-to-mouth and according to one interviewee "*the responsibility of learning is left to the listener.*" No unified knowledge for best practices exists in the case company, and the information at worst disappears and at best stays with the individuals after a project is disbanded. It is possible that the individuals don't have the necessary tools or knowledge to share these practices, since it was mentioned that the problems

related to sharing best practices “...*might exist because no method to share and implement best practices have been found.*” However, few interviewees argued that it hasn’t been a necessity to share best practices in the construction industry, and some best practices have been successfully shared at least in the past. While this might be true to an extent, as stated before, almost no standardization or a plan to share the best practices currently exists. The new management system GRIP should bring standardization to the organization, but in addition to it there are not any other initiatives to improve standardization as far as the researcher knows.

*Information flow* between people and systems was also determined problematic. Again, no consensus on information sharing or storing exists. In a sense, even while most of the existing information is available for almost anyone, there is no “collective” information. Rather, the information is fragmented into pieces around different information systems and databases, and there is not (to an extent) any set practices of what sort of information should be stored and where. A lot of information is created continuously, but it does not reach the right people on the right time, or there are too much of it. One of the interviewees suggested that this has led to a state where “*The people don’t know where and which tools should be used to process information.*” The amount of information systems and different tools was identified to play a major part in the overall confusion. For example, e-mail was partly criticized as a method to spread information, since there is so much e-mail to date that critical information might be lost during the process. Also, if one forgets to add someone as a receiver, the information does not necessarily reach that person. It was suggested that horizontal information flow should be increased by collaborative efforts between segments, and that the systems should talk more with each other to make automatic information update possible amongst the systems.

There are however some differences on how the interviewees perceived intrafirm information flow. Most of the interviewees thought that the information flow inside divisions is relatively good, but when it came to information flow inside segments (i.e. between divisions) and between segments, some felt that especially the information flow between segments is lacking. A few interviewees thought the flow is decent between segments, but it requires development. It was further argued that

the organization lacks transparency in this matter as there is no clear guidelines for information sharing. Additionally, it was emphasized that the intrafirm information flow is highly dependent on the personnel's individual relations in the organization and where the person is located. It was suggested that the merger of two companies in the year 2018 had a negative effect on the organization's information flow and this was acknowledged by multiple interviewees. An interviewee stated that "*The merger made segments more isolated than before merger. - - now the organization has been separated in a way that it (collaboration) is impossible in practice.*" It seems fair to assume that the merger has made isolation and the silo mentality more apparent in the organization.

*Feedback.* The interviewees' attitude towards internal feedback varies a lot in the organization. Some feel like the amount of feedback is adequate and they can freely talk with their peers and foremen, while others think that the overall feedback is still well underdeveloped. The yearly opinion poll to employees and internal auditions are mentioned as examples of a working feedback system. The bi-annual performance appraisal is another example of internal feedback. However, while it is instructed that the half-year performance targets should be updated regularly, no one is surveying whether this is being done or not, and the responsibility for this is left to the managers. Also, no method exists to know if the performance appraisal even took place the way it was supposed to, since the conversations are informal, and the HR department does not have the resources to follow this process. Ultimately this means that there is no way to know if any feedback is given, as once again there are no standardized practices to give feedback or to make sure that the people receive it. One of the interviewees argued regarding feedback that the negative aspects should be brought up more and their root causes analyzed, but this would require a change of culture since some might take negative feedback as a personal insult, when they should see it as a chance to learn new.

There have been some initiatives to develop the feedback system, for example by arranging a feedback meeting after submitting an offer in a bidding contest, to learn through self-reflection by going through successful practices and those that require improvements. Additionally, quarterly meetings have been organized to summarize

the quarter and to discuss how to improve things. There was minor critique that the feedback from subcontractors is collected only after a project and not during it. Further, only scarce feedback from or regarding the subcontractors exist. While the company has a system for supplier evaluation, its use has been lackluster, making accurate supplier evaluation (at least based on the system's data) nearly impossible. Moreover, it needs to be emphasized that based on the researcher's understanding the initiatives to improve feedback mentioned previously have been limited to one division in the infrastructure segment, meaning that no company-wide initiatives exist apart from the bi-annual performance appraisals and the yearly opinion poll. One of the largest problems in the organization seems to be the lack of analyzing failures and successes, whether they are related to personal or organizational attributes.

#### 5.1.5. Strategy and management

Several people note that Lean haven't necessarily been worded as Lean in the case company's strategy, but it has existed in the form of words like "reducing lead times", "teamwork" or "respecting others". It should be noted that these kinds of buzzwords cannot be directly credited to being Lean, but rather something that multiple companies have in their key values despite having no interest or knowledge regarding Lean. The interviewees were again quite divided on the strategy matter. While others felt like they have the needed support for Lean initiatives and the company's strategy has pursued a Leaner organization through initiatives like the Performance Leap, others felt like Lean has been heavily based on its tools and is not built on sustainable fundamentals. The unclear goal setting mentioned in the obstacles-section is also present in the strategy. It was argued that if the goal is to decrease lead times, not having a reliable comparison (e.g. project, process step) means that the process is incomparable, and decreasing lead times without understanding the value stream is dangerous and leads to extra waste.

The opinions regarding top management's Lean capabilities varied highly between the interviewees, and some couldn't give an answer regarding to this due to their lack of knowledge. Multiple interviewees believed that the top management does

not understand Lean and sees it as a toolkit – they haven't understood that Lean begins from the top or what kind of changes are needed in the organization for it to become Lean. Doubt was also expressed towards middle management's Lean capabilities. As one interviewee argued: *“One must understand that they don't understand, because if you don't understand that you don't understand, it is difficult to demand change from the other people in the organization. If one does not understand Lean, they begin to ask for things that are not realistic in their own organization.”* On the other hand, a few of the interviewees believed that the top management understands Lean to some extent and is committed to it, which was proven when for example they supported the development program Performance Leap. Still, all the interviewees believe that the top management should have more in-depth understanding regarding Lean. Contradictory to this, a couple of interviewees believe that top management does not have to understand Lean that deeply, rather only guide the organization with Lean professionals' help.

While the opinions regarding top management's Lean capabilities differ, almost all the interviewees put heavy emphasis on top management's crucial role in Lean implementation. It was argued that without the top management showing the way and giving their active support for the initiation, a Lean transformation is destined to fail. Based on the interviews, the researcher sees the support from the top management as nothing more than occasional attendances to events and meetings and as buzzwords in the strategy. It seems that the support has been somewhat absent in practice, noting that almost everyone who was interviewed emphasized greater top management participation and the need for top management to be pioneers in this matter. If the organization has truly been aiming for a comprehensive Lean transformation, the absence of top management seems strange. Further, as noted before the results produced by Performance Leap have been ambiguous to say the least. One could assume that if the top management was truly interested in a Lean transformation, the purpose of Performance Leap would've been better planned together with the methods to quantify the benefits of the initiative.

#### 5.1.6. Internal and external relations

Multiple interviewees thought that internal cooperation has been rather nonexistent in the past, but the organization is now moving in the right direction. In the past, the collaboration activities have been limited heavily inside segments and even divisions. Now the organization seems to be moving away from the siloed segments and divisions towards a more transparent and collaborative state, although some interviewees felt like not enough of concrete actions are being performed. Also, some interviewees thought that collaboration was better in the past and the collaborative efforts have been thwarted partly because of the merger. On the contrary, some interviewees thought that the current cooperative efforts are working surprisingly well. Due to the merger the organization has been working to unify for example working policies, contracts and instructions in the past year, which will likely benefit future collaborative efforts.

As mentioned before, incentives were identified to be a major obstacle in collaborative efforts by multiple interviewees. As an interviewee concluded: *“Now the incentives (for example bonuses) are segment-based, but still people are encouraged to work together. This mismatch tells about the organizational maturity in this matter.”* Also, some of the KPIs in the case company’s strategy are similarly mismatched, which naturally leads the segments and divisions to pursue the best result for themselves rather than what would create the largest benefit for the organization. However, few interviewees mentioned that there have been minor advancements regarding these mismatches.

More talk about partnering, alliances and collaborative models has emerged in the organization and several interviewees believe that the case company is moving towards a good direction when referring to subcontractor relationships. However, there seems to be a lot of variation in the subcontractor relationships and actions for a higher level of collaboration. To guarantee quality, the company prefers employing previously used subcontractors, whom range from one-time collaborative efforts to relationships that have lasted for years. New contractors are also tried from time to time. The company has started to talk about partnerships in the last few

years, but there are disagreements on the partnerships' stage of development. Interestingly, even inside the same segment there are contradictions:

Interviewee 1: *"In segment X, there are regular meetings with these partners to conclude what has been done and how things can be improved, to develop the outcome."*

Interviewee 2: *"In segment X, the partnerships are mainly expressions of intent."*

The interviewer is not certain why these differing opinions exist, but it is likely due to insufficient information exchange inside segment X. There is also the possibility that even if there are regular development meetings with certain partners, these partnerships are only considered as "expressions of intent", meaning that in a sense there is no true collaboration or strategic co-development, but rather implications of desire to continue the dyadic relationship based on previously successful collaboration.

Differences also exist between segments. In business premises, there are meetings with a few subcontractors approximately every six months and in housing, where the collaboration is more developed, every two months. Still, the interviewees agree that, as far as they know, there are only a few measured subcontractor relationships, but no systematic way of developing the partnerships exist. The researcher has a somewhat blurred understanding regarding the subject. It is implied that some forms of measurements are placed, but no collaborative or systematic efforts to improve the profitability of these partnerships exist, not to mention any tools or methods to quantify the advantages or disadvantages of said partnerships. Moreover, few interviewees argued that the collaborative efforts in the company are non-existent and contracts are not made for successful collaboration, and the subcontractors are further seen as stakeholders who are given money rather than as partners.

Roughly, there are two types of customers in the construction industry, B2C customers and B2B customers (i.e. clients). Especially in housing, B2C customers are in the center of attention and their needs are taken into consideration for

example through a systematic feedback system called Customer Journey. Some interviewees mentioned that the customer and creating value for the customer is more in the center of attention than before. While the B2B customers are also said to be valued, no systematic feedback from B2B customers is collected and continuous collaborative efforts seem to be absent. The type of a project affects how customers are addressed, and the project type might discourage cooperation with the customer. Further, if the client is unwilling to collaborate or hinders the project through micro-management, cooperation might be impossible through the entire supply chain. Additionally, it was argued that *“Recognizing customer value and the value creation process hasn’t been done in practice. - - customer is respected and talked about, but customer value is not in a concrete level not to mention that it would fit Lean’s framework.”* While another interviewee said that some research regarding customer value has been conducted, they haven’t seen any data or analyses of the results. The researcher couldn’t find additional information to confirm this. Lastly, there has been some concern that the role of the customer will be forgotten to an extent, if Lean activities are too focused on internal processes.

#### 5.1.7. Moving forward

A wide amount of different improvement ideas were given by the interviewees. The most frequently mentioned topics were management, developing Lean knowledge, standardization and collaboration. While the targets for improvements differentiated between the interviewees, it was evident that a lot of work needs to be done. Making continuous improvements are common sense, as noted by an interviewee: *“I think continuous improvement is self-evident, not improving activities continuously is irrational.”* There was however some doubt presented upon the timing of the new initiatives. Some interviewees believe that the merger gave momentum and now is a great time to make changes, but others felt like there might be too much information for the personnel to take in, and that *“...as long as we get tolerable profits there is no interest to do major changes.”* It was further established that *“A lot of time it is said that we are doing so poorly that we don’t have the funds for R&D, but doing the same thing all over again and waiting for a different result is absurdity.”* The researcher agrees with this sentiment. The case company’s existing practices

are what brought it to its current situation, thus making little to no changes seems counterintuitive and compromises the future state of the company. The quartal-based, short-term vision might restrain the organization from making the required adjustments and investments that are necessary for future success.

A lot of priorities were given for moving towards a Leaner organization, but the most frequently mentioned issue was management. It was suggested that they should understand Lean and how it is applied into practice, but also give clear goals and support achieving them. Ideally, top management would apply Lean practices to their own activities and make Lean thinking the dominant mindset in the organization. It was mentioned that "*The CEO wants to bring more Lean into the company*", but the method to achieve this and in what scale was left unanswered. The organization seems confused and indecisive in this matter. Lean is seen as something that has good attributes, but still, using the word Lean is being avoided. The indecisiveness might hurt the organization in the long run. Only picking the "best parts" of Lean – or even determining which parts of Lean fit best for the company – might become difficult when the organization does not have clear intentions what purpose Lean plays in its strategy and business activities.

Many of the interviewees believed that moving Lean forward in the organization is best achieved by using individual cases and their success stories. It was argued that developing people's Lean skills is essential and it could be made possible through various success stories and with continuous information flow about the initiatives currently in place. For example, e-platforms could be used for cross-project training. These projects should also have the necessary support and resources available to them and a clear priority in the company's strategy. It was also seen necessary to share the obstacles and failures together with the success stories. If people only hear about the success stories, they might repeat the same mistakes, which could be avoided if they knew about the difficulties and what has been done previously beforehand. Lastly, it was suggested Lean should also be brought to a practical level, because only talking about it in the abstract level serves a little purpose in the personnel's daily activities.

The need for standardization was highly emphasized amongst the interviewees and the lack of standardization has been discussed in the previous sections. The interviewees argued that both information sharing and production should be more standardized. Also, standardization is seen necessary to share best practices efficiently. For example, the new management system GRIP and segment-based meetings were proposed to share these standards and bring cohesion to the organization's activities. Spreading the standards requires footwork and they *"Should be actively brought to people's attention."* The need for systematic measurement indicators and identifying for example process-related lead times are viewed as a key factor when it comes to standardizing production. The organization's goals become unclear without clear performance indicators or understanding where the cost savings are made. For example, if procurement acquires elements on a lower price it means that the cost saving is not achieved through Lean. It was mentioned that *"I believe we don't have the necessary transparency now. The indicators must be created and developed. If an indicator says we need to save 20 to 25 % from the cost level, the indicator is extremely unclear – compared to what? Business cycles come and go and building costs change, you cannot determine whether the change is because something you have done or because the prices are lower due to the cycle. Time could be neutral to external influences."* This is the very key problem with the indicators. Without standardization there will be no reference values due to high variety in the processes and therefore quantifying the benefits becomes impossible and the actual reason for better or worse performance will remain unknown, which has been the case with the lead time improvements discussed earlier. The researcher, together with some of the interviewees, believes that standardization should be first developed in the housing segment, since the segment's idiosyncrasies best fit standardized production.

For information sharing, having some sort of communication instructions which define what and how information should be sent via e-mail is suggested. Having better communication should also be a companywide initiative. From a communications' viewpoint it can be argued that the message has reached the receivers when the e-mail is sent, or the information is added to the intranet.

However, in many occasions this is not true, and the communications department realizes this and is continuously trying to find better ways to improve the interaction and information flow. Information flow is a key aspect if the organization wants to share its standards and best practices efficiently. Failing to plan the information flow in an effective way or to execute it in practice will delay or partially prevent companywide implementations.

Much of the focus was also guided towards more cooperative practices inside the company as well as with external parties. It was suggested that cost estimation, procurement and production should all be integrated in the planning phase of a project, or else, using concurrent engineering is for example impossible. Improving the relations between functions (e.g. procurement and production) was deemed crucial by several interviewees. In addition, many saw the respect for individuals and encouraging individuals necessary – that value creation starts from the personnel and everyone is needed. The EVP of Strategy and Development has started an initiative where a small multi-functional team of process-owners is formed, and the purpose of this team is to develop production across and over segments. The team will act as an authority where production-related development ideas will flow to, since currently there are nowhere to share such ideas.

The role of external stakeholders was similarly perceived important. Creating value with the client and subcontractors was seen paramount for the company. It was suggested that there should be a continuous supplier evaluation process, and additionally further collaboration could be encouraged by a profit-sharing method. Lastly, some miscellaneous improvement suggestions were identified in the interviews: a new schedule management program that helps to synchronize work (Quintet 4.0), massive investments in the personnel's training and introducing Lean basics, developing on top of old programs instead of creating new ones and rationalizing meetings practices. The development on top of old programs is assumed to lower the resistance to change amongst people. This approach should help to implement new features or practices since the users don't have to learn a completely new program or platform. Rationalizing meetings in this context means evaluating whether the meetings should be changed to 55 minutes instead of one

hour, since moving from place to place takes time and this might often lead to being late in another meeting. Also, there are mandatory meetings where people feel like they have no agenda and where the meetings themselves are inefficient in terms of time use. Based on aforesaid, the case company should adjust their meeting practices and define their purpose more clearly.

#### 5.1.8. Scaled Agile

The case organization's first SAFe initiative was started around three years ago in the Customer Journey function, where there is a lot of activity in the customer interface. The purpose is to use SAFe for all the development activities in the company. It was argued that SAFe is not a hard methodology to use, but the terms are difficult and they must be understood correctly to be able to utilize SAFe. Similarly to Lean, the interviewees' believed that SAFe can be applied to any industry and that top management is a critical factor in its implementation. Further, it was mentioned that there has been some resistance to change regarding SAFe, but it has been declining gradually.

The merger-related integration went through with the SAFe model. According to one interviewee the "*Utilization of SAFe has not been orthodox but at least we've had massive congeniality for the development.*" The interviewees who had been working with SAFe felt mostly positive towards it. For example, risks and priorities have been managed with through SAFe to gain cost benefits, decreased planning times and other operational successes. Further, the threshold to plan activities together with different parties in different organizational levels has been perceived to be considerably lower when working in the SAFe model. However, it was highlighted that SAFe is too heavy to use in some development purposes, especially in the smaller ones, thus its applicability should be evaluated case-by-case. Another key challenge in SAFe seems to be to define the ownerships in SAFe, meaning who is responsible for each of the processes. Lastly, the crossroads between Lean and SAFe has not been considered, but it was mentioned that this should be thought of. SAFe is currently being applied in the development activities of the main office, while

Lean has been focused to the worksites. The purpose of each of these and how they apply in the organization and their relation to each other must be defined.

## 5.2. Survey questionnaire

The survey questionnaire (attachment 2) was sent to the employees of the infrastructure, business premises and the housing segment located in Finland. A total of 560 responses were given to the questionnaire. The questionnaire was roughly divided into four sections: Demographic qualities, Intrafirm Strengths, Development initiatives and Lean. The questions in section three (Development initiatives) and four (Lean) were somewhat interrelated.

Some data cleansing had to be done before further processing the data. First, the answers were coded to a number format. Further, if the nature of the question was “negative”, for example Q1.7. (There are problems in the intrafirm information transfer), the data was coded in a reversed way so that value 5 represented the least problematic option (e.g. Fully disagree) and correspondingly value 1 portrayed the most problematic option (e.g. Fully agree). Table 10 below shows how the coding was carried out.

Table 10. Options and their corresponding values.

Option	Value	Option	Value
Fully agree	5	Always	5
Somewhat agree	4	Often	4
Neither agree or disagree	3	Sometimes	3
Somewhat disagree	2	Rarely	2
Fully disagree	1	Never	1

Secondly, 112 “Yes” answers were given to Q2.9. (I have attended Lean training provided by the case company), while a total of 463 answers were given for the following Q2.10. (The Lean training was useful in my opinion). It is assumed that many of the respondents thought that all the questions needed to be answered. Therefore, if the respondent answered “No” to Q2.9., their answer to Q2.10. was

excluded from the data. Similarly, the respondents were asked to skip the last part of the questionnaire (Q3.1.-Q3.8.) and to return it if they answered “No” to Q2.11. (I have an understanding of what Lean is). However, some respondents answered “No” to Q2.11. and still answered to the last part of the questionnaire, hence these answers were excluded from the data.

#### 5.2.1. Demographic qualities

Demographic information regarding the respondents is presented in figure 3. A total of 413 employees, 87 managers and 60 directors answered the questionnaire. Age distribution for the respondents was rather balanced, median age being 30 to 39 years old. Almost half of the responses were given by the housing segment, and the least responses were given by the infrastructure segment. Most of the respondents (70%) answered to be working in the “Production” function, while the representation for Procurement, Cost estimation, Segment support and Development was rather homologous. The distribution of the answers between functions matched what was expected, although the number of “Other” responses was surprisingly high. Most of the people who answered “Other” were from sales related functions or from upper management.

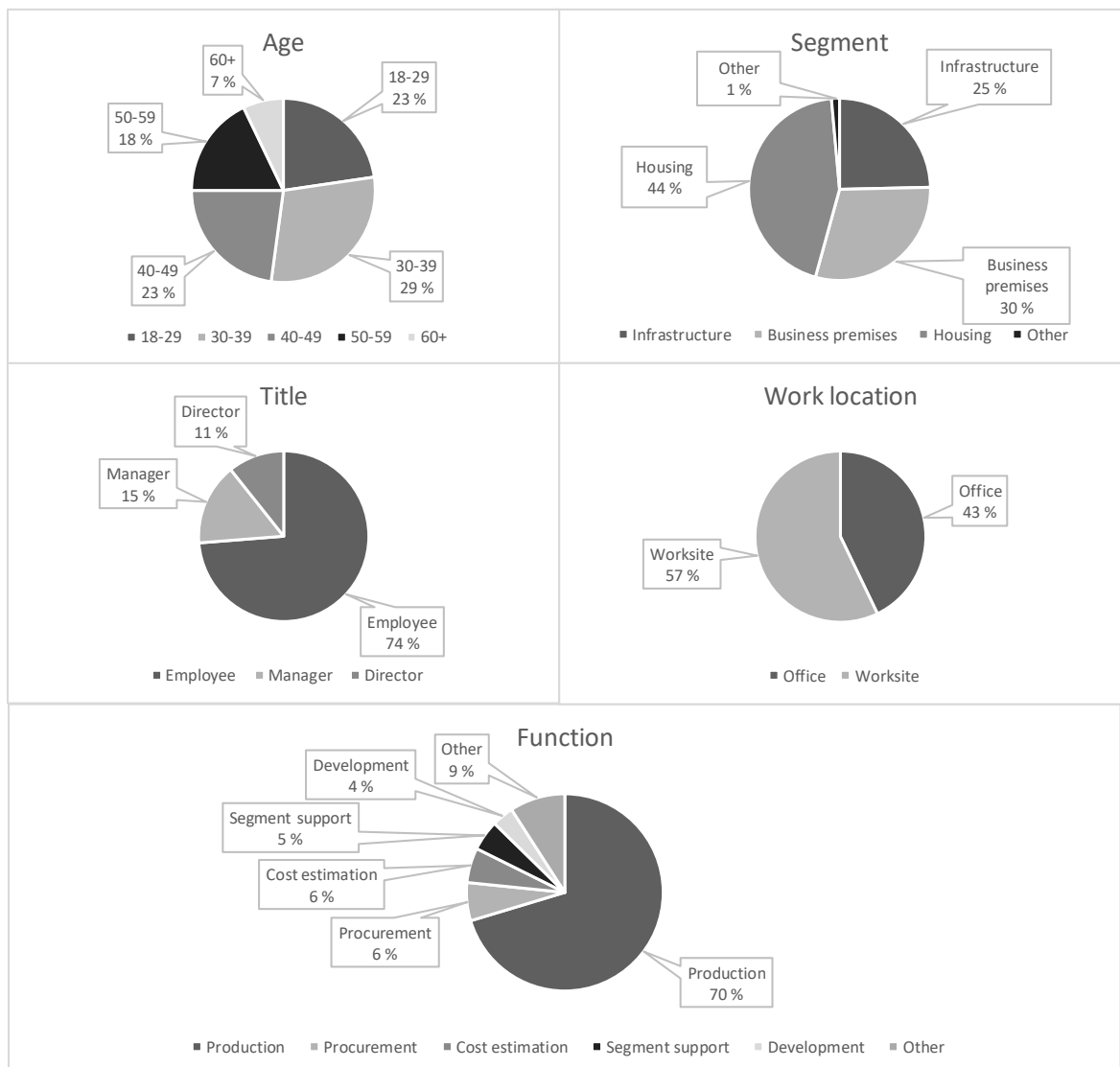


Figure 4. Demographic qualities in the survey questionnaire.

### 5.2.2. Intrafirm strengths

The results for the second section are shown in table 11, where the questions with reversed values are highlighted. Most of the respondents thought that the client or customer is always or often in the center of attention in daily activities. Similarly, 91,8 % either fully agreed or somewhat agreed that their actions affect the client's or the customer's opinion of the case company. This is in line with the interviews' results, where customer participation was emphasized and value creation with client was seen highly important. However, while the results suggest that value is being created by having the customers and clients in the center of attention, identifying the value creation process might still be inadequate, as noted in the interviews.

Table 11. Intrafirm strengths in the survey questionnaire.

Intrafirm strengths					Scale				
No.	Question	n	Mean	Median	5	4	3	2	1
1.1.	The client (or customer) is in the center of daily activities	560	3,96	4	27,4 %	49,5 %	16,3 %	6,0 %	0,9 %
1.2.	I influence the clients' (or customers') opinion of the company through my own activities	560	4,45	5	57,4 %	34,4 %	5,5 %	2,4 %	0,3 %
1.3.	We review what we have learned with our colleagues (including foremen)	560	3,18	3	3,2 %	35,9 %	41,3 %	15,5 %	4,1 %
1.4.	I regularly get feedback from my own (or another) foreman	560	2,96	3	1,5 %	22,4 %	51,0 %	22,6 %	2,4 %
1.5.	The organization's meeting practices are well designed	560	3,31	4	6,1 %	45,2 %	25,6 %	18,8 %	4,3 %
1.7.	There are problems in the intrafirm information flow	560	2,61	3	0,7 %	8,7 %	46,7 %	38,7 %	5,3 %
1.8.	There are problems in the interfirm information flow	560	2,81	3	0,5 %	12,0 %	58,0 %	27,1 %	2,4 %
1.9.	The information sharing systems in the company are functioning	560	3,13	3	5,3 %	40,9 %	21,8 %	27,3 %	4,8 %
1.10.	I collaborate with other functions	560	3,72	4	18,8 %	46,5 %	24,2 %	8,8 %	1,7 %
1.11.	We continuously develop collaboration with other functions	560	3,12	3	5,0 %	33,3 %	35,8 %	21,8 %	4,1 %
1.12.	There are problems when collaborating with other functions	560	3,23	3	3,0 %	31,0 %	52,9 %	12,7 %	3,0 %
1.13.	The responsibilities are clear between functions	560	3,24	3	6,9 %	33,4 %	38,9 %	18,7 %	2,1 %
					Never	Rarely	Monthly	Weekly	Daily
1.6.	I attend unnecessary meetings	560	3,49	4	8,30 %	48,70 %	27,40 %	14,90 %	0,70 %

Similarly to the interviews, feedback was recognized to be relatively problematic also in the company scale. There are more people who never assess their learning with their coworkers and superiors than those who continuously assess it. While a little over a third of the respondents evaluate their learning often, over a half do it sometimes or rarely. In a similar manner, 76 % of the respondents get feedback sometimes (51%), rarely (22,6%) or never (2,4%), while only around one-fourth gets feedback often (22,5%) or always (1,5%). These results strengthen the notion from the interviews that continuous learning and receiving and giving feedback is problematic in the organization. However, some variation is present in both cases. While most of the respondents receive feedback or evaluate their learning more scarcely, others do these more often. Whether the received amount of feedback is adequate or satisfactory cannot be interpreted from these results.

Also supporting the interviews' results, both intrafirm and interfirm information flow were perceived as problematic and their mean values were the lowest in the whole

questionnaire. The intrafirm information flow was perceived to be more problematic than the interfirm information flow. Over 90 % of the respondents felt like there are always, often or sometimes problems in intrafirm communication. Likewise, almost 90 % thought that there are always, often, or sometimes problems with the interfirm information flow. Interestingly, almost half (46,1%) of the respondents fully agreed or somewhat agreed that the information sharing systems in the organization are functional, while a third of the respondents somewhat disagreed or fully disagreed with the systems' functionality. The results indicate that the information sharing systems fulfill their intended purpose, at least to an extent, but there are other reasons beyond the questionnaire's scope that affect the information flow in the organization. There's a possibility that the root cause for the bad information flow is partially caused by the insufficiency of the information systems, but it is entirely possible that the organization's information sharing practices and information management are the root cause for the problems. Further, while the information systems in the case company are perceived to be functional, whether they are optimal for their intended purpose is out of the scope of this thesis.

Two-thirds of the respondents cooperate with other functions regularly. Only 10,5 % rarely or never cooperate with other functions. Almost everyone (57 out of 61) who rarely or never cooperate with other functions were from the housing segment. It is therefore possible that the silo mentality discussed during the interviews is more present in the housing segment than the other two. Relatedly, only 5 % of the respondents continuously develop collaboration with other functions, while 4,1 % never do it. Most people feel slightly positive or neutral towards the continuous collaborative efforts. Moreover, a third of the respondents feel like there is rarely or never problems with the cross-function collaboration, while the majority (53%) think that problems arise sometimes. Additionally, the responsibilities for each function are perceived to be clear by over 40 % of the respondents, as almost an equal amount (38,9%) neither agreed or disagreed with the sentiment.

While there exists active collaboration between the functions in the organization, much of this collaboration is not continuously being developed. The scale and amount of cooperation between segments, which was identified to be problematic

in the interviews, cannot be answered based on these results. However, the bad intrafirm information flow probably acts as a blockade for efficient cross-segment collaboration.

### 5.2.3. Development initiatives

The results for the third section are shown in table 12. The five most mentioned tools in the interviews were used in the questionnaire. Expectedly, most of the people in the organization had heard about Last Planner, Big room and concurrent engineering. Their utilization rate however is varying. The number of people who had used concurrent engineering was surprisingly low, considering that CE was one of the main tools used in Performance Leap. Last Planner has clearly been the most used tool in the organization, although it was anticipated as the Last Planner have been first deployed around a decade ago. Since only a fifth (20,1 %) of the respondents have attended a Lean training provided by the case company, these results mean that Last Planner has been used without any Lean training in most cases. However, the Lean trainings themselves have been extremely successful considering that over 70% of the respondents fully or somewhat agreed that the trainings have been useful, and no one fully disagreed with this sentiment.

Table 12. Development initiatives in the survey questionnaire.

Development initiatives					Scale				
No.	Question	n	Mean	Median	5	4	3	2	1
2.1.	The case company's development activities have been successful	560	3,14	3	1,9 %	38,0 %	36,3 %	19,9 %	3,9 %
2.7.	The new management system GRIP is clear (/easy to understand)	560	2,99	3	3,2 %	20,0 %	55,3 %	15,4 %	6,0 %
2.8.	I know what the new management system (GRIP) is used for	560	3,13	3	13,4 %	34,0 %	24,6 %	12,5 %	15,5 %
2.10.	The Lean training provided by the case company was useful	104	3,91	4	27,4 %	46,2 %	17,9 %	8,5 %	0,0 %
			No	Yes					
2.2.	I have heard of the initiative Performance Leap	560	43,5 %	56,5 %					
2.3.	I know what the purpose of Performance Leap was	315	22,5 %	77,5 %					
2.6.	I have heard of the new management system GRIP	560	18,9 %	81,1 %					
2.9.	I have attended a Lean training provided by the case company	560	79,9 %	20,1 %					
2.11.	I have an understanding of what "Lean" is	560	47,0 %	53,0 %					
			Last Planner	Big Room	CE	ConstraintLog	5Whys		
2.4.	I have heard of the following tools	560	79,63 %	74,0 %	63,16 %	28,86 %	20,37 %		
2.5.	I have used the following tools	560	49,07 %	36,5 %	15,28 %	17,83 %	7,47 %		

Most people think that the development activities in the case company have been successful or are neutral towards them, but surprisingly only 56,5% of the respondents have heard about the company-wide Lean initiative Performance Leap. Yet, as many as 81,1% have heard of GRIP. While it is logical that most of the people have heard about the new management system GRIP as it has been on display for the several recent months, Performance Leap was continuously on the display for example in the organization's intranet. This can be logically explained by the merger, as the organization gained a lot of new employees when the Performance Leap initiative was almost completed.

Most people in the organization have heard about GRIP, but only one fourth fully or somewhat agree that it is easy to understand. While almost half of the respondents fully agree (13,4%) or somewhat agree (34%) that they know what GRIP is used for, as many as 15,5% fully disagree with the sentiment. The problems in the information flows are likely at least partly responsible for this. The fact that over a half of the respondents do not know or are not sure what GRIP is used for seems lacking at best and detrimental at worst. If the people are not taught how to operate the new systems, it cannot be expected that the systems will be used properly, or used at all, considering that resistance to change will likely be high when the management of change, in this case the implementation of the new system, is handled poorly. If new systems like GRIP, which are intended to play a major part in the organization's operations, are not implemented properly and with enough training, the usage of these systems will surely be defective.

#### 5.2.4. Lean

The results from the last section of the questionnaire are presented in table 13. A little over a half of the respondents (53%) had an understanding regarding what Lean is (see Q2.11.). Considering how varied the perceived Lean understanding was among the interviewees, it is safe to establish that the variation in understanding what "Lean" means is likely very high also in this context. Overall people feel like Lean thinking is visible in the case company's strategy and objectives for Lean are clearly defined. Surprisingly many believe they know how to

utilize Lean in their daily work. However, far less people use Lean in their daily work, as almost 70 % of the respondents utilize Lean sometimes, rarely or never. The likely cause for this is that the people who have participated in Lean projects scatter to other projects as the Lean projects are finished, unable to keep further utilizing Lean in their work. People are also skeptic towards their capabilities to help other people in Lean-related matters. A third of the respondents somewhat or fully disagree that they could provide help to others when it comes to Lean, although a third also fully or somewhat agrees that they are able to help in such matters. It seems that the Lean capabilities of each person varies a lot in the organization, which was similarly established when analyzing the interviewees.

Table 13. Lean in the survey questionnaire.

Lean No.	Question	n	Mean	Median	Scale				
					5	4	3	2	1
3.1.	Lean thinking is visible in the case company's strategy	293	3,27	3	4,5 %	42,5 %	30,7 %	20,2 %	2,1 %
3.2.	The objectives for Lean are clearly defined in the organization	293	3,11	3	5,2 %	29,5 %	38,9 %	22,9 %	3,5 %
3.3.	I know how to utilize Lean in my own (daily) work	293	3,41	4	6,3 %	47,9 %	29,5 %	14,6 %	1,7 %
3.4.	I utilize Lean in my (daily) work	293	2,93	3	2,1 %	27,9 %	39,4 %	23,7 %	6,6 %
3.5.	I can help other people in Lean-related matters	293	2,92	3	3,5 %	30,2 %	33,3 %	22,9 %	10,1 %
3.6.	Lean has been useful for my work	293	3,29	3	9,5 %	32,6 %	39,6 %	15,1 %	3,2 %
3.7.	Lean has created extra pressure to my work	293	3,37	3	13,7 %	30,2 %	39,3 %	13,7 %	3,2 %
3.8.	Lean is suitable for the construction industry and the case company	293	3,99	4	30,7 %	45,7 %	16,7 %	6,5 %	0,3 %

Over 40 % of the respondents believe that Lean has been useful for their work while another 40 % does not agree or disagree with the sentiment. Interestingly, only 16,9 % fully or somewhat agree that Lean has created extra pressure to their work. The results imply that Lean has not created extra pressure to the work of most of the respondents. Further, an overwhelming number of people think that Lean suits the case company and construction industry. This would indicate that the people in the organization have a positive attitude towards Lean in general, or at least those who have an idea of what Lean means. The results are contradictory to those of the interviews, as it was implied that there is skepticism towards Lean and some even expect it to fail to avoid learning it. These results however are not mutually exclusive. There is a high possibility that people who have not had Lean training feel negative towards Lean, and people who have had Lean

training feel far more positive towards Lean. One factor that could explain this is that the Lean tools like Last Planner have been used without adequate Lean training, as concluded before. Not having adequate Lean training and being forced to apply the Lean methodology in one's work, even if it is only in the form of a tool such as the Last Planner, seems impractical and hard to manage. More research is needed to determine how extensive the Lean training has been during Performance Leap and in the more recent Lean projects, and what is the root cause of the negative opinions towards Lean.

#### 5.2.5. Correlation and linear regression analysis

Table 14 shows the results for the correlation and regression analysis. From all possible correlations, 30 different dyadic relationships were identified when the threshold value was 0,36 and higher (at least moderate correlation), from which 3 were negative. All the correlation coefficients in the Spearman's correlations analysis and the coefficients of determination ( $R^2$ ) in the linear regression analysis were found statistically highly significant ( $p$ -value  $<0,001$ ). Most of the variables had 560 observations, but some of the variables had 104 or 293 observations due to the data cleansing that was described at the start of this chapter.

Work location was the only variable with negative correlations and the only demographic variable that had at least moderate correlation with the other variables. It had moderate negative correlation with Q2.6. (I have heard of GRIP) and Q2.8. (I know what GRIP is used for). This negative correlation can be explained by the bad intrafirm information flow. Higher values in Q2.6. and Q.2.8. imply better knowledge of GRIP, thus the negative correlation indicates that if the respondent is from the worksite they have less likely heard of GRIP and less likely know what it is used for. These findings support the earlier results that outlined the problems in intrafirm communication, but also suggest that the information does not necessarily reach the worksite. However, closer inspection of Q1.7. (Problems in intrafirm information flow) between the office and worksite employees revealed no significant differences between the two parties, indicating that the information flow is problematic in the whole organization. There are also reciprocal correlations between Q2.6. and Q2.8.

and Q2.7. (GRIP is easy to understand) and Q2.8, which imply that having heard of GRIP will increase the chances of knowing its purpose and knowing the purpose will lead to understanding GRIP better.

Table 14. Results from the correlation and regression analysis.

Variables <i>dependent variable y</i>	<i>independent variable x</i>	n	Spearman's r	R <sup>2</sup>
Function	Work location	560	-0,62***	0,31***
2.6. I have heard of GRIP	Work location	560	-0,36***	0,13***
2.8. I know what GRIP is used for	Work location	560	-0,42***	0,17***
1.1. The client is in the center of daily activities	1.2. I influence the clients' opinion of the company	560	0,43***	0,21***
1.4. I regularly get feedback from foremen	1.3. We review what we have learned	560	0,45***	0,21***
1.3. We review what we have learned	1.11. Continuous collaboration development between functions	560	0,39***	0,17***
1.5. Meeting practices are well designed	1.7. Problems in intrafirm information flow	560	0,45***	0,21***
1.8. Problems in interfirm information flow	1.7. Problems in intrafirm information flow	560	0,42***	0,19***
1.9. Functioning information sharing systems	1.7. Problems in intrafirm information flow	560	0,39***	0,16***
1.9. Functioning information sharing systems	2.1. Development activities have been successful	560	0,41***	0,17***
1.10. Collaboration with other functions	1.11. Continuously developing collaboration with other functions	560	0,47***	0,21***
2.1. Development activities have been successful	3.2. Organization has clear objectives for Lean	293	0,39***	0,16***
2.2. I have heard of Performance Leap	2.3. I know the purpose of Performance Leap	560	0,76***	0,57***
2.4. I have heard of the following Lean tools	2.5. I have used the following Lean tools	560	0,45***	0,20***
2.8. I know what GRIP is used for	2.6. I have heard of GRIP	560	0,43***	0,18***
2.7. GRIP is easy to understand	2.8. I know what GRIP is used for	560	0,42***	0,17***
2.11. I understand what Lean is	2.9. I have attended a Lean training	560	0,44***	0,19***
3.3. I know how to use Lean	2.10. Lean training provided by case company was useful	104	0,42***	0,19***
3.4. I use Lean in my daily work	2.10. Lean training provided by case company was useful	104	0,45***	0,17***
3.5. I can help other people with Lean	2.10. Lean training provided by case company was useful	104	0,43***	0,18***
3.6. Lean has been useful for my work	2.10. Lean training provided by case company was useful	104	0,61***	0,36***
3.8. Lean fits construction industry and the case company	2.10. Lean training provided by case company was useful	104	0,45***	0,24***
3.2. Organization has clear objectives for Lean	3.1. Lean is visible in the strategy	293	0,62***	0,37***
3.4. I use Lean in my daily work	3.3. I know how to use Lean	293	0,71***	0,50***
3.5. I can help other people with Lean	3.3. I know how to use Lean	293	0,60***	0,35***
3.6. Lean has been useful for my work	3.3. I know how to use Lean	293	0,56***	0,33***
3.5. I can help other people with Lean	3.4. I use Lean in my daily work	293	0,58***	0,31***
3.6. Lean has been useful for my work	3.4. I use Lean in my daily work	293	0,59***	0,37***
3.5. I can help other people with Lean	3.6. Lean has been useful for my work	293	0,51***	0,23***
3.8. Lean fits construction industry and the case company	3.6. Lean has been useful for my work	293	0,49***	0,23***

Where  $p < 0,05 = *$ ,  $p < 0,01 = **$ ,  $p < 0,001 = ***$

It seems that Q1.7. influences Q1.5. (Meeting practices are well designed), Q1.8. (Problems in interfirm information flow) and Q1.9. (Functioning information sharing systems). The results imply that the more problematic the respondents perceive intrafirm information flow, the more likely they perceive the interfirm information flow to be problematic. Similarly, the people who saw problems in the intrafirm information flow are more likely to think that the meeting practices are not well designed and that the information systems are not functioning properly.

Expectedly, Q1.3. (We review what we have learned) has a positive relationship with Q1.4. (I regularly get feedback from foremen) meaning that reviewing what one

has learned will likely lead to increased feedback. Further, Q1.11. (Continuous collaboration development between functions) and Q1.3. having a positive correlation implies that when the personnel develop collaboration with other functions they increasingly review what they have learned.

Q2.10 (Lean training provided by case company was useful) had the most positive correlations with the other variables. It had positive correlation with Q3.3. (I know how to use Lean), Q3.4. (I use Lean in my daily work), Q3.5. (I can help other people with Lean), Q3.6. (Lean has been useful for my work) and Q3.8. (Lean fits construction industry and the case company). This suggests that when an employee completes Lean training they will likely utilize Lean in their work and have a more positive image towards it, which is logical as the trainings have been focused on people who are intended to work with Lean rather than the whole organization. These results further confirm the usefulness of the Lean trainings and the positive impact they have on the company's Lean activities.

Lastly, there are multiple intercorrelations among the Lean variables Q3.1. (Lean is visible in the strategy), Q3.2. (Organization has clear objectives for Lean), Q3.3., Q3.4., Q3.5., Q3.6. and Q3.8. The relationship between Q3.3. and Q3.4. is especially strong, suggesting that when people learn to use Lean they will more likely utilize Lean in their daily work, although this is probably caused by the focus of the Lean trainings as explained above. Further, it seems that the Lean training is the key attribute to make people use and believe in Lean. if people know how to utilize Lean the more likely they are at applying it to practice and the more positive feelings they have towards Lean.

## **6. DISCUSSION**

The purpose of this thesis was to understand the current state of Lean in the case organization and what kind of obstacles and success factors are present in the Lean implementations. Further, the purpose was to understand what kind of role external parties play in a Lean implementation and finally to create a framework to assess the Leanness of a construction company. We have conducted an extensive

literature review and utilized three data gathering methods to answer the three research questions. The author will next summarize the results from the literature review and the empirical section of the thesis and give the case company suggestions on how to move forward with Lean.

Much of the reviewed change management and Lean management literature have emphasized the importance of managerial support to create the basis for a successful organizational change (e.g. Kotter 1995; Kotter and Schlesinger 2008; Mann 2009; Grove et al. 2010; Jaros 2010), and when pursuing company-wide change the CEO is the key factor in the change management efforts (Kotter 1995). The results of this study suggest that top management participation and support has been lacking in the case company and the intended Lean transformation has not been led from the top. Accordingly, lack of top management support has been identified as one of the major Lean construction obstacles by multiple authors (Bashir et al. 2010; Ayarkwa 2011; Sarhan and Fox 2013; Khaba and Bhar 2017). However, it is somewhat hard to evaluate how satisfactory the managerial efforts have been when there is no clear consensus regarding the wanted purpose of Lean. The strategic emphasis on Lean would imply that it plays an important role in the organization's development and operational activities, but the lacking managerial support and the methods how the Lean efforts have been executed imply that its role is insignificant in the organization. While the Performance Leap initiative has aimed to create lead-time improvements and to decrease costs, the absence of any confirmatory data forces one to question whether any of the reported successes can be verified. Further, even though it is critical for the senior management to understand Lean to have a successful Lean transformation (Miller 2005; Emiliani 2006), the EVP of strategy and development admitted to not ever having learned or having applied Lean in practice. This supports the findings of Green and May (2005), who warned that the most likely result of LC implementations is that the managers maintain the existing practices and routines while giving lip-service to Lean.

The ambiguous nature of Lean in the case organization could partly explain the failed attempts to apply Lean in the case organization. Hines and Taylor (2000, 13) noted that usually knowledge is not the problem when applying Lean, but rather that

the initiatives are killed by the lack of adequate planning by senior management. Considering that the conditions created by the efforts of senior management account for 80 % of a successful Lean transformation (Mann 2009), lack of planning and therefore lack of creating satisfactory conditions for a Lean transformation is possibly one of the root causes for the current Lean initiatives' varying success in the case organization.

However, we have established that it is not clear what has been the purpose of Lean in the case organization. While the literature has clearly stated that Lean is a management strategy rather than a cost-reduction program (Miller 2005) and it requires comprehensive utilization beyond its tools (Shah and Ward 2007; Machado and Leitner 2010), the evidence here suggest that the purpose has been to only gain cost and lead-time benefits mainly through increased tool usage. For example, only 20 % of the questionnaire respondents had received Lean training while almost 50 % had used the Last Planner tool. These results are in line with the findings of Hines et al. (2004), who noted that many companies misunderstand Lean and disregard more integrative approaches, while tools and techniques play a leading role over strategic level thinking. Further, Leigard and Pesonen (2010) stressed that the implementation of Last Planner cannot be isolated from the implementation of Lean philosophy and practices, which has been the case in most of the Last Planner implementations.

Nonetheless, even if the Lean implementations have not been managed in a holistic manner, the interviewees understood that Lean should be adapted to fit the idiosyncrasies of the construction industry. Lean literature has recognized the need to modify the Lean practices to fit the industry (Lewis 2000; Cooney 2002; Lee and Jo 2007), and the LC literature has further emphasized this need (see e.g. Ballard and Howell 1998; Johansen and Walter 2007). The employees generally have a positive attitude towards Lean and believe it fits the construction industry, more so when they have had Lean training. However, whether Lean has been adapted to the needs of the case organization is questionable. The data in this thesis implies that the adaptation process has not been adequate in the company-level. However, since there is no case-specific information available regarding the projects who were

part of the Performance Leap initiative, it is impossible to give definite answer whether the project-level implementations have been managed thoroughly or not.

Since there has been no systematic Lean development in the case company, it is no surprise that people have heavily differing perceptions over Lean, although the ambiguous nature of the term “Lean” contributes to this. The questionnaire’s results suggest that over half the people in the organization have an understanding what “Lean” means, but the results from the interviews imply that there is a lot of variation in people’s understanding. Authors such as Puvanasvaran et al. (2008) have emphasized the necessity of people having to understand Lean, or waste identification and elimination will not succeed. Again, it is impossible to confirm or deny whether waste identification and elimination has been successful as there is no data available from the projects. While value stream mapping and especially waste identification and elimination has been emphasized in the literature (e.g. Womack and Jones 1994; Hines et al. 1998; 1999; 2008; Miletsky 2010), the data here suggests that the VSM efforts and waste identification and elimination have been in a very nascent stage in the case organization.

Despite the questionable Lean understanding in the organization, it seems that the Lean trainings and employee engagement through them has been successful, which is critical to achieve sustainable Lean implementations (Lucey et al. 2005). The LC literature has highlighted the importance of training the employees to successfully implement Lean in construction (Ayarkwa et al. 2011; Khaba and Bhar 2017) and the data from survey questionnaire implies that the Lean trainings have been extremely successful. Moreover, the trainings seemed to have had a positive impact in the personnel’s feelings towards Lean and to applying Lean to practice.

Similarly to the results of Seppälä and Klemola (2004), the case company’s employees perceived Lean activities in a positive light. Surprisingly, most of the respondents felt like Lean has not created extra pressure to their work, even though authors like Robertson (1996) and Seppälä and Klemola (2004) have argued that Lean leads to increased work-related stress. There are three possible explanations for this. First, the studies highlighted above are both conducted in the manufacturing

industry rather than construction. It is therefore possible that Lean implementations have a different impact to workers in the construction industry. Second, Conti et al. (2004; 2006) emphasized that stressful practices are not inherent in Lean or a necessity for a successful implementation. They continue that management practices and designing Lean systems are the critical factors in this context, yet considering the evidence presented in this study it is unlikely, but possible, that the Lean initiatives have been planned and managed so well that the stress factors have been negated. Third, the most likely reason is the lacking implementation of Lean. We have established that the Lean initiatives have been mostly tool-focused, so the notion that “Lean increases work-related stress” cannot be confirmed or denied based on these results, as the Lean implementations have lacked a holistic implementation methodology. Using a tool such as the Last Planner to help visualize and consequently to manage the process flows cannot be contributed to being “Lean”.

Table 15 below comprises the success factors and obstacles in a Lean implementation and how they compare to the case company’s current state of Lean. Some of these dimensions have already been discussed.

Table 15. The identified success factors and obstacles for a Lean implementation.

Identified success factors (SF) and obstacles (O)		Author(s)		Current state in the case organization
		Lean	Lean construction	
Organizational culture	SF / O	Shah & Ward (2003)	Sarhan & Fox (2013); Khaba & Bhar (2017); Sarhan et al. (2018)	Organizational culture seems open towards Lean. However, since Lean has not been applied properly this might change if Lean is applied more holistically.
Modifying Lean to fit industry characteristics	SF / O	James-Moore & Gibbons (1997); Lewis (2000); Cooney (2002); Lee & Jo (2007); Seddon & Caulkin (2007)	Ballard & Howell (1998); Fearn & Fowell (2006); Jørgensen (2006); Johansen & Walter (2007)	Lean has been adapted to fit the case company's characteristics at least to an extent, success unclear due to lacking data.
Lean not universally applicable	O	Cooney (2002); Lee & Jo (2007); Pettersen (2009)	Johansen & Walter (2007)	
Lean barriers are known beforehand	SF		Cano et al. (2015)	The Lean barriers were likely not identified before any implementations.
Lack of knowledge regarding LC approaches	O		Sarhan et al. (2018)	The case company has participated in LCI seminars and LC initiatives in the Finnish construction industry. Thus, knowledge regarding LC approaches is expected to exist, but its extensiveness cannot be answered based on the thesis' data.
Top management support	SF / O	Comm & Mathaisel (2005); Miller (2005); Grove et al. (2010); Jaros (2010)	Bashir et al. (2010); Ayarkwa et al. (2011); Sarhan & Fox (2013); Khaba & Bhar (2017)	Top management support has been lacking in the case organization. There has been emphasis on Lean in the strategic level, but actions towards its successful implementation and managerial efforts have been insufficient.
Continuous managerial efforts	SF	Mann (2009)	Johansen & Walter (2007)	Lean has not been a company-wide initiative with continuous managerial efforts.
Change management practices	SF	Kotter (1995); Seppälä & Klemola (2004)		Change management in the case organization has been insufficient.
Managerial practices in line with Lean	SF / O	Conti et al. (2004; 2006); Emiliani (2006)	Sarhan et al. (2018)	Managerial practices have been insufficient for successful Lean implementations.
Adequate planning of Lean activities	SF / O	Hines & Taylor (2000); Mann (2009)		The planning of Lean activities has been lacking in the strategic level. Project-level information not available.
Collaboration between managers and employees	SF / O	Emiliani (2006); Domrowski & Mielke (2013)		Project-level collaboration has had successes, but company-level collaboration has not existed apart from the Performance Leap initiative.
Employee engagement	SF / O	Lucey et al. (2005); Dombrowski et al. (2012)	Cano et al. (2015); Khaba & Bhar (2017)	Employees have been trained for the Lean projects and employee engagement seems to have produced positive results.
Employees understand Lean	SF / O	Puvanasvaran et al. (2008); Dombrowski & Mielke (2013)	Salem et al. (2005); Ayarkwa et al. (2010); Sarhan & Fox (2013); Sarhan et al. (2018)	Over half of the organization's employees believe they have an understanding of Lean. However, the results from the interviews show that the level of Lean understanding is highly varying among the employees.
Overcoming resistance to change	SF / O	Jaros (2010)	Johansen & Walter (2007); Bashir et al. (2010); Khaba & Bhar (2017)	Some resistance to change has been perceived. Lean trainings seem to have decreased resistance to change and consequently increased positive feelings towards Lean.

Using Lean consultants	SF		Kim & Park (2006)	Lean consultants have been used to help with the Lean implementations.
Increased work-related stress	O	Lewchuk & Robertson (1996); Seppälä & Klemola (2004)		Work-related stress has gone down when working with Lean. The possible reasons for this have been discussed.
Goal setting and feedback system	SF	Stansfield & Longenecker (2006)		Goal setting and feedback have been identified to be lacking in the case organization. However, some feel like they get enough feedback.
Identification and elimination of waste	SF / O	Womack & Jones (1994); Hines & Rich (1997); Hines et al. (2008); Wee & Wu (2009); Fullerton et al. (2014)	Koskela (1992); Huovila & Koskela (1998); Ballard & Howell (2003); Miletsky (2010); Cano et al. (2015) Jamil & Fathi (2017)	The identification and elimination of waste has been minuscule. There has been some efforts to identify waste, but as far as the author knows no comprehensive waste identification or elimination has been done.
Minimizing lead times	SF	Towill (2000)		The Performance Leap initiative aimed to minimize lead times. Successes are varying and the problems related to the qualification methods have been discussed.
Identifying customer value	SF / O	Emiliani (1999); Hines & Taylor (2000)	Khaba & Bhar (2017)	Customer value has not been identified.
Reducing variability	SF	Hines et al. (2004); Shah & Ward (2007)	Koskela (1992); Howell (1999); Fearne & Fowell (2006)	Cannot be answered based on the results. Variability might've been reduced in the housing segment, but other segments lack adequate process standardization to be able to reduce variability in a quantifiable way.
Holistic implementation of Lean	SF / O	Hines et al. (2004); Miller (2005); Shah & Ward (2007); Machado & Leitner (2010)	Fearne & Fowler (2006)	It seems that the implementation has not been holistic, but rather through the utilization of singular tools and in distinct projects. The discussed managerial problems contribute to this.
Value Stream Mapping (VSM)	SF / O	Womack & Jones (1994); Hines et al. (1998;1999); Rother et al. (2003); Dal Forno et al. (2014)		There has only been some very basic VSM efforts in one division in the organization.
Internal focus rather than having extended VSM approach	O	Tortorella et al. (2017)		The VSM efforts have been very basic and scarce and no extended VSM approach exists.
Intrafirm collaboration	SF	(Womack and Jones 1994)		Varying results. Some perceive intrafirm collaboration sufficient while others see it problematic. There are problems in for example communication and incentives.
Collaboration with supply chain participants	SF / O	Vitasek (2005); Pettersen (2009); Dombrowski & Mielke (2013)	Kim & Park (2006); Johansen & Walter (2007); Eriksson (2010); Ayarkwa et al. (2011); Khaba & Bhar (2017)	Almost nonexistent at the moment. Only the housing segment has cooperative efforts with a few "partners". Most of the collaboration is based on previous work-relations, but comprehensive supply chain collaboration is missing.
Lack of long-term supply chain partners	O		Ayarkwa et al. (2011)	Both the case company and the construction industry lack long-term supply chain partners.
Extensive use of subcontractors	O		Ayarkwa et al. (2011); Khaba & Bhar (2017)	The case company uses a lot of subcontractors and systematic collaboration is absent.
Aligning organizational subsystems with suppliers	SF / O	Simons & Taylor (2007)		Logically this has not been done considering the nascent stage of the supply chain relationships.
Process standardization	SF / O	Vitasek (2005)	Ayarkwa et al. (2011)	Emerging. The housing segment has standardized their processes to some extent, but it is considerably more complex to do in the infrastructure and business premises segments.

One of the most reoccurring topics throughout the entire literature review was the importance of supply chain collaboration and partnerships. Already in the early Lean literature Womack and Jones (1994) argued that the efforts to become Lean might become void if interfirm cooperation cannot be achieved. The importance of supply chains and interfirm collaboration in the Lean context has been further emphasized by many authors (e.g. Vitasek 2005; Taylor 2006; Dombrowski and Mielke 2013). The case company however does not have extensive supply chain collaboration or long-term partnerships. The current cooperation is mostly based on previous collaboration and the company lacks systematic development of supply chain partnerships. Only the housing segment has few partners whom with cooperation is being actively developed. These results are in line with the construction industry literature, where the absence of supply chain relationships and the lacking supply chain collaboration and partnering efforts has been widely noticed (Cox and Ireland 2002; Humphreys 2003; Fearn and Fowler 2006; Ayarkwa et al. 2011; Meng 2012). Fulford and Standing (2014) argued that the nonexistent productivity gains in construction will continue until the many organizations in the supply chains view their processes comprehensively across organizations.

There are multiple reasons why collaboration in construction supply chains is missing. The competitive biddings process, which the case company uses almost without exception, has been criticized by Elfving et al. (2005) and Pesämaa et al. (2009) of complicating supply chain collaboration. In addition, the fundamental effect that clients' have in the supply chain integration cannot be ignored. Briscoe et al. (2004) and Mesa et al. (2016) identified the clients to be the key factor in supply chain integration and the client's unwillingness to collaborate might jeopardize all the cooperative efforts in the supply chain. Further, even if the client is accepting towards supply chain cooperation, their understanding regarding supply chains and efforts to create collaboration are usually substandard (Baiden et al. 2006). The case organization has cooperative projects with some client organizations, but most projects in the construction industry are not performed in a cooperative manner. The problem is not limited only to the case company but is present in the whole industry. It is therefore possible that creating these collaborative efforts becomes impossible if the client is unwilling to work together with the main contractor. A key challenge

for the case company will be to decide which project types are fit for collaborative supply chain efforts if the client is reluctant to enable such efforts.

Another key challenge will be the information sharing inside the case organization and in interfirm cooperation. We have identified intrafirm and interfirm information flow to be problematic in the organization, and that these problems are present amongst both the office and the worksite environment. Further, sharing best practices through the intrafirm network has not been successful as the Lean-related knowledge has stayed with the individuals or in the worst case disappeared after the project has been completed. Smyth (2010) noted that that knowledge transfer could happen inside a company from one project to others by a trickle-down basis using intrafirm reporting and the knowledge of the people involved, but usually the knowledge transfer was perceived to be limited to general descriptions of improvements and the lacking information regarding what was done in the demonstration projects and how it was done prevented extensive transfer of knowledge. This is exactly what has happened in the case organization. The information coming out of the Performance Leap initiative has been limited to general descriptions of lead time improvements and no data is available from these projects.

The problematic information sharing extends to feedback and best practices. While the intrafirm intranets can be used to improve information sharing and to store best practices and feedback (Gann 2001), the case company has not been able to efficiently do this. Accordingly, Gann (2001) identified that having useful information in the intranet has been problematic to construction companies. There are no standardized methods to give or receive feedback in the case organization and the feedback mostly limited to the bi-annual performance review. Further, standardization in general is missing in the case company. Lacking process standardization was identified as an obstacle in LC implementations by Ayarkwa et al. (2011). The housing segment is basically the only segment where process standardization exists to an extent. This is logical considering that the housing segment has least variation in their project types and they know the volumes of

necessary materials and work very early in the project. The housing segment has the most potential to utilize Lean in their work.

### 6.1. Future direction

There are multiple aspects the case company should consider when moving forward with its Lean initiatives, but the most critical one is without the doubt the role of Lean in the organization. The ambiguous role of Lean in the case company is not a sustainable way to establish organizational transformation towards Leaner work culture. Being more cost effective, lead time improvements, continuous improvements and Lean have all been characteristics in the case company's strategy, but the methods to achieve these qualities have been absent. The lack of top management support and understanding regarding Lean plays a major part in this. Also, focusing on short-term financial results might hurt the long-term development of Lean, when results are wanted immediately while ignoring that developing sustained Lean behaviors is a five to ten-year challenge (Emiliani 1999).

The author suggests that the case organization should forget the Lean as a philosophy, as there clearly has not been enough support for it to be successful in the holistic picture. The company should instead focus on operational improvements keeping the ideas like continuous improvement present in the daily activities. The researcher is not convinced that speaking about Lean is necessary to gain the wanted organizational improvements that have been present in the strategy. Rather, the managerial practices are the most deciding factors in this context. However, should the case company want to continue to pursue being Lean, there are several improvement suggestions provided below:

- Top management should clearly define what is the purpose of Lean and create a long-term plan for the next 3 to 5 years and a short-term plan for the next 6 to 12 months as suggested by Hines et al. (2000, 14-15). Now the organizational focus on Lean is confusing and does not serve its purpose if the organization wants to successfully transition to have Lean culture established. Further, the cross-section between Lean and SAFe should be

thoroughly considered to make sure everyone in the organization understands the purpose of each methodology and how they are applied in the organization.

- Top management should actively participate in the Lean implementation since its role is crucial in the success of the implementation as we have established before. The managerial support needs to be more than just different key words in strategy. Management must understand at least the basic concepts of Lean and actively pursue towards a Leaner organization by leading by example. Further, they should communicate the objectives and benefits of going Lean since it is critical to overcome resistance to change (Vitasek et al. 2005). Even if the company continues to apply Lean in a smaller scale, the author sees top management support fundamental for its success. It is simply not enough to “green-light” the Lean initiatives, there needs to be active participation and interest to continuously develop the Lean initiatives. The management cannot expect its employees to feel positive towards Lean when they do not show much interest towards it themselves.
- Both the VSM and the waste identification and elimination efforts have been almost nonexistent in the case organization. It is suggested that these dimensions and the methods to apply them should be heavily considered in the case organization. Waste identification and elimination should play the leading role in this process. There likely has been some waste identification and elimination when the case company has applied the Last Planner and concurrent engineering into practice. However, the absence of any collective or other data prevents us from knowing whether these activities have been successful in the past. The company must develop a clear framework how it will measure the wanted benefits and how waste elimination should be done in the operational level. Further, VSM should be utilized to understand the processes more thoroughly and to identify the NVA activities to eliminate them, and it needs to be emphasized that VSM requires participation from all organizational levels (Hines et al. 1998; Hines et al. 1999; Dal Forno et al. 2014).
- The tool-heavy focus should be transformed to be more about the key enablers of Lean. People in the organization must understand Lean to use it

successfully and there should be training provided to projects that will utilize Lean to establish a basis for success. Moreover, the Lean must be continuously be brought to the worksites and new projects, so that eventually most of the employees in the case company know how to work in a Lean organization and the training is necessary for only the new employees and the subcontractors.

- Although we have established the integral role of supply chain management through both Lean and LC literature, the case company should first fix its internal processes before trying to bring Lean to the subcontractors. The subcontractors play a critical part in the success of the project, but the case company should at least define its own purposes for Lean before trying to push it down the supply chain. Else, the implementations will likely produce the same results as they have now and the subcontractors will likewise be confused of the activities. Teaching the subcontractors how the tools like Last Planner work is clearly essential, but the Lean working habits must start from the case company's change of culture.
- While the case company first focus in its internal Lean capabilities, it inherently needs more supply chain collaboration. Both the literature and the data in this thesis have shown the lack of collaborative efforts in the supply chains of the construction industry. There are some development initiatives planned in the case company's supply chain, but this information is not yet available. However, the case company should start developing supply chain collaboration and to find strategic partners for its operations. The researcher believe that this is essential for sustained Lean success and to be able to develop the processes continuously. Without the appropriate partners any long-term development activities with external parties cannot be performed and only the internal processes can be developed. Although the internal processes play a critical part in the organization's success, the significant use of subcontractors means that a lot of the possible successes in project partnering or projects overall cannot be achieved if there is no collaboration with the supply chain participants.
- Lastly, the standardization of processes must be a priority for the case company. Without standardization it is impossible to quantify the process

improvements if for example the average cost or time to make is not known. Standardization should be started from the housing segment due to the aforementioned reasons regarding the volumes and predictability. Also, the value stream is likely easier to understand in the housing segment, further supporting that the standardization of processes should be started there. The standardization will allow collecting relevant data and eventually the processes can be monitored and compared to average process time or cost and it will be easier to react to anomalies.

There are also some minor mismatches that need to be considered, but only after the above challenges have been comprehensively managed. For example, the mismatches in the intrafirm incentive system should be fixed. It seems counterproductive that the segments are encouraged to work together when the incentives are segment based, which will not likely increase collaboration between the segments. Further, non-financial rewards could be introduced in the Lean implementations as they have a positive effect in their success (Netland et al. 2015). The more insignificant factors can be managed with adequate planning after the case company has resolved the major obstacles currently present in the organization.

## 6.2. The Leanness framework

One of the purposes in this thesis was to create a Leanness assessment framework for construction companies to utilize. A preliminary assessment framework is presented in appendix 3. The weights in the framework are arbitrary and based on how important these topics were perceived in the review literature. It must be noted that the framework is at a very emerging stage and has not been applied to practice, and it could be argued that supply chain should have higher overall weight in the framework. However, the purpose here was to create a basis for future Leanness assessment frameworks by identifying the critical factors that should be included in a such framework. The framework could be improved for example by utilizing fuzzy technique, since now the framework gives a very subjective and only directional results, and fuzzy technique can be used to overcome the weaknesses of the

Leanness frameworks, such as uncertainty, vagueness and ambiguity (Vinodh and Vimal 2012).

The data from this thesis was used to evaluate the current state of Leanness in the case organization. Based on the researcher's input, the Leanness assessment framework gave the case company a grade of 31,6 implying poor overall Leanness. The author believes that this is representative of the current state of Lean in the organization. While there are positive Lean dimensions present in the case company, such as the training of employees and strategical emphasis, we have seen that the overall state of Lean in the case company is very ambiguous and the success of the Lean initiatives has been highly varying, if not completely unquantifiable. The Leanness framework however requires further testing and needs to be improved for it to be applicable to assess the Leanness of construction companies.

## **7. CONCLUSIONS**

We have now performed a comprehensive literature review on Lean, the construction industry and Lean construction. Further, we have linked the literature review to the empirical results of this thesis. The case company has been carefully and comprehensively evaluated to understand the current state of Lean in the organization. In addition, the success factors and obstacles for Lean implementations have been identified together with the critical success factors for Lean and construction supply chains. Following, the findings of this thesis will be summarized.

First, Lean thinking has been and currently is very fragmented in the case company. There is no unified knowledge regarding Lean and it mainly appears in the strategical discussion rather than in the operational level. There has been only one initiative that pursued a more comprehensive Lean transformation, but its execution was handled poorly. Nonetheless, over a half of the organization seems to have an idea of what Lean is, but their understanding regarding what contributes to being Lean is highly varying. Moreover, a significant amount of people have used the Lean

construction tools in practice, especially the Last Planner have been used widely. However, the Lean trainings have not been as comprehensive as the tool usage, implying that in most of the projects the tools have been applied without proper Lean knowledge. Currently, Lean thinking plays an ambiguous role in the case company and the initiatives towards Lean have been scarce in the recent months. We can conclude that Lean thinking does not play a major role in the organization and at company level Lean is at a very nascent stage. Much needs to be done if the organization wants to pursue a comprehensive Lean transformation.

Second, the success factors and obstacles in Lean implementations have been identified based on the reviewed Lean and Lean construction literature. Further, table 15 shows the current state of the case organization regarding each of these attributes. The most critical success factors and obstacles factors identified in this study were waste identification and elimination, VSM, top management support, employees understanding Lean and modifying Lean to fit the industry's needs. The lack of top management support has been evident in the case company and the lacking managerial efforts are most likely the root cause for the varying success of the Lean implementations. Also, waste identification and elimination and VSM are at a very emerging stage as the use of these principles has been rather nonexistent in the company. Further, it is impossible to evaluate whether Lean has been modified to fit the industry when there is no data available from the Lean projects. The case company has participated in some industry wide initiatives related to Lean construction, but there exists no information regarding the intrafirm operations.

Third, we have assessed the factors that affect supply chain performance in both Lean and the construction industry. Both the Lean and the construction literature highly emphasize the importance of supply chain integration and long-term commitment to it. Properly managed supply chains play a central role in successful Lean implementations. Further, the construction industry has continuously highlighted the importance of long-term partnerships and the importance of supply chains, but the dynamic and complex nature of the industry has slowed down the development process towards more integrated supply chains. Successful supply chain partnering in construction can be achieved by (1) evaluating the

subcontractors carefully, (2) selecting long-term partners, (3) developing the partnering relationships continuously and (4) continuously measuring whether the partnerships are beneficial for the company and evaluating if these partnerships should be continued or ended. In addition, successful supply chain performance in construction requires working communication, trust, transparency and mutual goals for example through shared incentives. However, the client's decision regarding the supply chain dynamics can completely dwarf any initiatives for successful project partnering, making the client the most critical factor in project-level supply chain integration.

Lastly, the case company has been provided multiple suggestions on how to move forward with its Lean implementations. The focus has been on the most crucial aspects such as top management support, waste identification, standardization and supply chain relations. The case company needs to completely re-evaluate the purpose of its Lean activities and what it wants to achieve through the Lean methodology. Without distinct objectives, the methods to achieve them and continuous top management support the Lean implementations will continue to be lacking and the transformation towards a Leaner organization will at best be hindered and at worst blocked. Following the suggestions provided before should help the case company to create a basis for future Lean success and better control over its Lean activities.

There are some limitations in the results of this study. First, it was a single case study which means that the company specific results cannot be generalized across the industry. However, the identified success factors, obstacles and supply chain characteristics were based on the extensive literature review and should therefore be applicable to the industry. Second, the topic of this thesis was so broad that it was simply impossible to collect all available information regarding the case company, thus the results might not represent the true nature of Lean in the organization, or the author might have missed some critical information related to the Lean initiatives. Lastly, the applicability of the Leanness framework created has not been tested and it might require major improvements to allow reliable Leanness assessment of the pre-implementation, current and future state of Lean in

construction companies. Further research should aim to improve the Leanness framework for example through fuzzy technique so that it produces reliable results and can be applied industry-wide. Also, the role of SAFe in the case organization could be studied more. This thesis gave a very superficial picture of SAFe and the literature regarding SAFe and the construction industry is scarce, therefore SAFe's applicability with Lean and the construction industry could be explored in further research.

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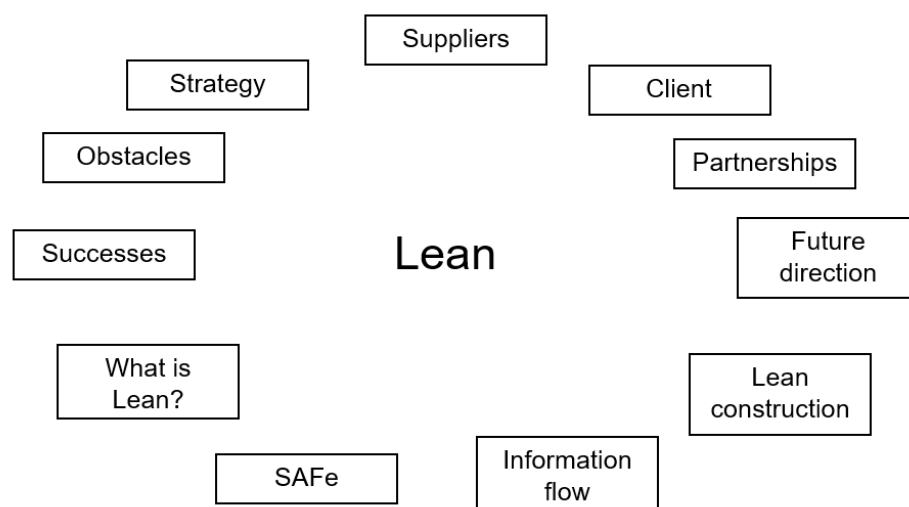
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## APPENDICES

Appendix 1. The interview guide



## Appendix 2. Survey questionnaire.

### Survey questionnaire

#### Demographic qualities

Age: 18-29, 30-39, 40-49, 50-59, 60+

Segment: Infrastructure, Business premises, Housing, Other

Function: Production, Procurement, Cost estimation, Segment support, Development, Other

Title: Employee, Manager, Director

Primary work location: Office, Worksite

#### Inner strengths

- 1.1. The client (or customer) is in the center of daily activities
- 1.2. I influence the clients' (or customers') opinion of the company through my own activities
- 1.3. We review what we have learned with our colleagues (including foremen)
- 1.4. I regularly get feedback from my own (or another) foreman
- 1.5. The organization's meeting practices are well designed
- 1.6. I attend unnecessary meetings
- 1.7. There are problems in the intrafirm information flow
- 1.8. There are problems in the interfirm information flow
- 1.9. The information sharing systems in the company are function
- 1.10. I collaborate with other functions
- 1.11. We continuously develop collaboration with other functions
- 1.12. There are problems when collaborating with other functions
- 1.13. The responsibilities are clear between functions

#### Development activities

- 2.1. The organization's development activities have been successful
- 2.2. I have heard about the initiative Performance Leap
- 2.3. I know what the purpose of Performance Leap was
- 2.4. I have heard about the following tools (choose all that you've heard of)
- 2.5. I have used the following tools (choose all that you've used)
- 2.6. I have heard about the new management system GRIP
- 2.7. The new management system GRIP is distinct (its purpose of use)
- 2.8. I know what the new management system is used for
- 2.9. I have attended a Lean training provided by the case company
- 2.10. I thought the training was useful
- 2.11. I have an understanding of what Lean is

#### Lean

- 3.1. Lean thinking is visible in the case company's strategy
- 3.2. The objectives for Lean are clearly defined in the organization
- 3.3. I know how to utilize Lean in my own (daily) work
- 3.4. I utilize Lean in my (daily) work
- 3.5. I can help other people in Lean-related matters
- 3.6. Lean has been useful for my work
- 3.7. Lean has created extra pressure to my work
- 3.8. Lean is suitable for the construction industry and the case company

## Appendix 3. The Leanness assessment framework.

	Grade 1-10			Weight
	Pre-implementation	Current	Future	
<b>Strategy and management</b>				
Lean has been modified to fit industry characteristics				0,5
Lean plays a central role in the company's strategy				0,4
There are clear objectives for Lean and an action plan to achieve said objectives				0,3
Top management supports the Lean implementations				0,5
Top management actively participates in the Lean implementations				0,4
Management practices endorse the implementation of Lean				0,5
Lean is implemented holistically in the organization				0,4
Lean barriers were known beforehand				0,1
<b>Total</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>Max. 30</b>
<b>Organization and people</b>				
Organizational culture is accepting towards Lean				0,4
Managers and employees collaborate towards Lean goals				0,5
The employees are actively engaged with Lean				0,4
Employees understand Lean				0,4
There is resistance to change regarding Lean				0,2
Knowledge is being transferred effectively inside the organization				0,1
Intrafirm collaboration is functional				0,2
<b>Total</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>Max. 22</b>
<b>Practical</b>				
Lean consultants are/have been used				0,1
The methods to identify and eliminate waste are clearly defined				0,4
Waste identification and elimination is continuous				0,5
Processes are standardized				0,3
Variability in processes is being continuously reduced				0,5
Value Stream Mapping (VSM) continuously used in process mapping and eliminating NVA activities				0,3
VSM is applied holistically in the organization				0,4
Lean tools are widely applied in the organization				0,5
<b>Total</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>Max. 30</b>
<b>Supply chain</b>				
Continuous supply chain collaboration inside the supply chain				0,5
Long-term partnerships established with critical supply chain participants				0,5
Continuous development of the critical supply chain partnerships				0,3
Partners are preferred over competitive bidding				0,2
The organizational subsystems are aligned with the subcontractors				0,1
Communication inside the supply chain is functional				0,2
<b>Total</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>18</b>
<b>Total overall score</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>Max. 100</b>
State of Leanness:				
>80 = Excellent				
>65 = Good				
>50 = Moderate				
>40 = Mediocre				
>30 = Poor				
<30 = Very poor				