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# Improving project performance through logistics outsourcing in an urban construction project

A case study at Veidekke

Master's thesis in Design and Construction Project Management

HANNA PETTERSSON  
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DEPARTMENT OF ARCHITECTURE AND CIVIL ENGINEERING

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## Abstract

The enhanced desire of living in urban areas contributes to increased demands for housing. Building in dense areas often lead to logistical challenges since the amount of space is limited. Additionally, previous research claim that productivity is low within construction projects and not following productivity developments in other industries. Both rearrangements of construction logistics and implementation of supply chain management is argued to be possible solutions to increase performance of the construction supply chain. Therefore, this thesis aims to investigate how outsourcing of logistics can improve the performance of the construction supply chain, as one way to increase the productivity in a dense city construction project. The study contributes to the understanding of the effects of applying third party logistics to the principles of supply chain management in construction. In order to reach results that align with the aim, an abductive research approach is chosen. Observations from a case study at one of Veidekke's construction projects has been executed, together with interviews and discussions. In total, nine interviews have been conducted.

The findings from the study shows that by outsourcing logistics, the workers at the project can focus on executing value adding work tasks leading to increased productivity. Outsourcing of materials handling relieves one hour every day for the construction workers. It is found that a supervisor spend approximately 22 hours during a week on activities that can be outsourced to a TPL-company. If these activities are outsourced, the supervisor can spend this time on planning for future activities in detail. More detailed planning will reduce the risk of unforeseen problems that can hinder the productivity. By planning every activity in detail, the need to have time buffers in the schedule will not be necessary. TPL-services can to some extent help achieve supply chain management within the construction supply chains. It is concluded that, to fully achieve construction supply chain management, one must also enhance the standardisation further. The results in this thesis provides Veidekke with suggestions that can increase the productivity of their projects.

Keywords: Construction Logistics, Construction Supply Chain Management, Project Performance, Third Party Logistics.

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This master thesis is an end of an era, a summary of the conducted knowledge of our five years at Chalmers University of Technology and the beginning of a new chapter as civil engineers. This thesis has been written on behalf of the construction company Veidekke during the spring semester of the year 2020. The report is the final degree project of 30 credits in the masters programme Design and Construction Project Management at the division of Construction Management.

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Hanna Pettersson & Fredrika Skoglund, Gothenburg, June 2020

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## Glossary

**Client** - Beställare

**Construction Engineer** - Entreprenadingenjör

**Construction Elevator** - Bygghiss

**Construction Manager** - Arbetschef

**Construction Site Plan** - Arbetsplatsdispositionsplan (APD-plan)

**Construction Workers** - Yrkesarbete

**Contractor** - Entreprenör

**Intransport** - Inbärning

**Site Manager** - Platschef

**Schedule** - Tidplan

**Supervisor** - Arbetsledare

**Supplier** - Leverantör

**Supply chain** - Försörjningskedja

## Notations

**CLC** - Construction Logistics Center

**CLS** - Construction Logistics Service

**CSCM** - Construction Supply Chain Management

**TPL** - Third Party Logistics

**SCM** - Supply Chain Management

**VDC** - Virtual Design Construction

# 1

## Introduction

This chapter presents the introduction to the thesis. Firstly, the background to the selected subject including a problem formulation is presented, covering the importance of the investigated problem. The introduction ends with a presentation of the aim and the research questions that will be investigated in the study.

### 1.1 Background

The desire to live in the big cities is increasing and leading to an enhanced need for urban development (Spillane & Oyedele, 2017). According to the United Nations (2019), it is estimated that the urban population in Sweden is estimated to rise up to 93.2 % in the year of 2050. The increased urbanisation brings a number of challenges to the construction industry. Janné (2018) states that when the population in the cities increases, the need for more housing, hospitals, office buildings and infrastructure is enhanced. The two main challenges that construction in urban areas face are the urban transport problem and the problem of coordinating multiple stakeholders (Janné, 2018). The urban transport problem consists of four challenges: space limitation, environmental concerns, accessibility and noise restrictions (Janné, 2018).

The construction industry is dependent on materials arriving to the construction site when needed (Lindén & Josephson, 2013). The process of managing this flow of materials is called logistics and in a construction setting, this is referred to as construction logistics (Janné, 2018). Janné (2018) defines this as dealing with supplying the right materials to the right customer and construction site with the goal to meet customers' requirements. Hulthén et al. (2017) claim that an important aspect of the challenges when building in urban areas is construction logistics. Agreeing with previous author, Janné (2018) emphasise the importance of logistics as one way to address these challenges. Although it exists proof of the benefits of putting extra resources in logistics, the construction industry has been slow to recognise them (Sullivan et al., 2011). It is estimated that between 10-20 % of all construction costs are related to transports but despite this, there is little consideration given to how the materials and equipment are delivered to the construction site (Sullivan et al., 2011). Moreover, Thunberg & Persson (2014) state that less than 40 % of deliveries to construction sites arrive in right amounts, at the right time and at the right location. Traditionally there has been little attention paid to logistics in the construction industry, only the final leg of materials delivery to the construction site are being recognised as important (Sullivan et al., 2011). Ekeskär (2016) claim that better

planned logistics, regarding both how to receive and handle materials, will decrease production costs and increase productivity on site. To improve construction logistics, Sundquist et al. (2018) suggest a potential change of arrangement; to rely on specialised actors in handling material flows. Moreover, Lindén & Josephson (2013) recommend outsourcing of logistics to service providers that are specialised in materials flow operations, so called TPL-actors. These organisations have contributed to enhanced logistics and supply chain management in other industries (Sundquist et al., 2018).

The construction supply chain is characterised to be a converging chain that is directing all materials to the construction site where the element is assembled from incoming materials (Vrijhoef & Koskela, 2000). The site is a temporary “construction factory” that is set up around the single product. The existing construction supply chain is claimed to be the main cause of the poor performance in the industry (Dubois et al., 2019). There are many actors involved in a construction supply chain, such as subcontractors, suppliers, and other stakeholders (Xue et al., 2007). Briscoe & Dainty (2005) state that there is a lack of will to implement supply chain management practices and obtain supply chain integration in the industry. With the existing construction supply chain, problems such as adversarial relationships and lack of exchange of information and communication can occur (Xue et al., 2005).

According to Vrijhoef & Koskela (2000), the construction industry suffers from poor performance and low efficiency. To increase efficiency in the construction industry, Vrijhoef & Koskela (2000) suggest that a better managed supply chain can be a solution. According to Hulthén et al. (2017), the lack of planned logistics systems can lead to problems at the construction site regarding the handling and movement of materials which can increase the risks of damages and waste. This leads to enhanced costs and consequences for the quality of the building materials and will therefore reduce the efficiency of the construction process (Hulthén et al., 2017). Additionally, the demands for a more sustainable construction industry with regards to reduction of resources and transportation is increasing. To reach these effects, Hulthén et al. (2017) state that logistics is a crucial factor. Construction logistics and supply chain management are identified as possible solutions to enhance performance and effectiveness (Hulthén et al., 2017). Agreeing with Hulthén et al. (2017), Vrijhoef & Koskela (2000) argue that problems within the construction supply chain could be resolved by applying principles and methodologies of supply chain management.

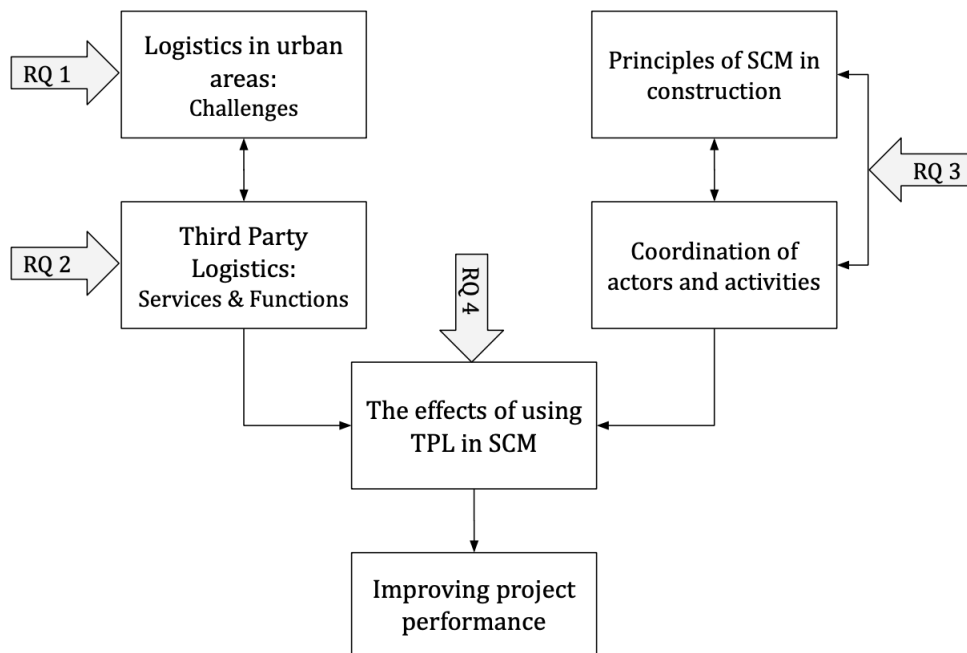
## 1.2 Third Party Logistics Company

Veidekke is a Norwegian construction company, that except from Norway also operates in Sweden and Denmark (Veidekke, n.d.). The company is the fourth largest within its industry in Scandinavia. CS Logistics is a third party logistics company (TPL-company) owned by Veidekke, that offers different construction logistic services. The TPL-company offers services such as logistics analysis, construction logistics centre and intransport of materials (CS Logistics, n.d.). This thesis will ex-

explore the potential effects of outsourcing logistics to CS Logistics to one of Veidekke's construction projects.

### 1.3 Problem Statement and Aim

As an effect of the existing challenges connected to logistics when building in urban areas, the company CS Logistics has been created to support construction projects with various logistics services. In this thesis, a construction project will be studied and will be referred to as "Mandolingatan". The project is situated in a dense area in Gothenburg with some logistical challenges. To be able to motivate the usage of third party logistics services, the aim of the thesis is to investigate how outsourcing logistics can improve the performance of the construction supply chain, as one way to increase the productivity in a dense city construction project. The figure 1.1 below gives an overview of the different areas that will be explored in the thesis and how they are connected to each of the research questions.



**Figure 1.1:** The connection between the investigated areas in the thesis.

## 1.4 Research Questions

In order to fulfil the aim of the thesis, following research questions will be answered:

1. What are the main logistical challenges in dense city construction projects?
2. What type of third party logistics services exist today and what are the pros and cons of utilising them?
3. How are the principles of supply chain management utilised in the production phase of a construction project?
4. What are the effects of applying third party logistics services to the principles of supply chain management?

# 2

## Theoretical Framework

This chapter presents the theoretical framework. The theoretical framework is based on a literature study with the aim to give context to the chosen area of research. The disposition of this chapter consists of three sections. Firstly, the construction industry and its characteristics will be explained and the strong focus on projects within the industry will be emphasised. Further, the term construction supply chain management and the concept construction logistics are explained and distinguished from each other.

### 2.1 Construction Industry: Strong Project Focus

According to Persson et al. (2009), the construction industry is project-based; each construction site is considered as an individual project and it is common that several projects are executed simultaneously by one construction company. Construction is about coordination of differentiated and specialised tasks at the site (Shirazi et al., 1996). This site-specific activities provide two central features of the construction industry; the focus on individual projects and the need for local adjustment at the construction site (Dubois & Gadde, 2002a). The focus on individual projects is in terms of decentralised decision-making and financial control. The reason for decentralised decision-making is founded by the managements' unfamiliarity with the local environment and resources. The need for local adjustments is necessary because of uncertainty factors such as lack of complete specification, lack of uniformity and an unpredictable environment (Dubois & Gadde, 2002a). Koskela (2000) have found that the construction industry have three distinctive traits. The first is that every construction project is a unique prototype. Secondly, each project is carried out on a production site which means that it will be exposed to different site conditions, such as weather. Lastly, a construction project is assembled by a team that can differ from project to project. The lack of consistency have great impact on the coordination of materials and information which is one of the main problems in the industry (Lindén & Josephson, 2013).

In general, the construction industry does not behave as an “industry”, more like a group of different industries or an “industry of industries” (Fernández-Solís, 2008). According to Fernández-Solís (2008), the construction industry is expected to be as efficient as other manufacturing industries such as the automobile or the aircraft industry. There are differences between the desired effectiveness of the construction industry and other industries when they are compared in practice (Fernández-Solís,

2008). Azambuja & O'Brien (2008) state that compared to manufacturing industries, the product demand is less uncertain in construction, since the amount of materials that is required is normally known in advance. The project site is dependent on labor productivity and availability, the use of tools and the open environment. There are also lack of standardisation and tolerance management at the sites (Azambuja & O'Brien, 2008). In construction projects, uncertainties are the result of temporary conjunctions in a turbulent environment (Bertelsen, 2003). According to Dubois & Gadde (2002a), the construction industry is blamed to be inefficient and has failed to adapt techniques that have improved the performance in other industries. A common view is that the construction industry would benefit of to change its behaviour and adapt more to other industries' norms (Dubois & Gadde, 2002a).

### 2.1.1 Performance and productivity in construction

The construction industry is continuously being accused of having worse productivity compared to other existing industries (Lind & Song, 2012). Productivity is defined by Lind & Song (2012) as how large the output of resources is in relation to the input of resources. According to Lind & Song (2012), the statistics also confirms these allegations as the productivity development almost has stagnated since the beginning of the 1990s. Dubois & Gadde (2002a) claim that the project-based characteristics of the industry is one possible suggestion to why the industry is lacking behind other industries with regards to the productivity. Moreover, Dubois & Gadde (2002a) argue that the short and weak relationships between different actors that a project-based industry consist of, is the reason for the industry's difficulty to follow productivity developments. According to Landin & Oberg (2014), productivity cannot be considered without regard to the role of labour as a primary resource as a result of the construction industry being crucially reliant on labor-intense activities on construction sites. In the construction industry's constant competitive environment, there exist a continuous pressure to reduce costs, especially targeting to decrease costs for on-site labor. Concerning this, Landin & Oberg (2014) state that increased efficiency directly lead to profit for an organisation. However, Lind & Song (2012) argue that the construction industry is not that far behind other industries regarding productivity development and that statistics are proving wrong. Since the measurement for productivity of the Swedish construction sector does not consider increased quality, Lind & Song (2012) conclude that the productivity development most likely is underestimated. According to Lind & Song (2012), the current quality adjustment is not adequate and that it is not possible to make a statement regarding the productivity development of construction with today's measurements.

Similarly, productivity development is questioned in the infrastructure industry. For that specific topic the Swedish government appointed a committee with the mission to improve both productivity and pace of innovation (Lind & Song, 2012). To reach the goals the report suggest some actions to support the industry increase productivity. These actions include enhanced amount of design-build contracts with functional requirements, development of functional requirements for design-build

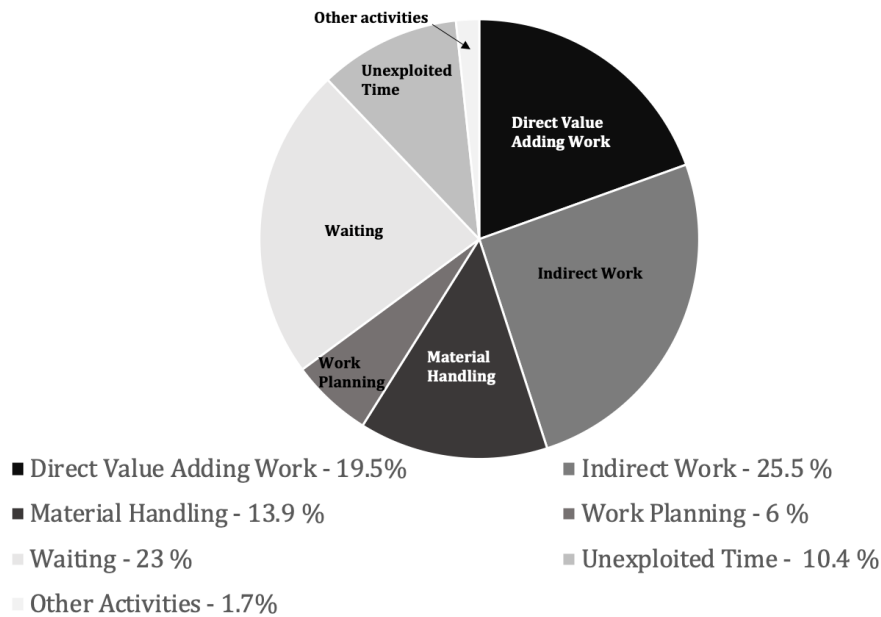
contracts, take advantage of repetition and standardisation, development of the work with evaluation and follow-ups, measuring productivity development and level of innovation (Lind & Song, 2012).

Construction projects have a strong tendency for tight schedules but despite this, both the contractor and subcontractors include a variable amount of “acceptable” waste in their cost calculations and in their schedules (Koskenvesa et al., 2010). Waste is defined by Basu & Wright (2012, p. 71) as “any human activity that absorbs resources but creates no value”. Koskenvesa et al. (2010) state that if it is desirable within the construction industry to manage truthfully and build more productively, the waste need to be identified and controlled so that the amount of waste will be able to reduce. According to Josephson & Saukkoriipi (2007), one of the highest priorities both for individual construction companies and the whole construction industry should be to reduce waste. Waste in a construction project can in some cases reach up to 30-35 % of the total production cost (Josephson & Saukkoriipi, 2007). Moreover, Josephson & Saukkoriipi (2007) have identified four categories of waste in construction projects:

1. Defects and checks
2. Use of resources
3. Health and Safety
4. Systems and structures

Studies indicate that the costs for defects during the production phase corresponds to 2-6 % of the production cost (Josephson & Hammarlund, 1999). Defect and checks is divided into visible and hidden defect costs. Visible defects costs are the costs that can be detected and registered, contrary to hidden cost where the knowledge to discover them or the measurements to register them is required. For example, hidden defects costs infer defects that occur on a material at the factory where it is produced and is something the contractor in the end have to pay. According to Josephson & Saukkoriipi (2007), costs for defects could reach up to 9.4 % of the total production cost for a construction project.

Furthermore, the second category of waste that Josephson & Saukkoriipi (2007) identifies is the use of resources. The use of resources includes how utilisation of work time, machinery and engineering materials is used. According to Josephson & Saukkoriipi (2007), it is of large interest to do observations studies of the work of a construction worker. The authors state that this reflects the view of how well the project organisation, the project management and the production planning is working. Strandberg & Josephson (2005) has executed an observation study of construction workers and identified the following activities performed by construction workers; direct value adding work, preparation, waiting and waste. The following figure (2.1) illustrate a more detailed view of how time is utilised by a construction worker on site based on the study by Strandberg & Josephson (2005).



**Figure 2.1:** Observed activities of a construction worker (Strandberg & Josephson, 2005).

Direct value adding adds value to the product, while waste is of the form of completely unnecessary work that can be eliminated without having any impact on the product (Josephson & Saukkoriipi, 2007). However, preparations are necessary work to be able to perform the direct value adding work but does not by itself increase value to the product. The direct value adding work correspond to 19.5 % performed by the observed construction workers. Preparations is divided in three parts, where the total preparations of 45.4 % equals; 25 % of indirect work (handling equipment and material, safety work), 14 % of material handling (mostly spent moving materials to the workplace) and 6 % consisted of planning work (Strandberg & Josephson, 2005). Waiting is mostly spent when moving between different working spots. However, waiting because of lack of machines, equipment or materials only is representing 1.3 % of the total time (Strandberg & Josephson, 2005). Furthermore, Strandberg & Josephson (2005) state that the observations shows that a construction spend 33 % of their day executing non value adding activities, in other words waste.

Furthermore, Josephson & Saukkoriipi (2007) examine other waste related connected to use of resources and claim that the utilisation of machinery is rather low on the construction site. Smaller machines was only used 5 % of the time, compared to 48 % utilisation for larger vehicles. The total waste regarding utilisation of machinery then results in 2-5 % of the total production cost. The third category of waste, health and safety, includes waste of work-related illness and accidents (Josephson & Saukkoriipi, 2007). Furthermore, Josephson & Saukkoriipi (2007) the last identified category is systems and structures (Josephson & Saukkoriipi, 2007). Systems and structure includes cost related to organisational structure and management systems in project, companies or federal authorities Josephson & Saukkoriipi (2007). The category deals with costs related to the duration of time it takes to develop new plans regarding land use. The authors mentions some examples in the Gothenburg

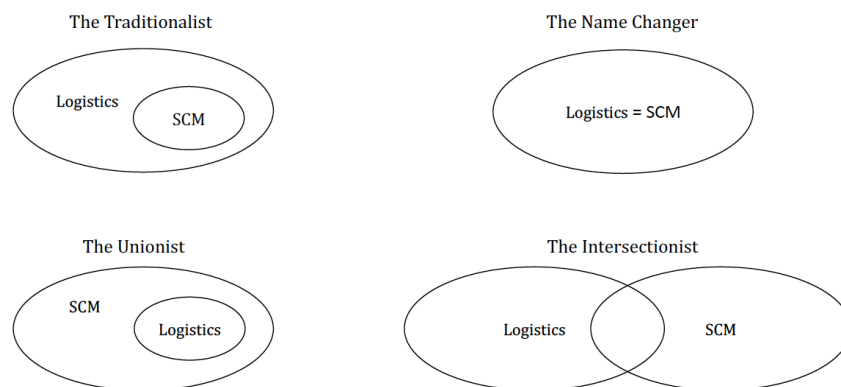
region were the process regarding plans for new land use took five and two and half years. Moreover, Josephson & Saukkoriipi (2007) mentions the Swedish tendering system as another example of waste in the same category.

## 2.2 Construction Supply Chain Management

For companies to gain competitiveness on the market, one option is to improve the performance of their supply chain (Pettersson & Segerstedt, 2011). Supply chain management, SCM, means that a company focus on their supply chain and strive for as low costs as possible connected to the supply chain as well as good service to the end customers (Sandberg, 2015). Sandberg (2015) suggest that SCM could be achieved by well-planned coordination with other actors in the supply chain. SCM is a concept that originated in the manufacturing industry and developed within the Just-In-Time delivering systems in the Toyota Production (Vrijhoef & Koskela, 2000). The most commonly known definition of supply chain management, SCM is made by CSCMP (n.d):

“Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies.”

There are different views regarding how logistics and supply chain management is connected to each another. Sandberg (2015) explains four different views regarding the connection of the two terms in figure 2.2 below.



**Figure 2.2:** Different views of the connection between logistics and SCM (Sandberg, 2015).

According to Sandberg (2015), the Traditionalist perceives SCM as a part of the bigger term logistics; SCM can be equated with the logistics outside the company,

the “external” logistics. The Name Changer does not make any difference between the two terms; their meaning is the same. The Unionist perceives SCM as a wide term that includes a lot of different areas, logistics being one of them. The intersectionist state that the terms SCM and logistics are overlapping with their content, but that SCM tends to contain strategic tasks that cannot be considered as logistics (Sandberg, 2015). In this thesis, SCM will be perceived from the unionist perspective.

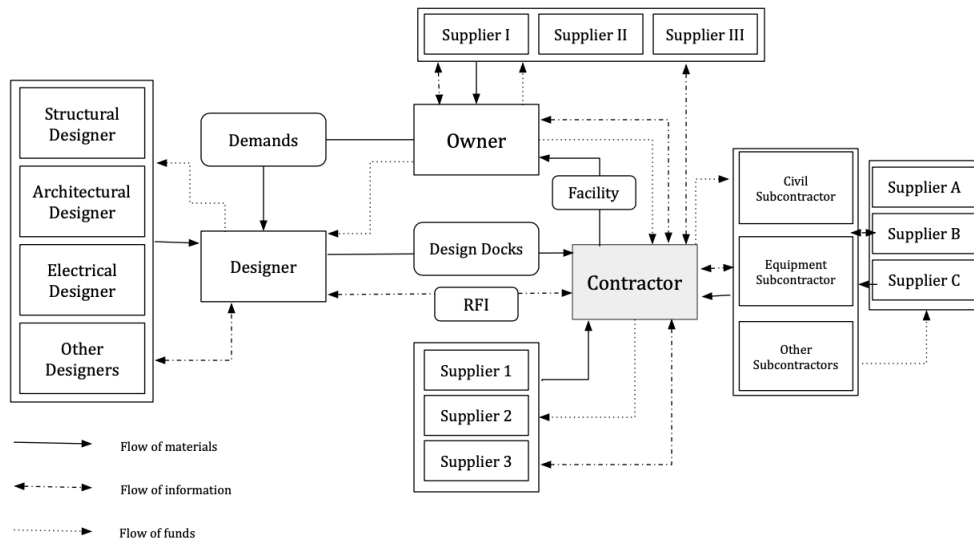
Bankvall et al. (2010) claim that the construction industry lacks the will to implement SCM and that the characteristics of the industry are not suitable with the concepts of SCM. However, Ekeskär (2016) argue that increased focus on logistics has been the main focus for some successful realisations of SCM in the construction industry. Unlike the manufacturing industry, the construction supply chain is temporary and differs from project to project (Vrijhoef & Koskela, 2000). This leads to an instability in the supply chain and a segregation between the design and construction of a built object. Based on the fact that the construction industry is project-based, the supply chains are also characterised by a completely new product to fabricate, leading to little recurrence (Vrijhoef & Koskela, 2000). Moreover, Vrijhoef & Koskela (2000) suggest that a construction project can be likened with a “construction factory”. All materials are sent to the construction site to where the product, in this case the construction object, is assembled. Compared to the manufacturing industry where multiple products pass through the factory and is later distributed to several purchasers. The most familiar way of using SCM in construction is to see every project as an individual supply chain and try to identify what is needed for that particular supply chain (Bankvall et al., 2010).

Vrijhoef & Koskela (2000) argue that two main issues are leading to consideration regarding the construction supply chain, firstly the slow productivity development and secondly the increased economic importance of the supply chain. The characteristics of the construction industry are reasons for the performance-related issues that the industry is facing (Xue et al., 2007). According to Xue et al. (2007), these problems are much related to the management of the construction supply chain and are in urgent need for improved coordination to reach better performance of the construction supply chain management, CSCM. Behera et al. (2015) presents following characteristics of a construction supply chain, explained in the following table 2.1:

**Table 2.1:** Characteristics of the construction supply chain

<b>Customer influence</b>	The end product are largely influenced by the customer regarding physical aspects and value of logistic parameters.
<b>Fragmentation</b>	The industry is very complex due to the large amount of involved subcontractors.
<b>Stakeholders</b>	Within construction projects there are many and different types of stakeholders involved.
<b>Buyer-supplier relationship</b>	The relationship between buyer and supplier is commonly characterised by mistrust and conflict. The tendering process and the focus on price are the central reasons for project delivery problems.
<b>Project-based</b>	The project-based nature lead to relationships focused on short-term thinking and a focus of self-interest.
<b>Change passivity</b>	The construction industry is negative towards change because the risks associated with the procurement of projects.
<b>Make-to-order</b>	Because the client takes the initiative to build a construction project they are seen as the source of change.
<b>Collaborative</b>	There is a need to explore collaborative models to improve inter-organisational innovation in construction.
<b>Cyclical demand</b>	There is a regular demand for the products from the construction industry as there end-product not transportable but durable.

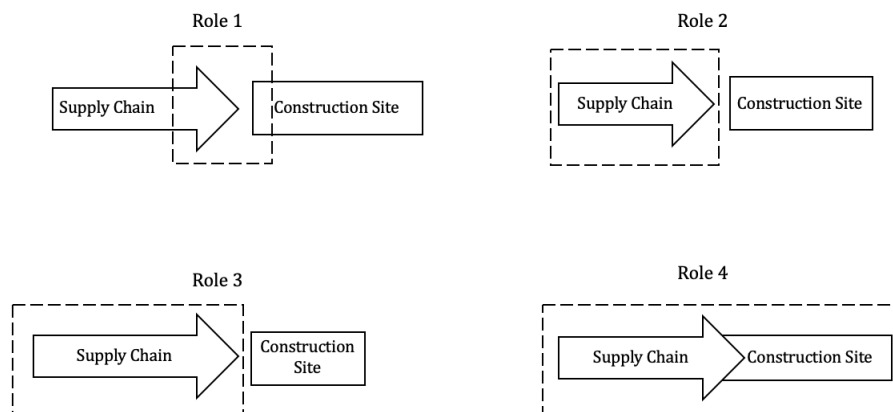
The focus of CSCM is to handle the suppliers' processes and to increase their competitive advantage. For every new construction project, the typical supply chain includes main contractors, engineers, architects, subcontractors and material suppliers that all join a temporary organisation for a specific construction project (Behera et al., 2015). Xue et al. (2007) state that the supply chain in construction consists of all the construction business processes; everything from the demands given by the client, design and construction to maintenance. The construction supply chain is not a chain of construction businesses that have business-to-business relationships; it is a network consisting of multiple organisations and relationships. This includes different flows of information and materials, services or products, and the flow of funds between client, designer, contractor, and supplier (Xue et al., 2007). Figure 2.3 gives a schematic overview of the general structure of a construction supply chain.



**Figure 2.3:** General structure of a construction supply chain (Xue et al., 2007).

### 2.2.1 Focus areas for implementation of SCM in construction

For the construction industry to be able to incorporate the principles of SCM, Vrijhoef & Koskela (2000) claim that the principles must be adapted for the typical characteristics of the construction supply chain. Therefore, Vrijhoef & Koskela (2000) suggest four specific areas where SCM could be embedded in the construction industry, as they refer to as the four roles of supply chain management. The areas differ depending on whether the focus is on the supply chain, the construction site or both (Vrijhoef & Koskela, 2000). Figure 2.4 visualises the four different roles and the focus area for each one of the four roles.



**Figure 2.4:** The four roles of SCM (Vrijhoef & Koskela, 2000).

The first role is focusing of the connection between off-site and on-site logistics, i.e. how the supply chain impact the logistics on-site. It is important that materials and

equipment is delivered to site on time to avoid any disruption of the production. The goal with the first role is to decrease both duration of site activities and costs. To reach the goal it is important that the project ensure trustworthy material and labour flows to the site to avoid any disruption of the workflow (Vrijhoef & Koskela, 2000). The contractor whose mainly focus on site activities has a lot to gain to shift some focus from on-site activities to the supply chain. Vrijhoef & Koskela (2000) suggest that the simplest way to achieve this is to focus on the relationship between the site and direct suppliers. One initiative to implement the first role focused on co-operation between suppliers and contractors.

The second role focuses on the supply chain itself with the goal to reduce costs related to inventory, lead-time and logistics. Except from the contractor, Vrijhoef & Koskela (2000) propose that material and component suppliers also should adopt to that focus. Ekeskär (2016) interpret the second role as a way to streamline the supply chain with the site, so that the supply chain are suitable in the best possible way and supporting the construction project. Ekeskär (2016) suggest that this could be achieved by customising deliveries, so it is specified in what way materials should be packed or how to pack pallets. To achieve global improvement, it is important to have in mind the trade-off between transportation, inventory and production cost. According to Vrijhoef & Koskela (2000), in-depth costs and time analysis should be executed to achieve a development of the supply chain. The same authors further suggest that the performance of the supply chain is a cause of varying site and capacity conditions and uncertainty in the supply chain (Vrijhoef & Koskela, 2000).

The third role focuses on transferring activities from the construction site to the supply chain and should be adopted by both supplier and contractors (Vrijhoef & Koskela, 2000). This is achieved by increasing compatibility between activities and to avoid inferior conditions on site. Enhanced compatibility of activities is not compatible with the conditions on site and have to be transferred to the supply chain due to their many technical dependencies. A common initiative is the utilisation of prefabricated elements in production, as well as other industrialisation initiatives, transferring on-site activities off-site. Lastly, the main focus of the forth role is to integrate off-site activities with on-site activities. This is achieved by subsuming the production on site with the supply chain. According to Ekeskär (2016), the forth role is realised when the supply chain is fully integrated with the construction site. Some actions in this area include open building and sequential procedure (Vrijhoef & Koskela, 2000). An open building postpones utilisation decisions regarding the interior of the building, while sequential procedure involves structuring the site work after self-governing procedures. However, the goal with both these procedures is to replace the temporary construction supply chains with new permanent supply chains. Another initiatives that could be categorised under the fourth role is design-build arrangements. Furthermore, Vrijhoef & Koskela (2000) state that the four roles could be used jointly and not only one by one.

According to Vrijhoef & Koskela (2000), it is shown that the construction supply chain have great potential for improvement. The major cause for waste and prob-

lems are related to traditional management of the supply chain and new principles and methods of modern SCM could be a solution. The practical methods for SCM implementation must be developed, so that the characteristics of, and the specific situation of construction, is taken into consideration (Vrijhoef & Koskela, 2000). In their study, Vrijhoef & Koskela (2000) draw three main conclusions. The first is that even in normal situations, a lot of waste and problems exists in the construction supply chain. These problems are often ignored or not recognised. Secondly, most of the waste and problems are caused in a stage of the construction supply chain different from where the waste and problem surfaced. This means that the root causes of waste and problems were rarely found in the activity where the waste and problems were encountered. On the other hand, it was found in a previous activity by a prior actor. The third and last conclusion is that waste and problems are often caused by a short-sighted control of the construction supply chain. The authors state that when activities are transferred from the construction site to off-site, the supply chain becomes more complex and must be managed well. This is important in order to profit from the benefits that occurs when transferring activities (Vrijhoef & Koskela, 2000).

### 2.3 Construction logistics

The general construction project involves a large number of different suppliers (Lindén & Josephson, 2013). These suppliers use different suppliers of their own to deliver goods and materials that is needed to for them to perform their work during the whole production phase. This leads to a generous amount of transports and deliveries to a construction site requiring both resources and attention from workers (Lindén & Josephson, 2013). Hulthén et al. (2017) claim that a change in managing construction logistics will generate more effective construction processes. Agreeing with the previous claim, Thunberg & Persson (2014) suggest that the performance of the construction industry would increase if more attention was paid to the supply chain. An increased focus of construction logistics can contribute to lowering costs, increase the quality and to improve sustainability (Hulthén et al., 2017). Sundquist et al. (2018) claim that enhanced efficiency in transportation and logistics could reduce total costs by 20 %. Hulthén et al. (2017) has identified that the largest improvement possibilities of construction logistics exist in the integration between on-site logistics and off-site logistics.

According to Ying et al. (2014), the efficiency of a construction project depends on the integration between on-site and off-site logistics and that problems can occur when there is a lack of planning of material deliveries and their site workforce. The opportunities for improved performance in construction logistics are according to Sundquist et al. (2018) dependent on two factors. The first one is to handle the logistics problems at the construction site and the second factor considers improvements of supply logistics that involves suppliers of building materials (Sundquist et al., 2018). Sundquist et al. (2018) state that research shows that rearrangement of site logistics have positive effects. According to a case study made by Agapiou et

al. (1998), logistics management is relevant in the construction industry and costs can be lowered with effective logistics management. The cost savings can be up to 5 % of the total costs and the largest contributor to this is the reduction of wasted materials and working days (Agapiou et al., 1998). Ekeskär & Rudberg (2016) states that in order for the supply chain to interact with the construction site, the logistics management at the site needs to be improved. To enhance efficiency in the industry Hulthén et al. (2017) suggest increased collaboration between different actors and implement use of new technologies.

### **2.3.1 Barriers against effective logistics management**

The construction industry lacks the ability and the appropriate skills to solve logistical problems (Ying et al., 2018). Costs related to logistics in construction is relatively unknown, but what has been discovered is that inefficiency (waste) in construction in some cases is equal to 30-35 % of the total production cost (Lindén & Josephson, 2013). This leads to an organisation unaware if their supply chain is in need for potential improvement. Ying et al. (2018) state that measuring of logistics is an important step to improve performance. Thunberg & Persson (2014) argue that if no measuring of sourcing performance is done, potential improvements will be overlooked. Moreover, Lindén & Josephson (2013) state that the cost of materials in construction often reaches to 45 % of the production cost and that there are a lot of hidden costs in logistics that needs to be discovered, especially the ones connected to handling of material on site. Materials are often delivered to one specific area and then have to be transported to another area. This means that materials are often doubled handled at the construction site (Sundquist et al., 2018). The double handling increases the risk of damaging the materials. Sundquist et al. (2018) further mention other problems connected to construction logistics. Material, equipment and tools is often managed poorly and construction workers often spend a lot of their time searching for both materials and tools. Construction materials often require a lot of storage capacity which is often not available on today's urban construction sites. According to Ying et al. (2014), logistics issues often occur as a cause of inadequate planning and for some cases, material is delivered to a construction site with as little as ten minutes notice. For those cases the site manager urgently have to create temporary teams to help with unloading and as a consequence creating scheduling conflicts and inefficient unloading.

Furthermore, the urban area also sets limitations regarding the execution of construction logistics (Janné, 2018). Multiple materials and resources must be delivered to and removed from construction sites at the correct time (Janné, 2018). In urban areas, additional transport flows are created and competing with the existing infrastructure and other traffic users. Urban transports can contribute to issues such as emissions, noise and accidents. At the same time, transportation of goods play an important role in the urban environment (Janné, 2018). According to Carlsson & Janné (2012), the urban transport system is complex, where both goods and passengers utilise the same, limited infrastructure. The urban transport system is used by

different vehicles and road users, which can increase the risk of accidents (Carlsson & Janné, 2012). With the increasing urbanisation, a large proportion of transports will take place in complex urban transport systems (Janné, 2018). To be able to manage the material deliveries to urban construction sites, Janné (2018) states that there is a need to improve how construction logistics is coordinated and executed. There are many actors and stakeholders involved and each subcontractor is responsible for the procurement of their own materials (Sullivan et al., 2011) which has led to a situation where no one has overall control of the project (Sullivan et al., 2011). As a consequence of this, other stakeholders related to the project are being adversely affected and the overall performance of the project is being diminished (Sullivan et al., 2011).

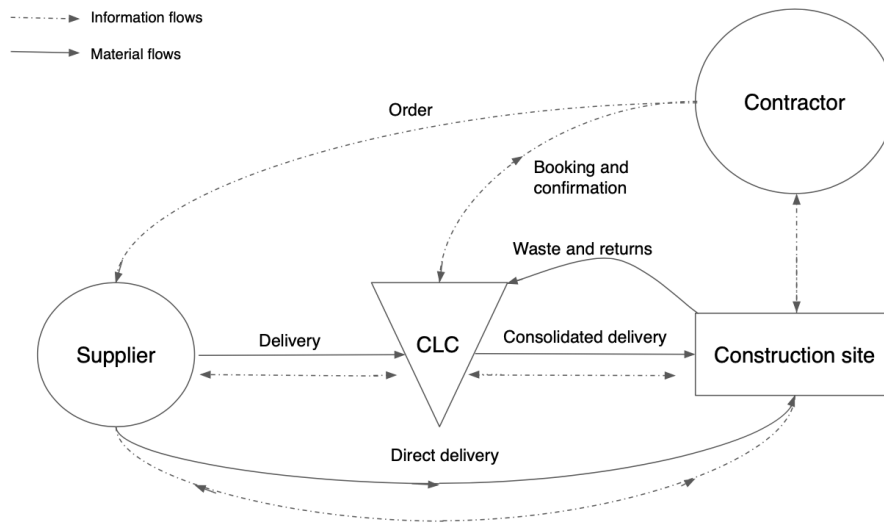
### 2.3.2 Construction Logistics Services

At the temporary fabric that a construction project is likened with, planning is very important. Révai (2012) states that even if the fabric is temporary it should be thoroughly planned without any emergency solutions in order for the production to be as effective and safe as possible. All construction projects have a construction site plan, including placements and how to utilise the construction site. The construction site plan should include where to place sheds, office spaces, storage of materials, storage containers, recycling station and where to place bigger machines and so on (Révai, 2012). According to Révai (2012), one important part of the preparation of the plan is to mark out transport roads and unloading sites to ensure accessibility. As mentioned regarding bigger machines, the crane should be marked on the plan as well as construction elevators, scaffolding and the station for reinforcement (Révai, 2012). Implementation of well-planned logistics, regarding delivery and storage it is possible to improve the logistics performance in construction (Sundquist et al., 2018). Hulthén et al. (2017) propose that to improve construction logistics, the merging of on-site and off-site logistics should increase together with implementation of technologies.

One suggestion to reduce the impact of transportation of goods in urban areas is to employ urban consolidation centres (Allen et al., 2014). If goods from multiple suppliers are consolidated to one shipment, the total amount of transports of goods within cities can be reduced (Janné, 2018). This idea of consolidating goods can also be used in the construction industry, creating construction logistics centres. The aim with a construction logistics centre, a CLC, is to coordinate deliveries to multiple construction sites within an urban area (Janné, 2018). Traditionally, many deliveries arrive to construction sites without coordination. By using a CLC, the amount of deliveries to the site can be reduced. Therefore, the number of times personnel on-site has to receive and handle materials decreases (Janné, 2018).

Generally, the procedure when using construction logistics centres starts with the contractor placing orders to their suppliers. These orders can be delivered directly to the construction site or to the CLC (Brunge, 2013). At the same time as goods are delivered, the contractor places a materials delivery booking in a planning system,

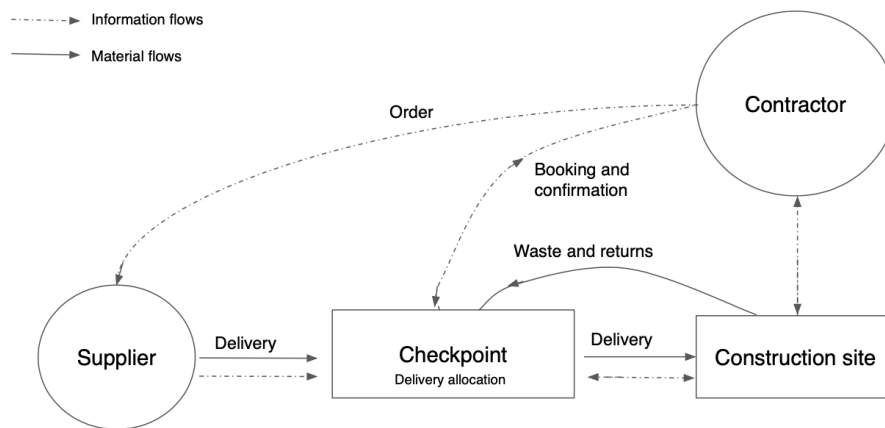
which is controlled by the CLC operator (Janné, 2018). The materials arrive from different suppliers to the CLC where they are controlled, registered and stored. When there is a need for specific materials at the construction site, they are packed and delivered to the site. Janné (2018) claims that by using a CLC, issues such as having too much materials on-site can be solved since most of the materials are stored at a different location. Making the CLC a coordinating contact point gives contractors the opportunity to focus on their operations, rather than coordinating deliveries (Sundquist et al., 2018). Figure 2.5 gives an overview of how a CLC works.



**Figure 2.5:** How a CLC can be used in a construction project (Janné, 2018).

Often, CLC's are located close to the construction site or in the form of a warehouse solution further away (Janné, 2018). Both materials and information goes through the CLC which can consolidate materials and information to the construction site. The supplier can deliver directly to the site or to the CLC but the booking and confirmation is handled between the contractor and the CLC.

Another construction logistics service is to use a checkpoint (Janné, 2018). In a checkpoint case, the contractor place an order with a supplier and at the same time makes a delivery booking in the checkpoint's IT-system (Ekeskär & Rudberg, 2016). Time-slots for deliveries are booked and information on sort of materials, type of vehicles, and the volume of goods is specified (Sundquist et al., 2018). According to Janné (2018), when the supplier is ready for shipment, a delivery announcement is sent from the supplier to the checkpoint operator and the contractor. The shipment is then delivered to the physical checkpoint and the shipment is stored until its allotted time-slot and therefore it gets delivered to the construction site (Ekeskär & Rudberg, 2016). In figure 2.6, the material and information flows when using a checkpoint service are described.



**Figure 2.6:** How a checkpoint can be used in a construction project (Janné, 2018).

There are differences between a CLC and checkpoint regarding the materials deliveries (Janné, 2018). The main differences concern how the deliveries are planned and carried out. When using a CLC, the focus is on the consolidation of deliveries while the checkpoint takes its point of departure in just-in-time deliveries (Brunge, 2013; Ekeskär & Rudberg, 2016). By using a checkpoint, all deliveries are delivered and stored at a specific location on site (Ekeskär & Rudberg, 2016).

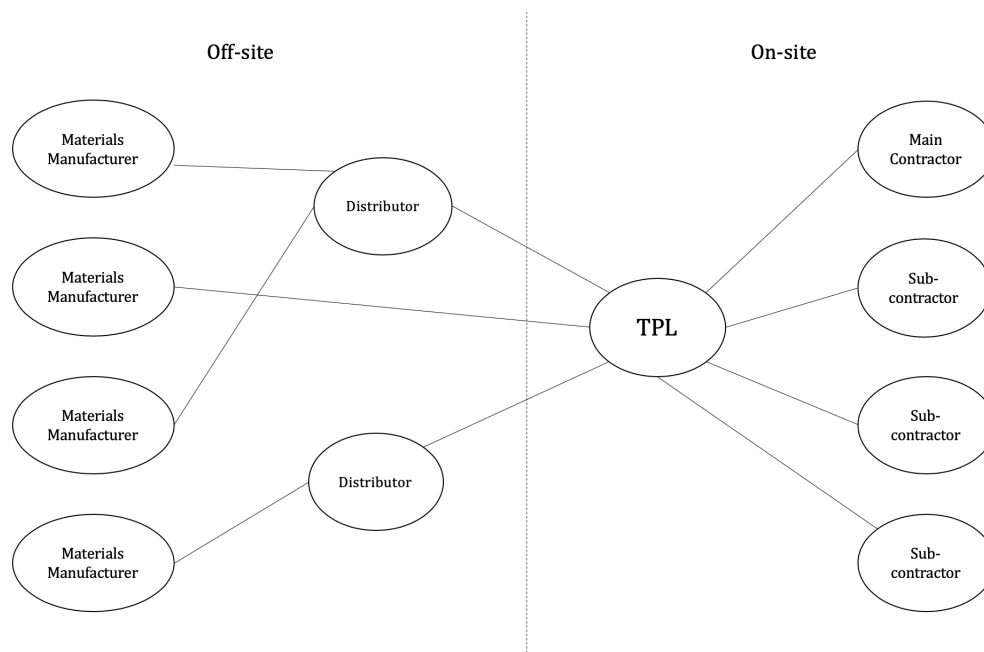
Just-In-Time (JIT) is designed for an efficient production with high quality (Akin-toye, 1995). JIT focuses on eliminating waste by reducing the waiting and storage time to bare minimum and at the same time carrying on the work according to a defined and precisely planned schedule (Gao & Low, 2014). In a JIT system, the suppliers are expected to deliver small sizes of materials frequently. Gao & Low (2014) states that the size of the lots delivered is determined by the actual consumption of materials and not the forecast demand. Some of the characteristics of JIT-deliveries are continuous flow, quick changeover and integrated logistics (Gao & Low, 2014). According to Tommelein & Li (1999), JIT can be used to describe the delivery of materials to the construction site. Materials will be brought to the project for final installation where they are being installed immediately upon arrival (Tommelein & Li, 1999). The objective with JIT production is to supply the right materials, at the right time and in the right amount in each step of the process (Tommelein & Li, 1999). The planning process is influenced by external factors such as weather conditions and environmental factors. As a consequence of this, the precise timing of deliveries can be difficult to achieve (Sullivan et al., 2011).

IT-services can be used to simplify digital parts of the construction process (MyLoc, n.d). One example of an IT-service is Myloc, which is a digital platform that can be integrated with other logistics services to increase the efficiency in construction projects (MyLoc, n.d). In a study by Sundquist et al. (2018) it was discovered that the TPL company that is being studied is using a web-based delivery system. All contractors in the study have to book their deliveries of materials through the system five days in advance which improves the conditions for resource exploitation at the construction site (Sundquist et al., 2018). Sundquist et al. (2018) state that this

web portal is a planning device for efficient use of materials handling equipment. If the construction sites' materials booking are coordinated through IT platforms, the contractors can plan material flows in accordance with demand (Brunge, 2013).

### 2.3.3 Outsourcing Construction Logistics

A suggested form of potential improvement of construction logistics is to outsource these activities to an actor specialised in logistics (Sundquist et al., 2018). Lindén & Josephson (2013) argue that outsourcing of logistics leads to less amount of non-value adding work. Ekeskär & Rudberg (2016) further state examples of activities that a TPL arrangement can include: transport of materials and goods, storage of materials, inventory management such as materials handling and repackaging, information-related activities as tracking and tracing together with distribution planning and lastly, design and reengineering of the supply chain. What kind of TPL-solution and services that is utilised at a construction project depends on the complexity of the project as well as what the client or contractor desires (Ekeskär, 2016). The following figure 2.7 gives an overview of a TPL-arrangement connecting on-site and off-site logistics.



**Figure 2.7:** On-site logistics and off-site logistics connected to an involved TPL-company (Sundquist et al., 2018).

In the case study “*Third-party logistics in construction: The case of a large hospital project*” by Ekeskär & Rudberg (2016) the authors present experiences from a case where the construction logistics is outsourced to a TPL-company. The initial driving force for implementing TPL was based on a perception that it lowered costs. Ekeskär & Rudberg (2016) also verify that assumption in their study as they in the end of the process were able to reduce unit times. Furthermore, other positive effects of

outsourcing of logistics was improved customer satisfaction, reduced tied-up capital (in assets), decreased inventory levels, improved delivery service, increased lead-time performance as well as more efficient operations (Ekeskär & Rudberg, 2016).

A common understanding among authors researching TPL is that the workers on a construction site spend less time looking for and handling materials and instead can focus on their expertise of work (Ekeskär & Rudberg, 2016). Ekeskär & Rudberg (2016) claim that outsourcing logistics also generates a better working environment among the workers as the stress level decreases. When the construction workers can focus on their work and activities that adds value to the product instead of handling materials, the project's productivity will increase (Ekeskär, 2016). When studying a case where logistics is outsourced, Hulthén et al. (2017) mainly discover positive experiences. However, some workers in the study felt that they lost duties they needed. They believe that material-handling and moving of materials are well-needed breaks between their regular working tasks. Some suppliers are also negative towards TPL-arrangements at construction projects since they have to pay for deliveries to the TPL-company instead of bringing the materials to site by their own (Sundquist et al., 2018). This leads to that the supplier tries to decrease the amount of deliveries.

Additionally, a study executed by Sundquist et al. (2018) also presents the effects from a TPL-arrangement in construction. Material handling is done after regular working hours since at that time, there is no clash between the regular working tasks and the services provided by the TPL-company. At the same time, it is possible for the construction workers to focus on their expertise of work and to have a more continuous work-flow without disrupting from handling of materials. Another positive effect at the construction site is that cranes, forklifts and elevators can be used only for material handling during those hours. By using the machines both during day and night time their utilisation is increased (Sundquist et al., 2018). For this case, one subcontractor was able to reduce their men hours at the construction project because they are not doing any material handling (Sundquist et al., 2018). According to Sundquist et al. (2018), positive effect on site can give negative effects off site. One logistics manager in the Sundquist et al. (2018, p. 59) study states "the prerequisites for efficient logistics on site are to a large extent due to adaptations made with regard to off-site logistics in terms of packaging and labelling of materials". Meaning that suppliers have to make costly adjustments to fit the logistical conditions on site as they have to increase the customisation of their deliveries. Suppliers have to change their usual way of work to adapt to the new rules and increasing time for planning since this way of work gives them less flexibility. However, Sundquist et al. (2018) claim that this will strengthen the connection between off-site and on-site logistics.

# 3

## Methodology

In this chapter, the chosen method of the study will be described. Firstly, the research design is presented. Secondly a presentation of the research process is described and followed by a more thoroughly explanation of the execution of the literature research and the data collection. Lastly, the ethical conduct and the quality of the research is discussed.

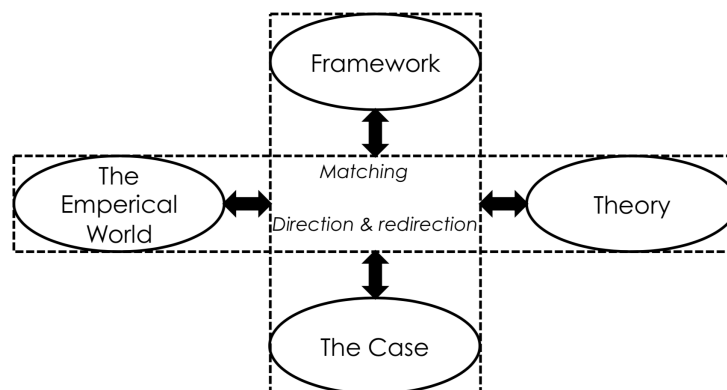
### 3.1 Research Design

The research approach in this thesis is based on abductive reasoning. The process of research in an abductive study is iterating between the empirical findings and the theoretical framework (Dubois & Gadde, 2002b). The research consists of a theoretical framework that initially was built on previous research and lately complemented by additional research that was considered relevant after the empirical data collection. Therefore, an abductive reasoning is considered to be the most suited research approach.

The empirical section in this thesis is partly based on a case study. A case study can be defined as an empirical research strategy that investigates a phenomenon within its real-life context (Halinen & Törnroos, 2005). Case studies can provide a versatile view of a situation in its context. According to Halinen & Törnroos (2005), instead of showing statistical representativeness, case studies offer depth and comprehensiveness to understand the specific phenomenon that is being explored. Case studies evolve as patterned configurations in interaction with processes that are taking place in the empirical world and what happens to the researcher's theoretical notions and assumptions during the course of research (Dubois & Araujo, 2007). Dubois & Araujo (2007) refers to this process as "casing". Casing demands iterative theoretical and empirical choices, including reconsideration of the focus of the case study. By using case studies, new findings during the investigation can change the focus or outcome. The boundary of the study is somehow formed throughout the investigation and the boundary will not be set until the analysis is written and completed (Dubois & Araujo, 2007). According to Dubois & Araujo (2007), the selection of the case that being investigated is important. The term *purposeful sampling* describes the process of selecting cases from the perspective of a particular study's research aims (Dubois & Araujo, 2007). When selecting cases according to purposeful sampling, it is important to choose cases that can provide in-depth understandings and insights, rather than empirical generalisations. In this study, the case referred to as

“Mandoligatan”, was predetermined from the company Veidekke. The reason that Mandoligatan was selected is mainly that it is a project that have the resources to provide in-depth insights, since the management was allowing that observations and interviews were conducted without any disturbances. The aim with the case study is to understand the processes at a construction site on a deep level, not to be able to make empirical generalisations. Therefore, this thesis is based on one single case, not several cases. According to Dubois & Araujo (2007), many researchers devote much space to justify their methodological procedures while they overlook the justification of why a case was selected. The relevance of a case is not necessarily known prior to the study and cases can turn out to be relevant for other reasons that was not foreseen in the beginning of the research process (Dubois & Araujo, 2007). Case studies can act as a reference point for theory development and as classic instances of particular phenomena. This is why the case study is chosen to be a suitable approach in this thesis.

One of the main difficulties with a case study is handling the interrelatedness of the different elements in the research work. Dubois & Gadde (2002b) state that a standardised conceptualisation of the research process as consisting of different planned “phases” does not take the potential advantages of case research into consideration. Dubois & Gadde (2002b) claim that if the researcher instead is constantly going “back and forth” between theory and empirical observations, it is possible to expand the understanding of both theory and the empirical phenomena. The main goal of research is to confront theory with the empirical world and Dubois & Gadde (2002b) refer this process as “systematic combining”, where this confrontation is continuous throughout the whole research process. Systematic combining is grounded in the abductive logic described above (Dubois & Gadde, 2002b). Dubois & Gadde (2002b) further state that systematic combining is described as a nonlinear, path-dependent process where efforts is combined with the ultimate objective of matching theory and reality. Figure 3.1 illustrates the components in systematic combining.



**Figure 3.1:** The process of systematic combining (Dubois & Gadde, 2002b).

“Matching” is about going back and forth between framework, data sources, and analysis. This process does not have any obvious patterns; the efforts to match theory and reality can take different directions and there is no single way of matching

(Dubois & Gadde, 2002b). The second component of systematic combining is the “direction and redirection”. Dubois & Gadde (2002b) state that this is an important feature to be able to achieve matching. Direction and redirection is about the importance of different sources and data, together with the methods of data collection (Dubois & Gadde, 2002b). Multiple sources can contribute to the discovery of new aspects and dimensions of the research problem. According to Dubois & Gadde (2002b), most methods for collecting data is directed towards the search for specific data in line with the theoretical framework and needs to be complemented with efforts that are aiming towards discovery. This can result in redirection of the study. To summarise, systematic combining is a process where the framework, theory, the empirical world, and a case analysis evolve simultaneously. Systematic combining includes two different processes; matching of theory and reality and direction and redirection of them (Dubois & Gadde, 2002b). Systematic combining is chosen to be the most suited research approach in this thesis. In the beginning of the research process in this study, the objective was to find the effects that occurred as an outcome of using outsourcing logistics to a TPL-company. The empirical data collection together with the creation of the theoretical framework formed the scope in a different direction. It was found to be more interesting to explore how the effects of using TPL-services could be used in order to increase the productivity at a construction project. Systematic combining allows this process to occur; that the direction can change during the study.

The thesis is based on a qualitative research study since qualitative research contributes to an understanding of the human condition in different context and of a perceived situation (Bengtsson, 2016). Qualitative data can be collected from interviews and observations and are expressed in words, not in quantitative numbers (Bengtsson, 2016). Dubois & Araujo (2007) claim that qualitative research seeks to explain situated events in detail and that this type of studies relies on analytical generalisations. One part of the empirical study is based on semi-structured interviews. This type of interview consists of key questions that contribute to define the areas that are meant to be explored and at the same time allows the interviewer to pursue an idea or response in more detail (Gill et al., 2008). Gill et al. (2008) claim that this is a flexible approach that allows the opportunity to discover or elaborate information that is important to participants but has not been previously thought of by the interviewer. Semi-structured interviews have prepared questions but gives the interviewee room to speak freely (Bell et al., 2018). The semi-structured interviews was a suitable approach since the interviewees is encouraged to give their own thoughts and inputs to contribute to the empirical data collection, but the approach controls that the interviewee is on topic during the interview. Observations were another part of the empirical data collection. The observations provided a deeper insight of the case, the project Mandolingatan. The thoughts of employees at Veidekke will be described in the empirical section in the thesis.

## 3.2 Research Process

The TPL-company CS Logistics, owned by the construction company Veidekke, was created to support different projects with logistics services. There is resistance from contractors to use the logistics services provided by CS Logistics since their services are mainly seen as extra costs, not as value-creating services. The idea of this thesis emerged from this view, that the outsourcing of construction logistics is perceived to be an additional cost and the potential benefits of the logistics services are neglected. If it is possible to proof the benefits of using TPL-services, it could motivate contractors to use these services in their projects. One way of proving this can be by showing that the performance of a project will be improved by outsourcing the logistics. In this thesis, a case study at one construction project was executed. The project that was used as a reference is in the report referred to as Mandolingtatan. Mandolingtatan was chosen as a reference project by Veidekke themselves. The project was a more or less “typical” housing project, located in a dense area in Gothenburg and with some logistical improvement areas. The next step in the process was to execute a literature study. The literature study made it possible to create a theoretical framework that contributed with knowledge to be able to answer the research questions. Further, an empirical data collection was made, based on interviews, observations and discussions. The empirical data collection was combined with the theoretical framework and thenceforth analysed. The analyse of the cohering of empirical data and the theory lead to a conclusion where the research questions were answered.

### 3.2.1 Literature Research

A literature study was initiated in the beginning of the process to build a base of knowledge around the chosen subject. The study was conducted by using mainly two different search engines; Google Scholar and Chalmers Library, to find relevant information. Prior to the research, keywords were identified for searching of literature. These keywords were: *construction logistics*, *third party logistics in construction*, *construction supply chain management*, *construction logistics solutions*, *productivity in construction*, *waste in construction* and *construction in urban areas*. A selection of the literature was then made to find appropriate articles that could contribute with relevant information for the theoretical framework of this report. The research involved characteristics of the construction industry, construction logistics today, challenges regarding logistics and implementation of TPL. Another part of the theoretical framework is the study by Vrijhoef & Koskela (2000), that explore the four roles of SCM in construction. The four roles, together with the conducted TPL-services, serve as a base of different models created to analyse the effects of outsourcing logistics.

### 3.2.2 Empirical Data Collection

The data for the empirical section of the thesis was mainly retrieved from three different sources. These sources were interviews, observations and discussions. The

interviewees participating in the study was chosen based on their expertise of knowledge that was considered important for the research and based on recommendations from both the supervisor at the construction company and the supervisor from the university. In order to reduce the risk of conducting biased answers, interviewees from other companies than the case company was also invited to participate. These interviews were also conducted to give a broader and deeper understanding of the concept of third party logistics. This resulted in two interviews with three persons from other companies working with TPL. Interviews with persons working at the studied construction site (Mandolingatan) was also conducted, to retrieve knowledge of how production at a construction project is executed, especially with regards to logistics. At Mandolingatan, interviews were made with two supervisors and the site manager. To involve the perspective from the client, one interview was conducted with two representatives from the client at Mandolingatan and one consultant hired by the client. The manager of production development initiated this thesis and has acted as a supervisor representing Veidekke. Information from several discussions with the manager of production development has been used as a source of information for the empirical part of the study and has been contributing to the data collection. Lastly, three discussions were executed. Two of them was together with two representatives from CS Logistics, discussing the effects of the logistics services provided by the company. The other discussion was together with the regional manager at Veidekke. The aim with this discussion was to explore how the effects of the logistics services could increase the productivity at Mandolingatan. The interviewees are listed in table 3.1.

**Table 3.1:** Interview participants:

Date	Interviewee	Alias in report	Company	Setting	Appendix
20-03-11	Egzon Mehmeti	Consultant A	Prolog	Face-to-face	A.1
20-03-17	Petter Wadmark	Consultant Ba	AFRY	Online	A.2
20-03-17	Jenny Olsson	Consultant Bb	AFRY	Online	A.2
20-04-16	Ferman Celik	Supervisor A	Veidekke	Face-to-face	A.4
20-04-16	Kristoffer Niklasson	Supervisor B	Veidekke	Face-to-face	A.5
20-04-24	Håkan Bowall	Site Manager	Veidekke	Face-to-face	A.6
20-03-27	Rasmus Linge	Representative A	CS Logistics	Face-to-face	A.3
20-05-07	Rasmus Linge	Representative A	CS Logistics	Online	-
20-03-27	Johan Svensson	Representative B	CS Logistics	Face-to-face	A.3
20-05-07	Johan Svensson	Representative B	CS Logistics	Online	-
20-04-24	Claes Olofsson	Consultant C	VBK	Face-to-face	A.7
20-04-24	Anna Runesson	Project Manager A	Framtiden Byggutveckling	Face-to-face	A.7
20-04-24	Christer Sjöstrand	Project Manager B	Framtiden Byggutveckling	Face-to-face	A.7
20-05-14	Mattias Bylerius	Regional Manager	Veidekke	Face-to-face	-

The interviews were conducted in a semi-structured way. The questions were prepared in advanced but the interviewees were also invited to speak freely expressing their opinions. Face-to-face interviews was sought for, which was almost achieved as nearly every interviewee was available for meeting. One digital interview on-line was executed and one discussion with the representatives from CS Logistics. However, it is beneficial to do face-to-face interviews. During a face-to-face interview it is easier for the interviewed person the answer questions and it is also possible to ask more questions (Dahmström, 2011). Due to unfortunate circumstances regarding the pandemic Covid-19 during the time for empirical research some interviews were rearranged to be executed online instead. In appendix A, it is possible to find the

### 3. Methodology

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questions that was asked during the interviews were questions was prepared in advance. The discussions did not have any prepared questions and therefore are not listed in the appendix.

The data collection additionally consisted of observations. These were conducted at Mandolingatan and included different elements. People working at the construction site was observed during meetings, at the site and in general on the project. The main focus of the observations was to follow the two supervisors at Mandolingatan. The observations are described in the empirical section of the thesis. The aim of the observations was to identify challenges related to logistics during the production phase, how the challenges are managed and communicated. In collaboration with the site manager at Mandolingatan, it was decided which meetings with regards to construction logistics that was relevant to attend. Scheduling meetings and regular planning meetings was then decided to be included in the study because of their connection to construction logistics. Additionally, the two site managers were observed during three days to identify challenges, interruption or other work that could be identify as potential waste, if they had help with the logistics from a TPL-actor. Tables consisting of the executed activities by the supervisor can be found in appendix B. Details regarding the observations is presented in the table 3.2 below.

**Table 3.2:** Observations made during the study.

Date	Observed	Setting	Appendix
20-03-10	Scheduling meeting	At Mandolingatan	-
20-03-17	Scheduling meeting	At Mandolingatan	-
20-03-23	Supervisor A	On site at Mandolingatan	B1
20-04-02	Supervisor B	On site at Mandolingatan	B2
20-04-03	Supervisor B	On site at Mandolingatan	B3
20-04-24	Consultation Meeting	At the clients' office at Mandolingatan	-

After the three days of observations was finished, the second round of interviews begun. First, the two supervisors are interviewed separately. The two supervisors at Mandolingatan have different backgrounds before entering the project. In addition to the interviews, two meetings with the two representatives from CS Logistics was executed. The representatives contributed with valuable information regarding the construction logistics services (CLS) the company offers. The meeting provided insight regarding the organisational structure of CS Logistics, the CLS, and the effect of the CLS and are presented in the empirical section. To be able to confirm some of the identified number from the study, mainly the observations, an additional meeting with CS Logistics was booked. The aim of that meeting was to, with the help of experts in the subject, ask about the duration of some activities. During the study a discussion with the manager of production development was executed in order to identify the organisational structure of Veidekke. Lastly, the discussion with the regional manager was carried out, in order to explore how the effects of different CLS could affect the productivity at Mandolingatan.

### 3.3 Research Quality

Bell et al. (2018) suggest that a qualitative research should be evaluated based on trustworthiness and authenticity in order to ensure the quality of the research. According to Bell et al. (2018), trustworthiness consists of the following four criteria:

- Credibility
- Transferability
- Dependability
- Confirmability

The first of the criteria, credibility, can be ensured by using the technique respondent validation. Respondent validation is executed by the researchers by providing the respondents their contribution to the research to make sure that the findings are understood correctly (Bell et al., 2018). Before publishing this thesis, the respondents from the empirical research was sent a copy of the report to make sure that they agreed with the interpretations of their answers from the interviews. Transferability tries to handle the fact that qualitative research tends to be focus on small groups and that the research tends to be depth instead of breadth (Bell et al., 2018). Bell et al. (2018) suggest that when executing a qualitative study, a rich and thick description of the research should be done. By doing a rich description, the reader can make a judgement of their own of the findings in the research. The case study includes one case, since just one construction project is being studied. However, the study provides a picture regarding the construction industry and TPL which is broad, meaning that the study is applicable on other construction projects as well. Furthermore, the study includes views from both the contractors, client and several TPL-actors. This leads to that the criteria of transferability is fulfilled.

One suggestion to fulfil the criteria of dependability is to try to keep records of each part of the process and that the others act as auditors of the process to ensure that the processes are being followed (Bell et al., 2018). The research process in this thesis is being described above, where each part of the process is motivated and described with the purpose to make the method of the thesis transparent. During the whole research process, the research and its chosen processes has been under continuous evaluation by the supervisor of the master thesis. Additionally, one opposition occasion and a peer-review has been executed where other students evaluate and ask questions regarding the research. Based on the opinions from the opponents, reconsideration of some parts and more detailed explanation of some of the content was done. These occasions were highly valued for the quality of the final product. The last of the criteria for trustworthiness, confirmability, includes making sure the personal values are kept aside from the research. Both authors have been equally involved in the research to ensure that the study shows a picture that is not influenced by the personal values of the authors. The interviews were also recorded to making sure that what was rendered is correct. Thus, the thesis achieves the criteria of confirmability. Lastly, Bell et al. (2018) discuss authenticity as one aspect regarding the quality of research. Authenticity is assured in the thesis by, as

mentioned, letting several views regarding TPL be brought up to the surface. Both the contractor, client and TPL-actors has been able to contribute with their views of the subject in the research.

## 3.4 Ethical conduct

Bell et al. (2018, p. 114) suggest four main areas regarding ethical consideration of research. The following four areas are suggested to evaluate:

- Weather there is harm to participants
- Weather there is a lack of informed consent
- Weather there is an invasion of privacy
- Weather there deception is involved

No participant was in any way harmed during the study as the empirical study mainly consisted of interviews and observations executed by the authors. During the observations physical harm was eliminated by attention and the necessary safety equipment that must be worn at a construction site. According to Bell et al. (2018) the principle of informed consent should indicate the participants are given as much information as possible about the study in advance, before they make the decision to participate or not. This was ensured by giving all interviewees as much information as possible in advance about the interview process, research area and how their expertise could contribute to the research. In the beginning of the interviews they were also told about the topics that they were going to be asked about and discussed during the interview. The interview questions, however, were not shared with the interviewees in advance. This decision was made because it was considered that the interviewees did not get the option to prepare their answers before the interview, their spontaneous answers would be more authentic and reflect their personal thoughts.

With regards to every participants privacy, they all were asked if it was approved that the interview was recorded and if they would like to be anonymous and not be named in the report. Those who are named in the report have approved this. The participants are not anonymous because of transparency. Since every participant in the thesis is named, it affects the trustworthiness of their claims as well. Furthermore, Bell et al. (2018) state that the research process should consider how to prevent deception. However, for this thesis the research area and aim has been presented with transparency and as clear as possible for everyone, both participants and other interested in the research. Lastly, for this thesis ethical question has been carefully regarded. The interviewees were chosen only based on their role in a company that was considered to be able to contribute with useful knowledge to our thesis.

# 4

## Empirical Study

This chapter will process the empirical part of the study and present information and data that has been conducted throughout the process. The first section describes the concept of third party logistics and how it is utilised in the construction industry. In the second section, the construction company Veidekke is described. The third section includes a description of the company CS Logistics, together with the effects of the construction logistics services the company offers. Lastly, the fourth section describes the case study Mandolingatan in detail, including findings from observations and answers from interviews.

### 4.1 Third Party Logistics Services

This section explores the concept “third party logistics”. The information has been collected through interviews with respondents working with third party logistics in the construction industry and with representatives from the client, giving their perspectives.

#### 4.1.1 Involvement of Third Party Logistics

The logistics need to be taken into consideration already in the procurement phase of a project. “*It is not possible to first decide what we should build and how much it will cost and then later start to think about the logistics, in that phase it is often too late*”, Consultant A states and adds that once the production phase has started, it becomes difficult to implement logistics services. This is confirmed by the two consultants Ba and Bb. The consultants prefer to be involved as early as possible in a project, preferably when the contractor is procured.

The consultants begin with a logistics analysis that explains how the logistics will be executed. It is important to inform the contractor about the logistical conditions of the project. The consultants strive to be involved as early as possible in the process but it is not always that it works. The greatest effects for the customer occur when the logistics is considered at an early stage, preferably before the tendering process. The logistics should not be seen as an emergency solution, one should plan for the logistics before problems occur. This is preferably done early in the process. One of the main tasks when building in urban areas is to emphasise the importance of well-functioning logistics. A risk when building in urban areas is that potential negative effects that can occur, can be strengthened by the effects of projects nearby.

Most contractors want their material deliveries early in the morning and if this is required by every project in the area, it can create a bottle neck effect.

### 4.1.2 Logistics within the construction industry

There is a difference between the client and the contractor regarding how they perceive logistic services and outsourcing logistics. The client has the authority to make decisions while the contractor often wants support with a specific solution. When TPL is used on the initiative of the contractor, solutions such as material storage is often required. When the client is taking the initiative, they often require logistics services as a package solution. It is more common that the contractor perceives the logistics services as an external cost and has some difficulties in seeing the benefits of outsourcing logistics. One reason to this is because of long supply chains and processes. There is a lack of understanding the whole picture of the supply chain and where in the chain benefits will arise. The contractor only sees the actual cost for the service on the invoice. The consultant working with the four projects at Mandolingatan agrees to this and state that it is probably easier to get the client to use TPL, rather than the contractor. Project Manager A from the client states that if a contractor uses TPL-services, they need to have some kind of purpose for using it. Clients does not often demand that the contractor should use specific logistics services in their project. One reason for this is that the client fears that the offers from the contractors will be higher if there is a demand of using logistics services. The consultant coordinating the logistics at Mandolingatan states that if the client demands that TPL will be used in a project, the contractor must take it into account in their offer.

The will to change the current ways of working is important and that it is about the customer as an individual, it is not a matter if it is a client or contractor. Consultant Bb refers to a project in the city Umeå, where both Consultant Ba and Consultant Bb was involved with handling the TPL-services. The project in Umeå is a large, complex project where a hospital is being refurbished. The client of this project is very innovative and dare to make changes. The client sees the potential of TPL. Some customers are more careful and does not want to try new ways of working. Consultant Ba agrees to this and states that “*one must dare to win*”. In this case, they were lucky to find a client that dared to work this way but that is even harder to find brave project managers. Since the project manager is responsible for their project, they are more resistant to make any decisions with perceived risks. Even though it is possible to proof the benefits and effects of using TPL, there are still resistance of implementing the services. If the management at a construction company decides that TPL is going to be used, the project managers that are responsible for their own projects still makes the decision not to follow this. “*It is a journey to make them to take this decision*”, Consultant Ba states.

Using the services from a TPL-company was proposed for the four projects at Mandolingatan but Project manager B declined this suggestion. The project manager did not see how it could be beneficial for the project. According to Project manager B,

TPL is required when executing large projects with a lot of ongoing businesses and with a large number of actors and contractors. Project manager B take the project in Umeå, where Consultant Ba and Consultant Bb was involved, as an example. “*That project was impossible to perform without using TPL*”, the project manager states. Project manager A also agree to this and state that in the project Umeå, TPL was a necessity. TPL-services can lead to time savings but probably most in complex projects. In a normal project, Project manager B does not think that TPL is useful. The consultant hired by the client explains that a large benefit of TPL is the possibility to use JIT-deliveries. Materials that are not being delivered to the right place, at the right time, are moved approximately three to five times before it is being used which increase the risk of damaging the materials. JIT-deliveries can be a solution to this, since materials are delivered when they are required. The same consultant further believes that it is possible to get more efficient projects when using this service, because there is less materials on site which increases the passability at the site. At Mandolingatan, one of the projects requires more space outside the area provided for their construction site. This would not have been necessary if a TPL-company was involved. The reason that the consultant was hired to coordinate the logistics at Mandolingatan was because the four projects was meant to be executed parallel with each other and that is only one road for transport and deliveries of materials. The two project managers from the client perceived that this was a possible risk that could hinder the four projects and therefore, a consultant was hired.

Logistics have gained more attention over time and several individuals working in construction industry understand the importance of well-functioning handling of materials. Because of the urbanisation and that new construction projects are being executed in dense areas, there are high demands regarding the handling and delivery of materials. Since the construction site is crowded there is no room for material storage on site which also can result in safety issues. Further, Consultant A gives an example of this by stating that no one that lives close to a construction site should be exposed to the risk of being hit by construction vehicles. Since more construction projects are located in urban areas, the importance of logistics is enhanced. There is a difference between how the industry previously worked with construction logistics compared with today. Each construction company is trying to optimise their own supply chain while several construction projects from different companies are located next to each other. For the project in Umeå, it is the same client for the whole area and therefore, every contractor and their deliveries can be coordinated by the same TPL-company. The connection between the contractors and that everyone involved is taking the city or area’s perspective when looking at the flow of materials are two important factors.

The suppliers are beginning to show increased interest to be a part of the supply chain, not just selling materials and to be involved in IT-systems as well. The suppliers are moving towards improving the logistics flow and are starting to see this as a competitive advantage. Some companies are very proactive and works actively with logistics together with planning of materials deliveries. Then there are

those who “takes the day as it comes”, Consultant A states. In some projects, when there are demands of a logistics solution that is well thought through, there can be a person hired as responsible for the logistics on site with the only task to make sure that everything is working well in the production and that the productivity is increasing. Those projects have come a long way, rather than those projects where the responsibility of logistics is on the site manager where there is no time or resources to handle the logistics. In a large complex project with several actors involved, there are higher demands of coordination and it can be beneficial to have one unit responsible for coordinating the logistics. This to avoid that every actor “make up their own rules”, Consultant Ba states.

### 4.1.3 Logistics Services

Regarding logistics services, one should start with the on-site logistics; the logistics in the production area. Furthermore, the importance of having a well-functioning IT-system is emphasised, since the other logistics services are hard to implement without it. One example of an IT-system that is being used in the industry is Myloc, which support the supply flow in several different steps. Myloc is a support for the workers when they are in need of a product. Logistics services should be implemented step by step since the construction industry is conservative and one should avoid making massive changes. Using construction logistics centres for storage is dependent on where the construction project is located. In the project in Umeå, one of the most critical aspects was that there was no space for material storage and therefore they chose to implement the construction logistics centre early during the production, because they had no opportunity to storage material at a temporary storage on-site. One easy and effective solution is intransport of materials, since the craftsmen do not need to search for the materials they need. It is easy to lose or damage materials on-site without well-planned logistics. If there is a system for materials handling, these problems would not occur.

### 4.1.4 Implementation of Third Party Logistics

Consultant Bb explain that they have gotten some reflections from workers in the project in Umeå where TPL was being used. The workers did not get their small break where they could have quick chats. The logistics services lead to that this time was removed which created some reactions. The workers also thought it was hard to work with a single position all the time, driving the same machine for six hours, as an example. This was solved by planning better rotations among the workers' different work tasks.

If there is one actor that is sceptical to TPL, it is the contractors. This because the contractors are the ones who notices the new changes the most. The contractors that are measuring the productivity of their projects, on the other hand, are satisfied since the TPL-services gives more room to be productive. One of the biggest barriers against implementing the use of TPL is that one does not see the direct benefits of using it, together with that there is no trust within the construction industry. The

contractor does not trust that the required material is going to be delivered the way that it is supposed to be. Often site managers state that the materials suppliers cannot be trusted since the materials are not being delivered on time. One factor contributing to this problem is that the materials are being requested with short notice, which can make it difficult for the suppliers to deliver it on time. With a well-planned system, the site manager can order the materials some days in advance which probably would make it easier for the suppliers to deliver on time and at the right place on-site, not just placing them outside the gates. Demands from the customer and better planning is two factors that the Consultant A define as barriers against using TPL. In urban areas the biggest challenge against well-functioning logistics is that there are lack of knowledge and competence regarding how logistics actually affects the total cost. Another challenge is that in urban areas, a lot of actors are sharing the same limited space. It is important to create good communication and dialogue between all the actors involved.

To motivate increased use of TPL-services, the client must understand the potential of having well-planned logistics. This requires that the client have some knowledge about logistics and effects such as productivity, sustainability and safety, that comes with it. There are plenty effects of having well-planned logistics that is not really quantified yet and that there is a lot to do within the construction industry regarding the logistics. Someone must dare to take new, innovative decisions. If someone is willing to change today's way of working within the industry, one must also be willing to "take the fight", since nothing will be executed by itself. "*How can we to implement what we believe in?*" Consultant Ba states. Even though Company B is showing the benefits of using TPL, it is still a decision that is going to be made by several individuals. If they do not feel comfortable with taking the decision or if they do not have enough competence about the topic, they do not dare to go through with it. Consultant A does not believe in demands from the client of using TPL, it should not be forced. Instead of forcing it, one should motivate the benefits by showing successful examples of projects where TPL has been used. The use of TPL should then be included as a natural feature based on the benefits that comes with it.

There is a connection between well-planned construction logistics and sustainability. At the project in Umeå, the number of vehicles that arrives to the construction site and how much of every vehicle total storage capacity that is utilised has been measured. The capacity was utilised around 20 %. By utilising the capacity of the vehicles to a higher degree, the number of transports could decrease drastically. Efficiency can improve sustainability. As a result of TPL in the project in Umeå, the number of vehicles to the project is reduced by 50 % because of co-loading. The same vehicle collects material at local suppliers and delivers to the projects. This results in increased efficiency, cheaper transports, higher delivery precision and reduced number of vehicles.

## 4.2 The Construction Company Veidekke

Veidekke is a Norwegian construction company, that besides from Norway also operates in Sweden and Denmark. Today Veidekke is the fourth largest construction company in Scandinavia with a turnover of 35,6 billion NOK and with around 8500 employees. The company believes that commitment and strong corporate culture is a foundation for success. In line with this, Veidekke invites its employees to become part-owners of the company and is today owned by 20 % of its employees. Another characteristic of Veidekke is that the company only allows procurement of a maximum of two subcontractors in a row to ensure that it is possible to control the whole chain of subcontractors. The Swedish organisation consists of two departments; construction and infrastructure. The construction department focus on both new construction projects and refurbishment of residential and commercial buildings. The infrastructure department carry out projects in the areas of groundwork, foundation, energy, concrete, underground, wind, drain and industrial activities. Figure 4.1 gives an overview of the organisational structure of Veidekke Sweden.

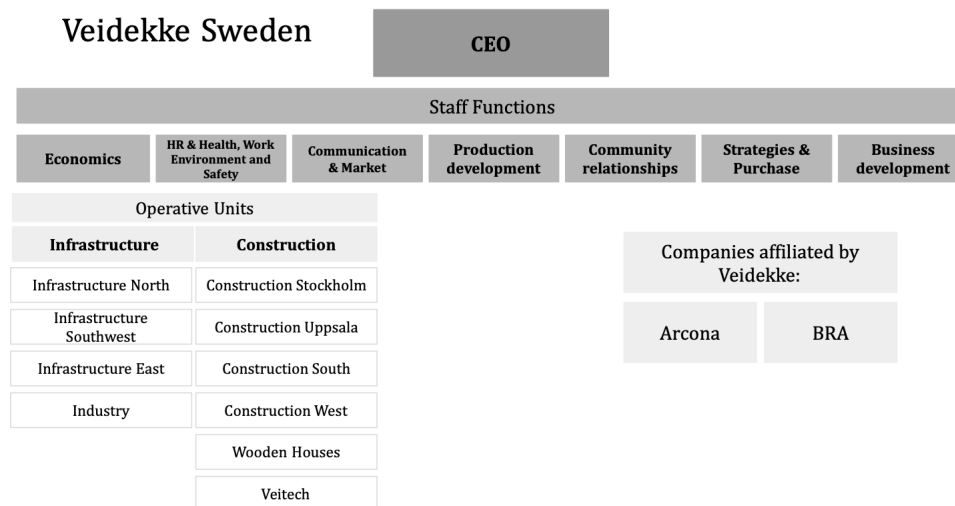


Figure 4.1: Organisational structure of Veidekke Sweden.

### 4.2.1 The construction department

This research is executed on behalf of and focusing on the construction department of Veidekke. The construction department is divided based on geographical location in four departments and is one of the largest builders of apartment buildings in Sweden. However, another large part of their projects consist of commercial space as offices, premises, hotels, shopping malls and public spaces as schools, hospitals and arenas. Veidekke claims that there are five main factors to why the construction department succeed with a project; an involving design where we sit together and design in the same model, involving production planning to shorten the paths for decisions, right function and quality within budget, great working environment and

a systematic and effective purchasing system.

Within the area of involving planning Veidekke state that it is important to engage all participants in a project in order to make use of all possessed knowledge and ideas among the employees, suppliers and customers. The focus is on the team, an enhanced engagement, team spirit and the importance of setting joint goals is crucial. Veidekke's involving planning is based on a known lean-concept, where the planning is executed with the ones who will perform them and a continuous follow up. The involving way of working creates prerequisites for increased control over the production when the participants is aware of what activities that are going to be performed which leads to better coordination. The main reason behind this is that everyone should have the chance to affect their own working situation, which in turn leads to increased engagement and accountability. This way of working is aiming to achieve a better order during the production at the construction site. A better planning and coordination lead to a more even work rate, which in its own turn will lead to decrease amount of injuries and accidents. Another goal with this way of working is not that the work is executed faster but in a smarter manner with the help from a wide involvement in the process.

#### **4.2.2 How the contractor perceives the effects of TPL**

In this section, the opinions from the regional manager of the unit Construction West is described. The regional manager believes that if the logistics at Mandolingatan was outsourced to a TPL-company, it will affect the productivity of the project. The supervisors would have more time to plan for future steps of the production and if the project is well-planned, it is possible to make it more efficient. When the supervisors are given the opportunity to plan in detail, the risk of unforeseen problems is being reduced and therefore the efficiency is increased. One problem in the industry is that the planning process often occur very close to when activities will take place in practice. Once something is planned, there is no time to try different solutions. If the activities in practice are not working according to what has been planned, delays will come as a consequence since one must plan again and try new solutions. If one can plan far ahead, there will be time to try them and unforeseen problems will be discovered. Therefore, outsourcing the logistics of be a solution that relive some workload from the site manager and the supervisors.

In order to increase the productivity of the project by using TPL-services, an important aspect is that the subcontractors need to be involved as well. In every procurement, with every subcontractor, TPL-services must be involved. One suggested example is that it is not possible to demand that the subcontractors are going to use a CLC in the middle of a project for their own deliveries. The reason for this is that the subcontractors have their own suppliers, with their own agreements. On the other hand, if the subcontractors are procured with the demand that a CLC will be used, they need to follow this and their suppliers as well. One potential way of arrangement involves TPL already in the planning of the project, before the procurement. Today, size of the packaging or the possibilities for storage of materials

are not taken into consideration. The responsibility of solving challenges connected to this is handed over to the supervisors or site managers at the construction site, that already have a heavy workload. Therefore, the planning of the project must be more detailed in order to increase the productivity. The competence regarding the logistics must be increased among every actor involved in a project, including the purchase and calculation departments.

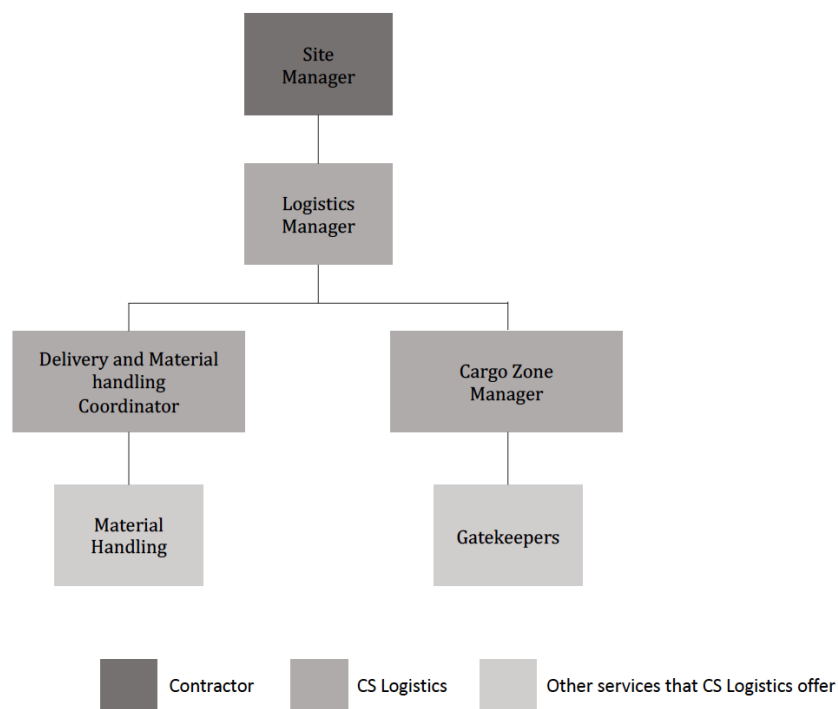
To shorten the duration of a construction project, one opinion is that the planning phase must be longer instead. Planning is the key to increased productivity. Better preparations and planning leads to increased productivity. The length of the schedule is dependent on different factors that needs to be taken into consideration, such as the number of personnel, weather conditions, cleaning at the construction site and the logistics. In order to shorten the schedule, it is not just the logistics that needs to be taken into consideration. It is common that external time is added when creating a schedule, to create a time buffer if any moment of the production would be delayed. It is possible to shorten the schedule because of the extra time. To be able to do this, one must convince the project organisation since the extra time buffer is a safety aspect. Another aspect that enhance the importance of the logistics is that more and more projects are constructed in dense environments and the projects are more complex today. It is hard to calculate indirect costs and therefore it is difficult to motivate the usage of TPL-services. One aspect is that TPL-services can highlight the deficiencies in the planning, and how it is possible to plan better. One service that can affect and shorten the schedule is the intransport of materials. It is important to include more disciplines in this service. Several disciplines are dependent on the construction elevator, as an example. To be able to reduce the waiting time, intransport is a good solution. There are some drawbacks of using TPL as well, one example of this is the intransport of materials. Even though it is beneficial to be able to extend the working hours of the project and have intransport during evenings but this can lead to some practical challenges. For example, someone must be able to open the gates to the construction site and when the intransport-personnel are finished, the construction site must be closed and the electricity needs to be turned off. These tasks are often the supervisors' responsibility, which can lead to increased amount of work for them. Intransport is a service that the contractor buys but it also requires some preparations and effort from the contractor as well. This is an important aspect of outsourcing logistics that should be taken into consideration. There is a gap between the logistics service-providers and the management on site.

It is perceived that it should be possible to save time with well planned logistics. To quantify the effects of this, one must examine every aspect of the project and plan earlier and more in detail. For the case study it would infer that if TPL-services was utilised at the project, the supervisors would have more time for planning and reduce the risks of problems in future stages of the projects. TPL-services can be used to relieve some time and work tasks from the supervisors and they can utilise this time to more detailed planning. This can contribute to increase the productivity of the project, because of the planning. To be able to shorten the

schedule at Mandolingatan, logistics needs to be taken into consideration already in the procurement phase of the project.

### 4.3 CS Logistics

As mentioned in the introduction, CS (Construction Supply) Logistics is a TPL-company owned by the construction company Veidekke. The concept of CS Logistics started as an internal project in another one of Veidekke's affiliated companies, Arcona. Since Veidekke has an overall strategy to enhance their productivity on their constructing projects, it was decided that CS Logistics should develop from an internal project into a company. CS logistics offers different logistics services to a contractor or client. An example of an arrangement with CS Logistics as a service provider and with a contractor is demonstrated in the following figure 4.2.



**Figure 4.2:** A possible constellation of a project organisation in a construction project where CS Logistics is involved.

CS Logistics services are led by a logistics manager that reports to the site manager of the project. The organising of the logistics is customised after the size and needs of the project. CS Logistics claim that when using their services, the logistics of the project is outsourced to competent personnel and the employees at the project can focus on their specific work tasks.

### 4.3.1 Offered services

CS logistics offer four main services; analysis, organisation, CLC and material handling. Firstly, CS Logistics offers to do an analysis for the specific project and customise their services after the needs for that typical project. They also offer an organisation that are responsible for the logistics at the project that guides and control anything connected to logistics, for example deliveries to the site. A logistics consultant from CS Logistics begins the process with inviting participants to the project to participate in a workshop. The aim of the workshop is to identify challenges and to set goals for the process. After that, it is possible for CS Logistics to propose a customised solution for the project. One success factor is to get as many people as possible from the project organisation to participate in the introductory workshop. However, as stated by the CS Logistics “*Every project is unique in its own way. One logistic service that is successful in one project, may not be the best solution for another project*”. Meaning that their logistics service can be customised after the size of or special circumstances regarding the project. These circumstances can involve the geographical conditions, the amount of loading docks, demands from the client and stakeholders. The two main questions that CS Logistics is trying to answer while doing the analysis are “What are the logistical challenges?” and “What are the customers goals connected to the challenges?” Followed by the analysis, the logistics manager (a representative from CS Logistics) present the challenges to the customer and proposals regarding how the logistics can be executed. Examples of the services they propose are delivery planning, delivery containers and intransport. CS Logistics can also be involved in the subordering from the suppliers to the site. Subordering could be done in the IT-system Myloc, which requires that the suppliers are included in the IT-system as well.

CS Logistics emphasise the importance of one specific service they offer; the delivery planning. There are some unforeseen factors that will lead to changes from the initial plan in the production phase of a project. By using the delivery planning service that CS Logistics offer, every change is going through the IT-system Myloc and everyone involved in the project will be informed about the changes in real time. CS Logistics makes a delivery plan for every activity and supplier in a project. When adding these plans, it is possible to see what is going to be delivered and at which occasion and then all resources can be disposed. The information is digital and accessible for everyone involved in the project. CS Logistics claim that without a delivery plan, it is hard to plan for all resources that is required during the project.

CS Logistic also offer storage possibilities at a construction logistics centre. The current CLC that CS Logistics use is located in Jordbro, a small town outside of Stockholm. At the CLC it is possible to store material, have reception of deliveries, co-loading and to offer JIT-deliveries for projects. The co-loading can decrease the amount transports to the construction site, which also releases capacity in the unloading zone. At the terminal the personnel check the delivery for any potential damages. CS Logistics also offers intransport of materials to specific locations on site. For example, this could infer that personnel carries materials to a specific floor or to specific apartments where the materials are supposed to be mounted or

assembled. The intransport-personnel are trained in how to carry the materials in an ergonomic way. After a delivery has been unloaded the intransport-personnel controls the deliveries and documents any possible deviations. CS Logistics further state that the aim with this service is to increase the utilisation of other resources. This creates a possibility to schedule the intransport-service at any specific time during the day. In other words, it could for example occur during night time or late evening. The purpose of scheduling this service during those hours is to decrease any disturbances and because both the crane, construction elevator and the loading zone is free from any other personnel during those hours and free to use for the carrying personnel.

Another CLS that the company offers is a storage container, called Qlocx. The Qlocx container makes it possible for any supplier to deliver during anytime of the day to a construction site. The container decreases the amount of time any workers on site have to spend receiving deliveries or materials. The system also controls what deliveries that has been received, when it was received and who received the delivery. Qlocx state on their website that the container contributes to decreased amount of materials losses, since material losses mostly depends on lack of information regarding the position of the goods (Qlocx, 2019). CS Logistics offers to do the construction site plan at a project, but actually suggest that the project to do it by themselves. However, in very large projects where a construction site plan for each floor is required, it could be beneficial that CS Logistics supports the project and makes these plans.

### **4.3.2 Effects of the provided TPL-services by CS Logistics**

The company that offers the Qlocx-container has measured the effects of their container at a construction project. At that project, the effects before and after the start of using the Qlocx-container are measured. The main effect that was discovered during the daily work was that the supervisors was interrupted less times per day. Qlocx (2019) estimates that the container saves up to 3 hours of work every day. Phone calls regarding the deliveries was decreased by 45 minutes per day and two hours less interruption in work every day due to the usage of the delivery container Qlocx. The representatives from CS Logistics does not completely agree with those numbers as they are rather high and probably based on a project larger than Veidekke's at Mandolingatan. Instead the representatives argue that the effects on the delivery container are linear. Meaning that the bigger the project is, the larger are the effects of the Qlocx.

CS Logistics has further measured the effects of their CLS on a construction project where they were involved. The project was an apartment building consisting of 107 student apartments where the order sum was 127 million SEK. The chosen CLS from CS Logistics was a CLC, intransport and delivery planning in Myloc. From the beginning it was decided that all material is co-loaded and delivered to the site after 16.00 from the terminal. When the material has been delivered, only authorised intransport-personnel are allowed to carry the material to the right location.

For this project the material was to the greatest extent as possible packed by room number. Except from allocated storage, no storage of material was allowed on site. Results from that project shows that 91,8 percent of the deliveries arrived on time. Other general comments from the contractor regarding the CLS at that project is listed below:

- “*The terminal gives an opportunity to have more space in the schedule.*”
- “*We can avoid that the construction workers have to work overtime.*”
- “*All supervisors have been very pleased as they do not have to worry about the delivery of material.*”
- “*Instead of looking for materials or waiting on deliveries, we can start working directly after the morning meeting.*”
- “*The project would never have managed the high pace if it wasn't for the CLS.*”

At a housing project such as the case project in this study, the representatives from CS Logistics assume that the intransport-service would probably take three hours and be executed two times per week by two persons. Even though the intransport-personnel are an expense for project, the representatives state that the personnel performing the intransport cost less than if the construction workers executed the materials handling. One of the representatives claims that “*One electrician cost 500 SEK per hour and our intransport-personnel cost 350 SEK per hour, then you are aware of what you at least can save*”. Furthermore, the representatives argue that it is possible to increase productivity if activities are moved from daytime to evening time. Because the intransport personnel also receive the deliveries, it is possible to schedule deliveries during evenings.

### 4.4 Case: Mandolingatan

The studied project Mandolingatan is a part of the initiative Bostad2021 (Veidekke, 2019). Bostad 2021 is a cooperation between the city of Gothenburg and private and municipal construction actors with the aim to build 7 000 new apartments (Bostad2021, n.d). At the street called Mandolingatan, four projects are established. Veidekke is the contractor for the project studied in this thesis and are building 130 rental apartments and a parking garage on behalf of the client, Framtiden Byggutveckling (Veidekke, 2019). The client's project team consists of two project managers that are responsible for the four projects at the street. The project managers have created the specifications for all the projects on Mandolingatan and executed the procurement for every project. At the beginning of the production phase, a consultant was hired as a support to the four projects. The consultant has the role as a construction manager to one of the projects at Mandolingatan and as logistics and work environment coordinator for all projects. The role as a logistics coordinator was created because four projects with different contractors are going to be constructed parallel with each other and that there is only one road available for transports. The project team representing the client perceived a possible risk regarding coordinating the transports to the different projects and the logistics. To solve this, the consultant has created a construction site plan that all the projects must

follow in order to coordinate the transports for the road. The project team from the client, the consultant and the three site managers from every project have meetings every third week to summarise the progress of each and every project and to ensure that there are no problems regarding the transports and logistics. The picture below, figure 4.3, represents a drawing visualising the four projects at Mandolingtatan. Veidekke is constructing block E and F, another contractor is constructing block D and BC and a third contractor is responsible for block A. All blocks except D is currently under construction. The construction of block D was supposed to have started approximately at the same time as the other projects but was appealed. The start date for block D is yet unknown.



**Figure 4.3:** The four blocks at Mandolingtatan. © Liljewall Arkitekter

The calculation of Veidekke's project was finished by the end of 2018, the project planning started 2019 and in April 2019 Veidekke started with the groundwork of the site. The contract sum for Veidekke's project is set to 273 million SEK and it is a turnkey contract but is divided in two parts, one based on variable costs and the other parts is based on fixed cost. The daily operations at the project is mainly lead by one site manager and two supervisors. In the tendering phase of the project, the planning is done more roughly, only containing a start and end date and some important parts in between. One does not plan in detail in the tendering phase, this is done later in the stage of project planning. The initial planning, that is done during the tendering, is almost not followed except from the start and end date. The calculation and the first rough planning are mostly done based on the experience of the people involved in the planning. However, for this project a detailed planning has not been prepared before the project started. As a consequence, the people

executing the groundwork did not have any schedule to follow and the groundwork was delayed.

### 4.4.1 Current logistical conditions

Mandolingatan is situated in a dense area in the west part of Gothenburg. At the current state of the project, some logistical challenges have been identified. As mentioned earlier, there are more than one construction project executed on the same street, causing both small and dense construction sites. For the entire area of new blocks there is only one road available to use for deliveries for all three projects. The project had an initial plan to store material inside the parking garage. The parking garage was delayed due to that the ground workers did not have any detailed schedule to follow. As a consequence of this, there were no possibility to use this area for material storage which led to an unstructured construction site where all materials are stored instead. There is one crane at the project and according to the supervisors and the site manager, the crane has a high utilisation of its capacity during the production work hours. Another major challenge that was faced during the beginning of the project was the delivery of the shell walls. The mounting of the walls was different than originally planned. When the walls arrived, they first had to be unloaded and then turned before mounting, leading to that the walls were lying on the ground taking up space at the project. The delivery road is a bit narrower than what was perceived during the planning of the project. Overall, the site manager thinks that the major problem at the site is that the original plan has not been working, leading to a lot of ad hoc solutions during the project. Problems are solved on the spot and just for the moment, with emergency solutions.

Improvement possibilities at the project are mostly connected to material storage on site as the construction site is very dense and materials, tools and equipment continues to grow in volume. According to the site manager it takes a lot of time and effort to handle this challenge and one idea would have been to a temporary storage somewhere else. The greatest effects of a TPL-arrangement would occur if the site had a temporary storage somewhere else. One effect of removing materials from the site is that the safety for the workers on site increases. In addition to this, it can decrease the time workers have to spend organising materials and instead focus on executing their expertise of work. There is always a risk with storing materials on site, some are sensitive to weather and the risk of damaging them increase every time they are moved. However, the site manager does not know how to and if it is possible to save costs if they had access to a CLC at the project, since the service cost money as well.

### 4.4.2 Coordination and collaboration at Mandolingatan

Today, there are no collaboration regarding the deliveries between the four projects at Mandolingatan, every project operates as completely separated projects. The site manager adds that two of the projects (A and BC) probably have some kind of communication from a safety point of view, because their cranes are operating

close to each other. The site manager claims that it is very difficult to collaborate with the suppliers in the construction industry because it is the suppliers who sets the conditions and the construction companies has to act according to them. The management at Mandolingatan strives to customise the deliveries to suite the project but it is too expensive. For this project it infers that in order to not having to pay for trucks that are only partly loaded, elements that are not required until the next coming weeks must be ordered as well and therefore stored on site. Because of the large cost of JIT-deliveries from suppliers, the site manager claims that this is one of the major reasons to why the TPL-companies and their services exist. Unlike the manufacturing industry, the supplier has the ability to set the demands in the construction industry, because they have an enormous number of customers to choose from. The site manager mentions Mandolingatan as an example, where a supplier has four potential customers to choose from only at that street.

### 4.4.3 Observing the supervisors

In this section the information that was collected from the daily observations of the supervisors are described. The observations were executed during three days. The first day, one of the supervisors was observed and will be referred to as Supervisor A. The second and third day the second supervisor, Supervisor B, was observed. This section includes a summarised description of activities performed by the supervisors, that are perceived to be connected to construction logistics. Tables containing more precise duration of measured activities can be found in Appendix B.

The day begins with a short morning meeting where the site manager informs about important aspects regarding the upcoming day. After the meeting, the staff moves to the construction site to perform their daily work tasks. However, for a supervisor, the work tasks can differ from day-to-day. The supervisors are more or less managing the production on site and controls that every goes as planned. If problems occur, it is the supervisors' task to solve them. The supervisors' work tasks also include receiving deliveries and answering questions and phone calls regarding the project. Furthermore, it is noticed that the supervisors have to attend to several meetings. During the three days of observation at least two of them consisted of participating at meetings. Most meetings are scheduled every week and handling the same topics. One aspect that is found during the observations is that the supervisors are spending a lot of time solving problems connected to the lack storage opportunities on site. There is not enough space for storage and the materials are located all over the construction site, as can be seen in figure 4.4. During the first day of observation, Supervisor A and the site manager participates in a meeting with a subcontractor regarding a construction elevator. At the meeting, the participants discuss potential placing on site for the construction elevator. Another activity during that day includes that both supervisors goes around the site to plan and look for possible storage areas in order to clean up some parts of the site. Additionally, the supervisors are searching for pallet trucks during the same time. However, it is only one of the supervisors, Supervisor B, that actually know that they have pallet trucks on site at the moment.



**Figure 4.4:** Material storage at the construction site.

During the morning of the second day of observation a delivery of stairs arrives to the site and the supervisor controls the delivery and that it includes the right number of stairs. Supervisor B explains that the stairs are planned to be stored at the same location they arrive, in order to not have to lift them with the crane over people to limit any risks. Moreover, the supervisor mentions that since the last observation they have moved a lot of the material and that this activity took them about two full days. The figure 4.5 below shows before and after one part of the site where materials was moved. One supervisor had to work with the moving of the materials during the two full days. One telescopic loader was rented in order to support with moving the materials. Supervisor B is responsible for the delivery planning at the project. During the second day of observation, Supervisor B are spending several hours planning for the deliveries to the project. The supervisor plans the deliveries based on the production schedule and orders materials based on when it is supposed to be mounted according to the schedule. Based on experience, the supervisors decide when and what to order and when the deliveries will arrive. The supervisor's goal is to always be ahead of the schedule. Because of this, the supervisor plans the schedule very tight which can result in complaints from the staff on site. After ordering the materials, the supervisor place the deliveries in the delivery calendar. The supervisor explains that when deliveries arrive, a lot of materials will take up space on site. The supervisor writes information regarding what type of delivery that is subordered in the delivery calendar.



**Figure 4.5:** Before and after materials are moved.

The delivery planning is done one-two times during the week but the supervisor's ambition is to do it only one time per week and then try to order more at a time. When the supervisor is done with the delivery planning, information about the deliveries are written on a white board situated in the lunchroom. The whiteboard is available for everyone and every subcontractor at the project is encouraged to write their deliveries on the whiteboard as well. At the end of the lunch break that day, supervisor B goes through the deliveries at the calendar on the white board with the staff. The employees, the supervisors and the site manager discuss the placement of cassettes containing prefabricated elements. At the moment, the cassettes are placed where trucks arriving to the project are supposed to park. The day ends with subbordering of shell walls. The subbordering needs to be done ten working days in advance. There is also some planning that need to be done before the delivery of the walls because if the delivery and unloading takes more than two hours, the project must pay for the overtime.

The last and third day of observations begins with the daily meeting at the project where the site manager informs necessary information regarding the production during the day. The morning meeting is followed by another meeting, a team leader meeting. This meeting includes at least one representative from every subcontractor at the project. During the meeting, different subjects are being discussed. However, one main topic that is being brought to the surface is the missing update of the

construction site plan which has not been updated in a long time. As a consequence of this, there is no order at the construction site with a lot of stored materials. All participants at the meeting agree that one big problem at the construction site is the lack of storage space. Further into the meeting the subcontractors mention problems with getting access to the crane to be able to lift their materials. The heavy utilisation of the crane is a problem for the subcontractors. At the end of the meeting it is discussed when construction elevators will arrive to the project. One construction elevator will arrive, this was discussed during the first day of observations. This construction elevator is only allowed to be used by the bricklayers, a demand that was procured in the beginning of the project. Therefore, there will not be a construction elevator available for other group of professions at the project. After the meeting, both of the supervisors control the site again and helps one of the subcontractors with a delivery of a container.

Followed by this is another meeting, this one regarding planning. At this meeting, the supervisors, the site manager and construction engineer participate. The planning meeting have a standing agenda with different subjects to go through. One of the main points concerns the construction site plan and the courtyard. One of the participants states that “*The courtyard is under all criticism; it will be a question regarding safety in the end*”. Drone flyovers are used during the meeting as a base for the updating of the construction site plan. It is the construction engineer who is responsible for the update of the construction site plan and the last update was made almost one and half month ago. After a long discussion about the construction site plan, the next point of the agenda is the deliveries. It is again emphasised that all workers should add their deliveries in the delivery calendar, even casting and the subcontractors. The delivery calendar on the whiteboard should also be updated. After the meeting, Supervisor B and the construction engineer walk around the site to have a clearer picture of what needs to be updated on the construction site plan.

Both supervisors state that they like to solve problems, which is a big part of their daily work. One of the major challenges at the project is to follow the schedule. The logistics at this project has been another major challenge. Supervisor B thinks a lot of his time is spent planning and thinking about the current logistical situation at the project. This also involves planning deliveries and the questions that arise regarding deliveries. Another factor that takes time for the supervisors is when they are interrupted, which occurs several times during a day. One of the supervisors claimed that during his day 60-70 % is spent out on the site, solving problems and answering question and 30-40 % is spent which doing administrative tasks at the office. Office duties is mostly executed after regular working hours, after 16.00 in the afternoon. Furthermore, the supervisors agree that most of their working tasks are in some way or another linked to logistics, especially regarding the dense area the project is executed at and a lot of time is spent planning for deliveries. Since the site is small, there are a lot of aspects to consider and plan in advance before a delivery. Many of the problems that occur every day are closely connected to logistics and the dense site being a crucial factor.

#### 4.4.4 Planned logistics at Mandolingatan

The construction logistics was not taken into greater consideration during the planning of the project, except from the construction site plan that was received from the client. The plans retrieved from the client mainly consists of the intended delivery route for each and every project on the street. The delivery root for Veidekke's project at Mandolingatan is thought to serve the project with all deliveries. That was more or less the only planning that was done with regards to logistics in the planning phase of the project. However, outsourcing of logistics was discussed at Mandolingatan but the question was quickly turned down. The manager of production development at Veidekke has the opinion that a TPL-arrangement could have great effects of the schedule at a construction project, with the aim to shorten to total production phase. One of the major expenses in construction projects is connected to how long the contractor is established at the site. If the period for establishment is shortened, there is a potential to save money when increasing productivity at the construction projects. The site manager at Mandolingatan has the opinion that TPL probably could have some effects on the schedule at a construction project, but mainly on the expenses that are connected to the work executed in order to be able follow the schedule. One example of this is when staff must work overtime. The site manager further states that it would have been useful to have a TPL-service at this project. A complete TPL-arrangement would probably not been necessary but a service as a CLC could give the project the opportunity to shorten the schedule. The site manager gives an example that if a CLC was used, 20 curtain walls and 5 shell walls could be mounted since storage opportunities would not been needed to take into consideration. Now, without the service, it is only possible to mount 20 shell walls since there are no room for storage. The site manager believes that these aspects can increase the productivity at the project.

At the project, logistics planning is mostly connected to the delivery planning. Because of the lack of material storage on site, the supervisors are trying to use JIT-deliveries to the greatest extent possible. Deliveries are booked to arrive the early morning, around 07.00. If deliveries are scheduled early in the morning the risk for delays is reduced since Mandolingatan probably is the first stop of the day for the supplier. In some cases, it is too expensive to have JIT-deliveries and for the deliveries that comes from outside of Sweden, it is not possible to use JIT-services. However, if suppliers arrive to early comparing to when the delivery was booked to arrive, they are not welcome to deliver and have to return on the set date since there are no possibilities for storage on site.

One of the supervisors have experienced some type of TPL-service at a previous project and Supervisor B, who had no experience, stated "*No, you have had to solve your own problems*". However, Supervisor A only had experience of the intransport-service. The experience from Supervisor A is both positive and negative. One benefit is that the service relives time to do other work tasks. One negative aspect is that the service requires preparations; the floor that the materials will arrive to must be marked in advance. The supervisor states that this both takes time and is an external cost. Instead of using a CLC, they have negotiated with their supplier

of plasterboards so that they are able to store plasterboards for their project at the factory where they are produced. When plasterboards are required at the project it is possible to order directly from the stock at the factory. The administrative parts of the supervisors' work tasks are postponed, or not executed at all. If the supervisors would be given one extra hour of time every day, this time could be used to documentation. Another activity that is not prioritised is feedback to subcontractors and Supervisor B adds that controlling the quality of the project is something that should be done more often. By controlling the quality, errors can be discovered and be corrected in advance which can decrease the risk of delays.

The delivery calendar is a part of logistics planning, this is useful with regards to utilisation of the crane. The subcontractors can look at the calendar before ordering, so that their deliveries that requires a crane do not clash with other deliveries that also needs the crane. This will decrease any potential waiting time since the crane is heavily loaded during working hours. A lot of unexpected events occur when there is only have one crane at the site. At the project, the waiting time is limited as much as possible, in order to not disrupt the piecework. Regarding the construction site plan, the site manager state that this plan at the project is not working well. Drone pictures are used as an overview of the site but this has negative effects because with these pictures it is only possible to see how the site looks at the moment, not how the site is supposed to look like according to the construction site plan. The drone pictures do not correspond to the intended construction site plan at the moment.

### **4.4.5 Planning and following the schedule at Mandolingtatan**

The site manager has the overall responsibility of the schedule and the construction site plan at the project. The site manager makes the schedule but updating the construction site plan is not a part of his duties. The schedule at Mandolingtatan is based on the experience of the site manager and the supervisors and the unit times that Veidekke is providing all of their construction projects. The production schedule is made during the planning of a project. For the case of Mandolingtatan, Supervisor B was involved in the process of making the production schedule. The production schedule is more or less how the reality looks like and contains of how much resources that is needed for each activity. The site manager, supervisor B and the construction manager are responsible for making the production schedule at Mandolingtatan. Every week during the scheduling meeting, the rolling schedule, that is based on the production schedule, is updated and this schedule is valid for five weeks ahead. Supervisor B usually prepares the rolling schedule in advance before the scheduling meeting every week. This is done so that the duration of the meeting can be shortened. The supervisors agree that they can keep up with the pace according to the main schedule, and that it is their goal to always follow the original plan. The main reason why they work overtime every week is because it is a lot worse to fall behind the schedule than working overtime. At a construction project unexpected problems and disturbances often occurs that the supervisors have to solve. However, it is unusual that the main schedule needs to be changed. At the project, they always want to work fast in order to be finished in advance. By

doing this, they have more time to fix errors and can hand over the best product as possible to the client.

At Veidekke they plan according to VDC (Virtual Design and Construction) and with involved planning that is previously mentioned. For the case of Mandolingatan, this means that as soon as the subcontractors are procured, they are involved in the planning. The subcontractors are invited to participate in the planning and are asked what how much time they required to finish their work tasks . The involved planning is essential because otherwise, it is impossible to know when the involved actors are supposed to be on site and there is a risk for stops in the production. According to the site manager, the schedule always contains of some “air”; time that is not set for any specific activity in case of delays of other activities. It is both an advantage and disadvantage with air in the schedule. It is not possible to catch up with other activities since the following activities are not scheduled directly after the previous one. At the same time, if an unforeseen problem occurs, the risk of delays is reduced. It is a trade-off between increasing the productivity at the project and having air in the schedule.

# 5

## Analysis

The literature research and the empirical study will lie as a base for the following chapter, the analysis. Examples from reality will be compared and analysed with theoretical findings in order to reach a conclusion of the study and to answer the research questions in the following chapter.

### 5.1 Logistics challenges in dense city construction projects

In previous research it has been discovered that construction in urban areas face two major challenges; the urban transport problem and the problem of coordinating multiple stakeholders. One part of the urban transport problem is space limitation. According to the site manager, the supervisors and the representatives from the client, the largest challenge at Mandolingatan is the lack of space. The empirical study shows that because of urbanisation there are high demands regarding the handling and delivery of materials, since there is no room for material storage on site. This is confirmed since the supervisors at Mandolingatan are striving to use JIT-deliveries at the largest extent possible to avoid storage of materials on site.

From the empirical findings it is discovered that it is important to have well functioning logistics when building in urban environments. When several construction projects are executed in dense areas close to each other, the negative effects of what is being built on one place can be strengthened of the effects of what is being built in another place. At Mandolingatan, four projects are going to be executed next to each other. As an example, if one project is blocking the road, it will hinder the deliveries to another project. Previous research shows that the desire to live in big cities is increasing, leading to enhanced urbanisation. This could infer that the already dense construction sites will continue to be reduced in size. One can state that this leads to that the importance of logistics is going to be a crucial factor for efficient construction projects. One of the main challenges with construction logistics today are the dense construction sites. If the future sites are going to be denser, the challenge will be even more important to solve and therefore, the importance of well managed logistics is enhanced. At Mandolingatan, challenges connected to the dense site is occurring today, such as the lack of space for material storage.

From the interviews and observations in this thesis, it is confirmed that most contractors want their deliveries early in the morning and if this is required by every

project in the area, it can create a bottle neck effect. One of the supervisors at Mandolingatan is striving to only have early morning deliveries. If every contractor at the projects at the street Mandolingatan have the same idea regarding the scheduling of deliveries, the road could be highly trafficked during the mornings. Apart from creating a bottle neck effect, this could create problems such as high noises for people living close to the construction site. High noise levels are, according to previous research also one challenge connected to the urban transport problem. Regarding the problem of coordinating multiple stakeholders, Sullivan et al. (2011) state that there are many actors and stakeholders involved in a construction project and every subcontractor is responsible for the procurement of their own materials. Stakeholders related to a construction project is being affected by this and the overall performance of the project is being decreased. With a lot of actors involved, it can be hard to manage the coordination between them and to make sure that the communication between every single actor involved is working. An effect could be that materials are stored everywhere at the construction site, since there are lack of directions and coordination of where to store materials.

From the observations at Mandolingatan, it is confirmed that subcontractors and other construction workers lack clear directions on where to store materials, causing that the courtyard has turned in to a temporary storage without any order. This can be an example of the effects caused by the problem of coordinating multiple stakeholders. This is confirmed in the empirical section, since it is stated that one challenge when building in urban areas is that a lot of actors are sharing the same limited space, as the case of the street Mandolingatan. It is important to create a good dialogue between all the actors involved. To be able to do this, one solution can be to involve a third part that coordinates and handles the logistics. If someone is responsible for coordinating the actors and stakeholders involved, it could solve the problem of coordinating multiple stakeholders.

The site manager states that it is difficult to collaborate with the materials suppliers in the construction industry. To avoid the risk of paying for under loaded trucks at the project, large volumes of materials are ordered and therefore materials that is not needed until the next coming weeks are stored on site. If the suppliers are setting the conditions regarding the amount of materials, this can contribute to the problem of storage in an already crowded environment. This is also one factor that can hinder the ability to use JIT-deliveries which, as mentioned earlier, is something they are striving to achieve at Mandolingatan. If the cost for under loaded trucks is too high and it is required to order large amounts of materials to store on site, JIT-deliveries is not an option. The collaboration with the suppliers can be important in order to reduce the logistical challenges at the construction site, since it can affect the amount of materials that are delivered to the site and the use of JIT. Previous research shows that construction materials often require a lot of storage capacity, this capacity is not available on construction sites in urban environments. When construction projects are located in urban areas, the importance of logistics is enhanced. This can be a bit problematic if there are poor coordination between contractors and suppliers, since the demands on the logistics is high in urban areas.

## 5.2 TPL - Services and functions

Theories show that when implementing well-planned logistics regarding delivery and storage, it is possible to improve the logistics performance in construction. One logistics service is a construction logistics centre (CLC). The aim of using a CLC-service is to coordinate deliveries to multiple construction sites within an urban area. A CLC can therefore be used to store materials off-site and to provide customised deliveries. The service is useful in projects where the space is limited and where there are no room for storage. Therefore, a CLC can be useful at Mandolingatan, since the limitation of space and lack of storage possibilities on site are two challenges at the project. Theories explain that a CLC often are located close to the construction site in the form of a warehouse solution further away. CLC is a service that is provided by CS Logistics as well. In the CLC, the personnel control the delivery and make sure that there are no damages. A CLC makes it possible to store material, co-load the materials and to offer JIT-deliveries to a project. When goods from different suppliers are consolidated to one shipment, the total amount of transports within urban cities can be reduced. This is beneficial since the infrastructure in urban areas is heavy loaded. Seen from an environmental perspective, less transports decreases the amount of emissions from the transport vehicles which is another benefit.

When using the CLC-service, issues such as having too much materials on site can be solved. At Mandolingatan, one of the main challenges is that there is no space for material storage on site. In a housing project, as Mandolingatan, materials can be packed and sorted by floor-level or apartment at the CLC. When materials are sorted this way, it is possible to fit materials aimed for different apartments in the same vehicle and deliver them to the site. This can increase the degree of filling in the vehicles and therefore reduce the number of deliveries to the site. At the same time, this can relieve some workload for the workers on site. If materials arrive in packages sorted this way, the workers do not have to spend time to sort them themselves. This can save time and the workers can focus on executing other value adding activities instead. Another benefit of reducing the number of deliveries is that it can release capacity from the unloading zone on site. The only road available for deliveries at the street Mandolingatan could also be relieved by using a CLC. According to the site manager at Mandolingatan, the schedule could have been shorter if a CLC was used at the project. An analysis of this statement is that the temporary storage could give more opportunities to increase the productivity at the project. Materials do not need to be moved because it is possible to receive deliveries only when the materials are needed. If the materials are sorted and packed in a way that makes it efficient for the construction workers to assembly, the time workers have to spend on executing non-value adding activities can be reduced.

However, what has not been discovered in the literature study is the delivery container, Qlocx, as a tool for construction logistics. This service is discovered during the empirical study provided by the representatives from CS Logistics. The Qlocx-container could be used together with other services in a TPL-arrangement or by itself to facilitate deliveries and make it easier the workers on site. In this thesis, the

Qlocx-container is considered as a service similar to the checkpoint-service discovered in the literature research. When using both a checkpoint and a Qlocx-container, the deliveries are delivered to one specific location. The information regarding the deliveries, both with the Qlocx-container and when using a checkpoint, goes through an IT-system and the workers can collect the materials when they need them. According to CS Logistics, the Qlocx container offers the opportunity for deliveries to take place during any time of the day, since there is no need for a person to be present and receive the deliveries. This means that goods can be delivered during evenings. The road available for transports at Mandolingatan can be more equally utilised since the deliveries are spread during the whole day and not just only during daytime.

Another benefit of the container is that it decreases the time workers have to spend on receiving deliveries of materials. Materials are delivered and stored in the container on site and the workers can collect the materials whenever it suits them. This can save time for the workers and they can focus on value adding activities. The productivity at the project can therefore increase, since the workers do not have to spend time to receive deliveries or look for materials. The container can contribute to decreased amount of material losses, since the loss of materials can depend on lack of information regarding the position of the goods. When measuring the usage of the Qlocx container at a construction project, it was discovered that the daily work was interrupted less times a day and it is estimated that the container saves approximately three hours of work every day. The representatives from CS Logistics, on the other hand, argues that this statement cannot be applied on every project that uses a Qlocx container. They argue that the effects are linear, the bigger project; the largest effect if the container. Even though the effects of a Qlocx container at Mandolingatan would not be as large as a time saving of three hours a day, it could reduce the time the supervisors are interrupted. According to one of the supervisors at Mandolingatan, they are interrupted several times during the day which takes a lot of time for them. The other supervisor states that 60-70 % of a working day is spent outside on site, solving problems and answering questions. Not all problems may be related to deliveries but during the observations it was confirmed that some of the interruptions was caused by issues related to deliveries.

The supervisors at Mandolingatan state that the lack of storage possibilities on site is one reason to that they are striving to use JIT-deliveries as much as possible. From the interviews it is discovered that JIT-deliveries are in some cases too expensive to use and that some suppliers from outside Sweden are not able to provide JIT-deliveries. One complication with JIT-deliveries is that the planning process is influenced with external factors, such as weather conditions and the precise timing of deliveries can be difficult to achieve (Sullivan et al., 2011). To reduce these disadvantages, it could be useful to have a CLC where materials can be stored and later on be delivered Just-In-Time when they are required on site. This service is provided by a TPL-company and as the site manager at Mandolingatan states, one major reason to why TPL-companies exists is because of the large costs of JIT-deliveries from suppliers. It is probably more beneficial to use the services provided

by a TPL-company and therefore have JIT-deliveries, instead of having the suppliers deliver materials with JIT. According to literature, the objective with JIT is to supply the right materials, at the right time and in the right amount. This can be very useful at construction sites in urban areas, since the space is limited and there are no room for material storage. If the goods and materials arrive when they are supposed to be assembled, there are less materials stored on site and the problem of lack of storage can be reduced.

From the interviews, it is confirmed that JIT-deliveries requires planning in order to work efficient. The supervisor responsible for delivery planning at Mandolingatan spends approximately four to six hours every week on delivery planning in order to make it possible to receive JIT-deliveries. If this service was handled by a TPL-company instead, the supervisor could spend less time on delivery planning and use the time on other value adding activities in order to increase the project performance. From the interviews with the site manager, it is confirmed that today, they are not prioritising activities such as quality control. By relieving more time for the site managers, quality controls can be done more often. This can make it possible to discover errors before they become very costly and time consuming to solve. Activities such as quality control and planning can reduce the risk of unforeseen problems. Quality controls can increase the quality for the end customer which is one of the goals with supply chain management. Therefore, if a TPL-company handles the planning of deliveries instead, the supervisor can spend their time focusing on planning future activities instead. From the empirical study, it is confirmed that some "air" is often included in schedules, as a time buffer in case if unforeseen events occur. When future activities are planned in detail, the time buffer is not necessary because the production is well-planned and the risk for unforeseen events is limited. This means that in a long-term perspective, the time buffer in the schedule can be removed and the schedule can be shortened.

Furthermore, construction site plans are identified in the literature study as a tool for the construction projects to help them organise logistics. This is often done by the project themselves, as in the case for Mandolingatan, where the construction engineer is responsible for updating the construction site plan. However, this is a service that CS Logistics offer and could be done by them instead. This is, on the other hand, not recommended by the representatives from CS Logistics. The effects are greater if the staff on the project are responsible for the construction site plan. One reason for this could be that the staff on the construction site are directly aware of any sudden changes that needs to be included in the plan. At Mandolingatan, the construction site plan is not updated as often as it should. From the observations it is possible to claim that the updating of the construction site plan is not prioritised. The reason for this could be that the construction engineer, have other work tasks that are higher prioritised. This affect the materials storage on site, since there are no room for storage on the construction site plan, the materials are stored on temporary locations such as the courtyard. Seen from a safety aspect, this can lead to consequences such as accidents. In addition to this, materials can be damaged or lost. It takes time for the workers to look for or move materials. An analysis is

that it probably cost less to update the construction site plan, rather than having the construction workers spend time looking for materials.

Another CLS that is discovered in this thesis is the IT-services. Previous research shows that a web portal planning device can be used for efficient materials handling. When the ordering of materials is coordinated through IT-platforms it is possible for contractors to plan material flows in accordance with demand. This can also be a way to solve the problem of storing too much materials on site since when using IT-systems the deliveries are planned based on the current need for specific materials. CS Logistics are offering delivery planning through the web-system Myloc, which is an important service according to them. One benefit of this IT-system is that every change is going through Myloc and therefore, everyone involved in the project is being informed in real time. This can increase the communication between every actor involved and reduce the amount of misunderstandings. As an effect of this, the amount of errors caused by misunderstandings can be reduced. One example of this could be deliveries that arrives at the wrong time that can cause interruptions during production. From the empirical section the importance of IT-systems is discovered, since the effects of other logistics services are strengthened by adding an IT-system to the service. As one example when using the CLC-service, the deliveries can be booked through an IT-system and all information is stored and available for everyone involved in the project. This is a service that can free some time from the supervisors, since they can communicate important information to everyone at the same time. If information is stored in the IT-system, the supervisors would not be interrupted in their daily work as many times by answering questions. They would therefore have more time focusing on other activities that makes the production go forward.

One way to reduce the handling of materials on site is the intransport. CS Logistics claim that the aim with this service is to increase the utilisation of other resources. One benefit with intransport is that it is possible to schedule the service at any specific time during the day, preferably at evenings, when there are no construction workers on site. The crane, construction elevators and loading zone is available for the service only and there are no disturbances. This makes it possible for the construction workers to focus on their competence of work and they do not need to spend time on handling materials. An analysis of this is that intransport is also one way of increasing productivity; the workers can have a continuous workflow and are not disrupted by being forced to look for or move materials that are required. In the study by Josephson & Saukkoriipi (2007), the machines are being used approximately 50 % of their capacity. By improving the utilisation of the machines, the productivity of a project can increase. The machines are situated on site during the days, evenings and weekends, even when there are no workers on site. By scheduling handling of materials to other hours of the day when there are no workers on site, the machines are utilised to a higher rate. At Mandolingatan, it is observed that workers spend time waiting on their turn to use the crane. If materials are moved during evenings as well, this waiting time can be reduced. By shortening the waiting time, the workers can focus on their specific work tasks instead. By using the crane

during more hours of the day, it could probably be situated on the site for a shorter period which can lead to cost savings for the project.

From the interviews, it is confirmed that intransport of materials is an efficient TPL-service since the workers do not need to search for the materials they require. It is easy to lose or damage materials without well planned logistics and if a system for materials handling exists, these problems would not occur. Intransport can be a solution to this, since the materials handling is outsourced to a third part that controls the materials, make sure that they are not damaged and provides the workers with the right materials when they arrive to the site. According to the supervisor, one benefit is that the service increases the possibility to be able to execute more work, since the materials handling decreases. One negative aspect is that one must mark the floor in advance, so the intransport-personnel knows where to transport the materials. The supervisor state that this takes time from the supervisor and is an external cost. The regional manager at Veidekke states that intransport is an efficient service with the disadvantage that the service demands preparations that often is the supervisor's responsibility. Someone must make sure that the construction elevator is working, or that the construction gate is open for the personnel and this is often the supervisor's task. Intransport is a service that requires planning and preparations but according to previous research and the empirical data collections, when it is working as it should it is efficient and contributes to increased productivity.

### **5.2.1 The connection between sustainability and increased performance**

Another benefit of outsourcing logistics is except from increasing performance, the connection increased sustainability. By analysing outsourcing of logistics, it is discovered that except from economical sustainability, as decreasing costs it can contribute to help achieve better sustainability connected to the supply chain and construction logistics overall. Both the theory and the empirical study has contributed with examples stating that outsourcing of logistics can contribute to better sustainability. Challenges related to emissions from transport can be improved by consolidating transports at a CLC. Increased emissions are affecting the environment but can also worsen the air quality. TPL-services can help to counteract these challenges by decreasing the amount of transport in the cities. One example from the empirical study indicate that the transports for a large construction projects where halved by consolidating transports. A result that indicates the effective and well planned logistics as TPL-companies offer can help maintain good air quality and lower emissions by a reduced amount of transports. The literature study that has been the ground to this study has not processed the subject of sustainability with regards to environmentally questions in greater extent. One can assume that the environmental demands from the government and customers in the construction industry in the future will both increase and be harder and that the effects of TPL can be seen as one solution to increase sustainability and that it can be possible to keep track of transport and their emissions by the project being more

aware and in control of its logistics and the supply chain. With an increasing focus on sustainability and environmental issues in the world, it is believed that stricter requirements will occur as a response to try to decrease emissions. A TPL-company that is expert in logistics could probably help contractors to decrease the amount of transports to the construction site as one way to contribute to a more sustainable construction industry.

Previous research suggests that there is a lot to do when it comes to quantify specific effects of outsourcing logistics in the construction industry. To be able to enhance the performance of the supply chain, one must first be aware of where improvement areas exist. The empirical study showed that logistics are not considered during the planning phase, but that it should. At Mandolingatan, logistics has pretty much been overlooked, leading to other problems, as lack of storage possibilities for example. When logistics are not considered, no one is aware of the potential cost regarding logistics except that it is expensive. By looking at the most common challenges connected to logistics in construction a lot of cost connected to these could be saved by planning for logistics at an earlier phase of the project. For the best-case scenario, logistics is considered already in the tendering phase of the project. The contractor then needs to be aware of the costs connected to logistics and where one could save by planning and preferably outsourcing logistics.

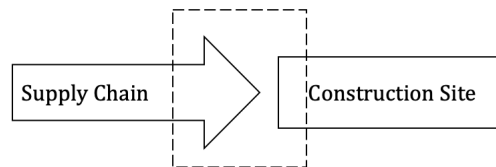
### **5.3 Utilisation of the four roles in construction supply chains**

Another suggested way to improve productivity in the construction industry could be to emphasise the concept of SCM and to put more attention to the supply chain. Vrijhoef & Koskela (2000) suggest that the problems encountered in the construction supply chain could be solved by applying SCM-principles and developing principles towards construction supply chain management. The theory shows that SCM could have positive impact on construction supply chains. The project at Mandolingatan is striving to achieve JIT-deliveries due to the lack of storage material at the site and therefore could benefit from applying the concept of SCM to their supply chain. A company embracing the principles of SCM is striving for decreased costs regarding its supply chain and increased service for the end-customers.

Previous research argues that the concepts of SCM does not fit well with the characteristics of the construction industry and that the industry lack the ambition to try to implement SCM. To implement SCM, it is suggested that one should perceive the construction project as a “construction factory” instead. The few initiatives that have been trying to implement has mainly focusing on certain supply chains at a certain project. The focus has then been to try to optimise that supply chain only at the specific project. If the construction industry would try to adapt more to the SCM-principles and shift focus from the project only to a construction factory it could lead to more stable supply chains. The empirical study showed that the project at Mandolingatan use prefabricated materials which is one way to achieve

more standardised processes in construction. An analysis is that if the construction companies increase standardisation in their projects, it is possible to go further away from the project-based environment. There are probably a lot of similarities between Veidekke's construction projects and other construction projects. These similarities could be taken advantages of with the goal create more permanent and stable supply chains. Based on the empirical findings, the project-based traits of the construction industry often lead to a focus on self-interest. This could be one of the reasons to why it has been hard to implement new technologies within the industry. Seeing the whole TPL-arrangement as a new technology it is mostly seen as a cost rather than a concept, helping construction projects to increase performance.

The article by Vrijhoef & Koskela (2000) suggest four areas, or roles, to focus on when striving to implement the principles of SCM in the construction supply chain. From the first area to the fourth the complexity increases, leading to more stable supply chains. An analysis is that the characteristics of the supply chain in the construction industry, as it looks today, can be seen as improvement areas where the four roles of SCM can be applied to the construction supply chain. The relationship between buyer and supplier in the construction industry is often bothered by conflicts and mistrust. The case study confirmed these allegations as it was stated that it is almost impossible for the project at Mandolingatan to customise deliveries to fit the project best. The first of Vrijhoef & Koskela (2000) roles mainly focuses on the connection between the supply chain and the site. Hulthén et al. (2017) also claim that the largest improvement possibilities exist in the same connection.

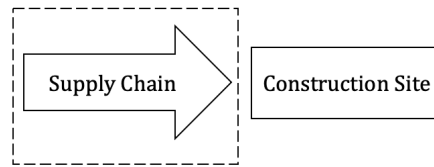


**Figure 5.1:** First role

Furthermore, Vrijhoef & Koskela (2000) suggest that the first role could be achieved by the contractor shifting focus from the site to the supply chain by improving the relationship with the direct supplier. As mentioned earlier, the case study confirms the allegation that the relationship between the buyer and supplier is in need of improvement. It is the supplier that sets the demands and even if the contractor tries to customise the deliveries it is often too expensive and the suppliers are not making efforts to improve the situation. However, seen from a TPL-actors point of view, the suppliers are becoming more and more interested to improve their position on the market by working more with IT-systems. This is not connected to customising deliveries, rather as one way to improve their position on the market. On the other hand, this could lead to better performed supply chain and more thoroughly planned construction logistics. This is leading to the discovery that improvement areas connected to the first role in construction supply chain exists.

The second role shifts the focus from the connection between the site and the supply

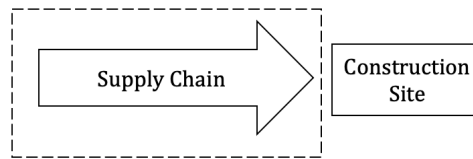
chain to the supply chain itself. The goal with the second role is to reduce costs connected to the supply chain and agreeing with previous research who suggest that the goal of SCM is to strive for as low costs as possible connected to the supply chain.



**Figure 5.2:** Second role

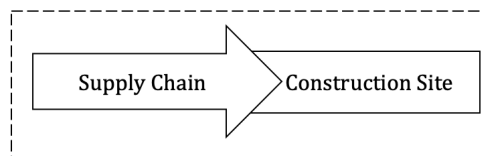
According to Vrijhoef & Koskela (2000) the second role can be achieved by decreasing the costs related to inventory, lead-times and logistics overall. In order to achieve this role in the construction supply chain the construction companies should first start with trying to measure their logistical performance. Previous research shows that most companies today are unaware of their costs related to logistics. One major challenge connected to construction logistics today is that the enhancing building in urban areas is leading to small and dense construction sites where the ability to store materials is limited. During the case study it was discovered that this was a major problem and an underlying problem to other logistical challenges at Mandolingtatan as many issues was related to the dense construction site. Acting according to the focus of the second could lead to improvements at Mandolingtatan. When materials are stored on site, it is assumed that the productivity could be decreased, since a lot of problems occur as a consequence. Based on the experiences from the case study, it is analysed that when storing materials at the construction project, productivity could be decreased since it can be difficult for the construction workers on site to find their materials. It is also an aspect of cost since the risk for damaging materials increase every time it is moved, assuming that it is moved a lot when it is stored at the site. Since previous research shows that the urbanisation continues to increase, improving today's way of handling and deliver materials is important. This is possible to achieve by focusing on the supply chain, as the second role suggests.

Based on the theory, it is discovered that the concept of SCM has originated from the manufacturing industry and developed within the Toyota-industry where standardisation is an everyday principle. The third role, as the second role, is focusing on the supply chain but trying to develop the construction supply chain more by moving activities that usually takes place on site to off-site, in this case the supply chain. As can be seen in the figure 5.3 below, the supply chain in the third role has increased in size compared to the previous roles.



**Figure 5.3:** Third role

Vrijhoef & Koskela (2000) suggest that standardisation and prefabricated materials are two approaches in order to achieve the third role of SCM. By analysing the third role, it becomes clearer that the principles of the manufacturing industry are suggested to be implemented in the construction industry. At Mandolingatan, prefabricated elements are used, especially as a part of the framework. The interior walls are shell walls that are prefabricated to some extent but these walls require some casting on site as well. One can state that these walls are partly prefabricated. The site manager states that prefabricated elements probably could have been used even in further extent, for example using prefabricated walls with installed doors. Today, prefabricated walls with pre-installed windows is used at the project. There are other ways to increase prefabrication as well, for example by using kitchen or bathroom modules. An analysis is that it is possible to use more standardisation at the project which infers that the third role is not fully achieved. The last and fourth role by Vrijhoef & Koskela (2000) suggest that the supply chain is merged with the production on site.

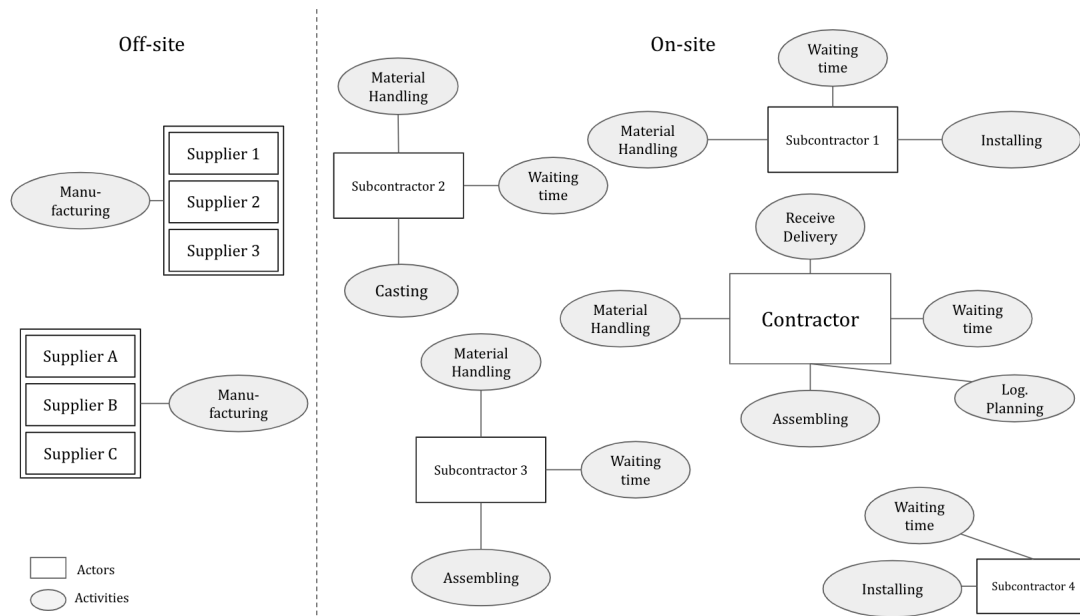


**Figure 5.4:** Fourth role

Vrijhoef & Koskela (2000) suggest open building and sequential building as initiatives regarding the fourth role. This means that more decisions regarding the interior could be postponed and be decided later on depending on utilisation or tenant. As the complexity increases from role to role, examples fully connected to the fourth role has not been recognised during the case study. The third role was to some extent achieved but in order to reach the fourth role, the utilisation of prefabrication and enhanced standardisation will probably have to be increased even further to fully reach the potential of SCM in construction. An analysis is that there are a lot of potential by enhancing standardisation and taking advantages of using the same principles from project to project. However, standardisation is probably already used to a high extent in construction. The construction companies use the same working methods from project to project and the difference between projects is presumably the interior and exterior of the end product.

The literature study and the empirical study of this thesis has together developed a view of how the construction supply chain looks like. The figure has been developed

based on the assumption that SCM is not implemented at all in the construction industry and to show why it could be beneficial for the industry to apply more of the principles of SCM and try to move activities and actors from the site to the supply chain. The following figure 5.5 represents actors and activities at a construction project and the separation between off-site and on-site. Off-site can be likened with the supply chain for the project.



**Figure 5.5:** How the construction supply chain is perceived.

The figure is visualising “Role Zero”. No role is implemented in the supply chain, trying to show how the situation looks today. The majority of the production today is taking place on site and there are more activities and actors involved on-site than off-site.

## 5.4 Potential effects of applying TPL in SCM

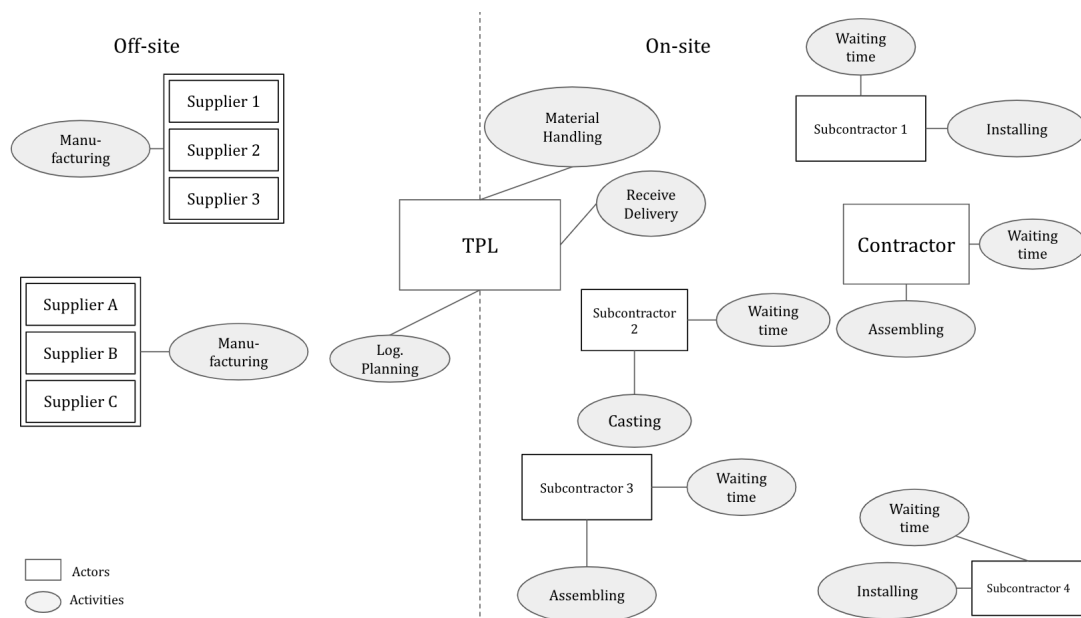
The roles, or focus areas, are working towards the goal of replacing temporary supply chains with more stable and permanent supply chains. Based on previous theory, other researchers also claim that the construction industry would benefit from adapting more other industries norms and change its behaviour. Moreover, it is also suggested outsourcing of logistics as potential improvement connected to construction logistics. Therefore, the roles and outsourcing of logistics have been combined in this section to investigate what the potential effect could be by merging TPL or using TPL as a key-player to achieve SCM at Veidekke’s construction project at Mandolingatan. In other words, it is investigated the potential effects of using a TPL-company and its offered services as a facilitator for SCM in construction.

Previous initiatives to increase productivity in the infrastructure industry have suggested that the industry apply more to the principles of standardisation and rep-

etition. As the infrastructure industry and construction are very much a like and since Veidekke are operating in both this could be applied in this study as well. The theory state that SCM is originating from the manufacturing industry and Toyota principles where standardisation is high utilised and a part of the SCM-principles. The analysis will investigate if a construction project could gain by adapting those principles. When activities are transferred from on-site to off-site, the supply chain becomes more complex. This means that the supply chain must be well-managed in order to profit from the benefits of transferring activities. The analysis suggests that a way of managing this can be by using TPL, since one actor coordinate the activities and therefore control and have full attention on the supply chain.

#### 5.4.1 Role 1: Improving the connection between the contractor and suppliers

The theory claims that the efficiency of a construction project depend on the integration of off-site and on-site logistics. Hence, the focus of the first role is on the connection between the construction site and the supply chain with the goal to achieve reliable material and labour flows to the construction site. Moreover, previous literature suggest that performance of construction logistics could improve supply logistics by involving the supplier of building materials with the operations on site. Therefore, TPL is investigated in the analysis to act as a key player in order improve the connection of the operations off-site and on-site. A potential constellation regarding the first role and TPL is visualised in figure 5.6 below.



**Figure 5.6:** TPL acting as a connection between the operations on site and the supply chain.

By outsourcing the logistics in the first role, the TPL-company could act as the connection between the supply chain and the production in order to reach a better collaboration between the two. The TPL-company offers several services but for the first role not all are applied since the complexity of the roles increase, so will this analysis do as well. The TPL-services that are considered suitable and in line with the goal of the first role will be analysed. These are delivery planning, intransport and delivery control. For this case it is the TPL-actor that plans all deliveries and plans them according to when their personnel are present on site to both receive the deliveries and to transport them to the place where they should be assembled. Compared to the initial position, role zero, (figure 5.5), figure 5.6 shows on-site operations with same number of actors but with less activities. The aim with figure is to visualise that construction workers can focus on their core competencies and spend less time performing activities that in this case can be outsourced to the TPL-company. Material handling are moved from the actors on site to the TPL-company instead. Information from the empirical study suggested that it is also a more effective solution, regarding cost savings, since the people handling the intransport from the TPL-company cost less compared to, for example a carpenter. From the case study, it is discovered that especially one of the supervisors put a lot of effort and time into planning for deliveries. If the TPL-company have the larger responsibility of the delivery planning, the analysis is that supervisors can focus on more on other activities instead.

By outsourcing logistics to a TPL-company it is possible to relief the construction workers from the part of their work that consist of material handling since that is performed by the intransport-personnel instead. Previous research claim that a construction worker spends 14 % of their daily work to handle material. The theory suggest that the reduction of waste should be one of the highest priorities, both for individual companies and the whole construction industry. Waste can reach up to 30-35 % of the total production cost in some projects. In other words, waste can be a factor that can impact the cost and productivity of a project a lot. The theory in this study identified that pure waste corresponds to 33 % of the work time, 23 % of this was time spent waiting and 10 % of time that was not utilised. By analysing previous research, it is suggested that the waste could be reduced and the workers could use the time differently. By enhancing the amount of direct value-adding activities, it is argued that it contributes to an overall increase of productivity at the project. The theory shows that a construction worker spends some of their time waiting on materials, missing tool or lack of work instructions. By having well-planned logistics, it is in this analysis, investigated if the time spend on waiting on materials or missing tools can be reduced and if third party logistics could be used in order to reduce waste.

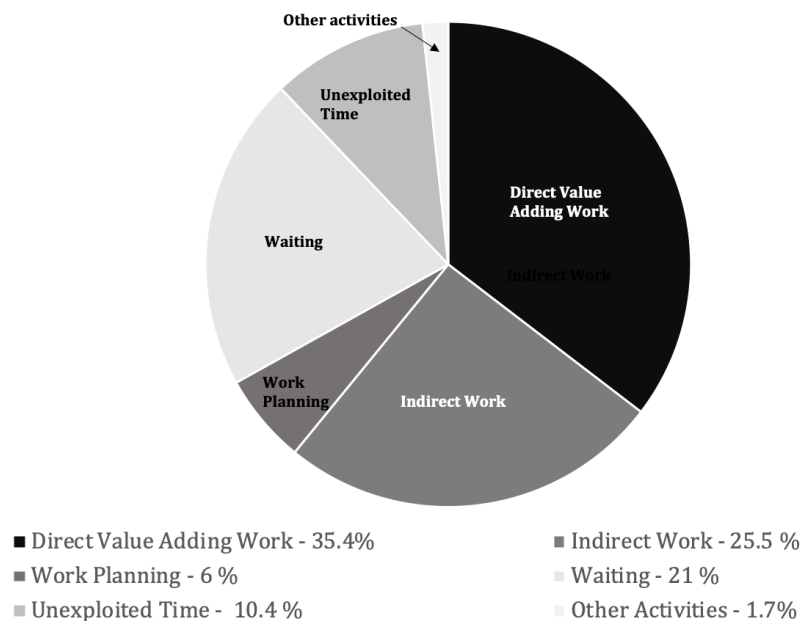
The analysis investigates if it is possible to eliminate waste, identified based on previous research and rearrange the supply chain by outsourcing logistics. The 33 % of waste, that was claim in the literature is not directly applicable on the case study at Mandolingatan. Instead, it is in this analysis suggested that material handling and some of the waiting time can be eliminated by outsourcing logistics.

The theory shows that the majority of the time spend waiting consisted of moving between working stations. By outsourcing logistics, one can claim that it is difficult to fully eliminate this activity. Even when outsourcing logistics, the construction workers still must move between different work stations. However, other activities connected to waiting can be decreased; waiting caused by lack of material, equipment or machines. It is assumed that the majority of the material handling is moved from the construction workers to the TPL-personnel. By outsourcing material handling to a TPL-company, like CS Logistics, it is analysed that it is possible to decrease some of the waiting time. If material handling is outsourced, the order on site regarding materials and storage also can increase. This could therefore lead to, in a best-case scenario, that the amount of waiting time will be reduced. Especially the waiting time that arose from lack of equipment, materials or machines. The table below, 5.1, includes the suggested activities that will could be removed from the construction workers by outsourcing the logistics.

**Table 5.1:** Suggested activities that could be moved or will be eliminated from workers on site.

Activity	Amount of total work (%)
Material handling	13.9
Waiting because of lack of equipment, machines or material	1.3
	=15.2

The table shows a total amount of around 15 % of work that will be removed from the construction workers based on the study by Strandberg & Josephson (2005). An analysis is that the direct value adding work then will be enhanced by 15 %. The direct value adding work will therefore increase to 35.4 %, compared to the previous 19.5 %. In the following figure 5.7, it is presented how the work performed by a construction worker has changed when the logistics are outsourced to a third part.

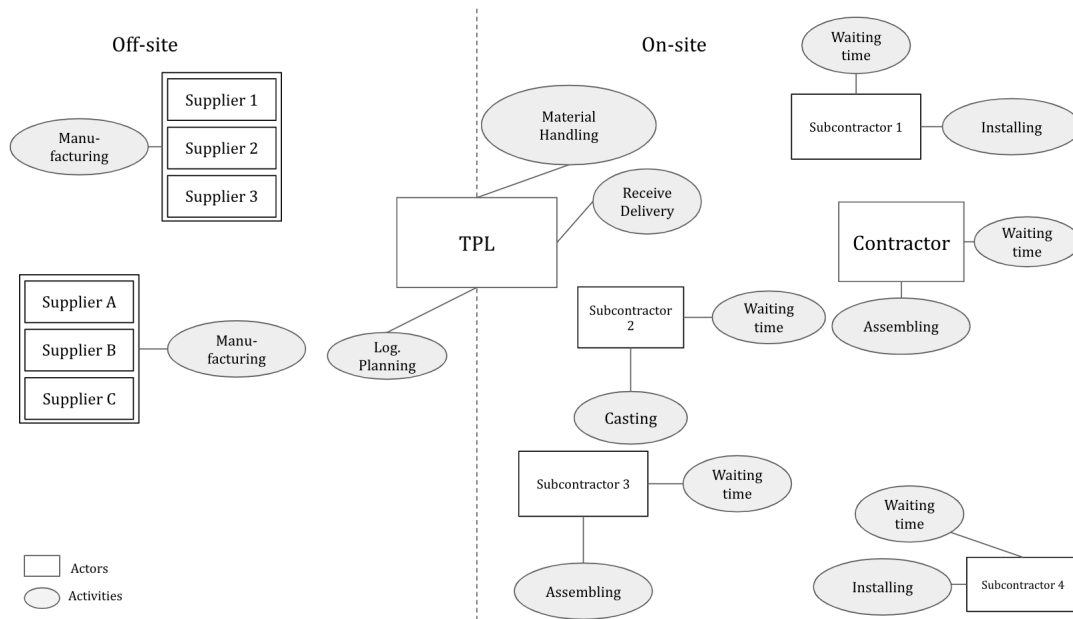


**Figure 5.7:** Increased value of value adding work

One analysis is that it is still a rather low number, inferring that a construction worker only spends a third of their day executing direct value adding activities. However, a construction worker, for example a carpenter, works eight hours a day on site. 15 % then corresponds to 1,2 hours a day, meaning that they have one hour more per day to execute value adding activities. Previous research claim that the utilisation of machines on site is very low today. The smaller machines are only used around 5 % of the time it is on site and bigger machines up to 48 %. When outsourcing logistics and using the intransport-service, it is possible to increase those numbers as some equipment and machines can be used during evening time as well, especially the elevators and the crane. Considering the crane that is highly utilised today at Mandolingatan, it is possible to spread out the usage over more hours instead. Then it is possible to decrease the waiting time for the construction workers. During one of the meetings at site, one of the subcontractors expressed that they have trouble with getting to use the crane. The analysis confirms that by outsourcing the logistics within the first role, it is possible to move activities, especially material handling, from the construction workers on site to other personnel. As an effect, the analysis shows that the direct value adding work performed by a construction worker increase. Additionally, the supervisors are also reviled from some workload by moving the activities logistics planning and receiving of deliveries to the TPL-actor instead. From the empirical study it was discovered that at a project where TPL-services was used, the involved actors were very pleased with the services. The actors never had to worry about the delivery of materials. A CLC was used at this project and it was stated that the terminal gives an opportunity to have more space in the schedule. The TPL-services also made it possible to avoid that construction workers had to work overtime and the supervisors did not have to worry about materials. By analysing these findings, it is possible to confirm that outsourcing logistics to a TPL-actor can have positive outcomes that in long term can increase the productivity of the project. It was also stated that this project would not have been able to manage the high pace without the TPL-services, which also is an indication that TPL can increase productivity.

#### **5.4.2 Role 2: Decreasing inventory and increasing order on site**

The second role focuses on the supply chain itself and the goal with the second role is to decrease costs connected to the supply chain. Implementation of SCM related to the second role is appropriate since previous research states that one intention with SCM is to reduce logistical costs. Furthermore, Vrijhoef & Koskela (2000) suggest that the second role should focus on reducing inventory and lead-time costs or other costs related to logistics. Outsourcing of logistics is one potential solution in order to embrace the second role, hence it was proved in theory that both inventory levels and tied-up-capital was decreased by using a TPL-solution. Additionally, to achieve the goal with the second role, the first role is therefore complemented with a CLC, see figure 5.8 below. Consolidation of goods is then added as one activity that takes part off-site.



**Figure 5.8:** Reducing inventory levels by applying TPL in SCM.

Based on the empirical study it was found that a large logistical challenge in today's construction project is that the sites tends to be smaller and smaller from project to project as they are located in urban areas. The issue is also important from a safety perspective, it is important to ensure the security of people of living in the surrounding areas. A CLC, that is used in the second role could help implement the principles of SCM within the second focus area and solving issues related to a dense construction site. The analysis shows that using CLC lead to less material needing to be stored on site, since the project will have the ability to both store at and order JIT-deliveries directly from the CLC. This leads to increase productivity since the waiting time is limited. Furthermore, it is possible to decrease lead-time and inventory levels if it is possible to use JIT-deliveries. JIT-deliveries is beneficial for the project since it is possible to order material based on when it is needed, instead of both having to wait for deliveries and having to store the materials on site. From the case study it was discovered that today's construction sites often are dense with limited storing abilities. During the observation at Mandolingatan the lack of space was one of the major logistical problem on site, both in itself and leading to other issues.

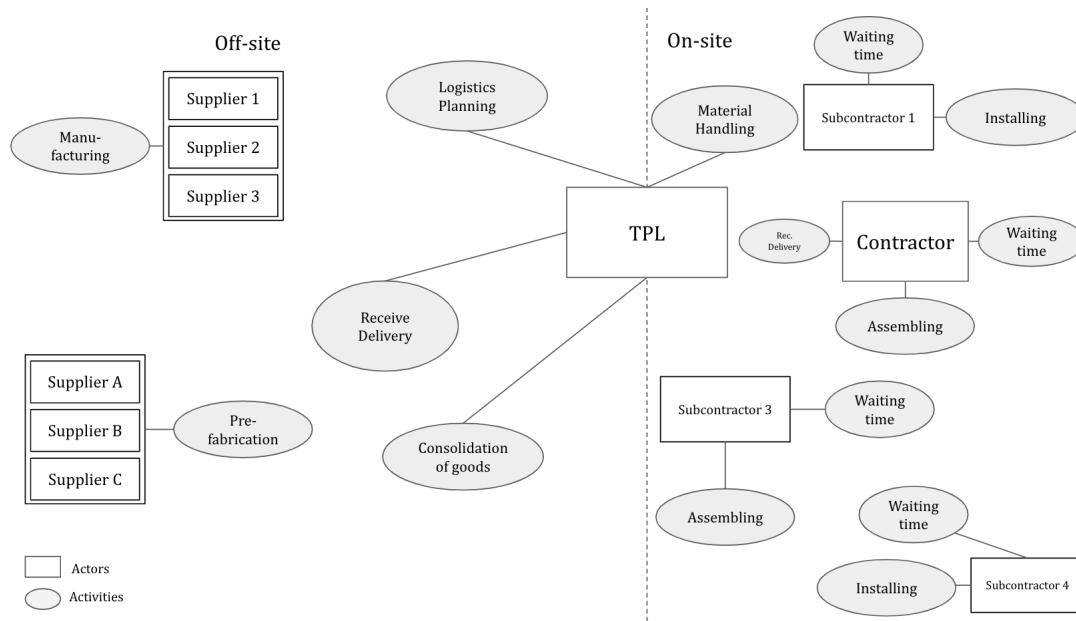
From the previous role are both material handling and receiving of deliveries handled by the TPL-company. When moving activities form the actors that are not connected with their expertise, the amount of time the construction workers have to focus on the work they are connected to their expertise areas will increase. Based on previous theory, the focus of the second role should try to make the supply chain fit the principles on site in the best way possible, for example by customising packaging and size of pallets that arrive at the site. At a CLC, personnel are receiving deliveries and are able to consolidate deliveries. For this case, the personnel at the CLC are able to pack the pallets based on a certain building or apartment. The intransport personnel are then able to carry the materials exactly or close to the

sport where it should be mounted or assembled. This will then lead to less time spend looking for materials for the construction workers, and less time spend going back and forth between a storage area and their specific working spot.

Previous studies mention that depending on the size and characteristics of a construction project, the TPL-services offered to a construction project can differ based on the needs of the project. The analysis has until this moment, included two different cases based on the roles. The analysis indicates that these two (first and second roles) can be likened with two different construction projects with different needs. Theory has stated that the construction industry is conservative and resistant towards change. Based on that theory it can also be suggested that a construction company can start by implementing the first role because it is less complex. A CLC might not be of use in every construction project or that it is not accessible. An analysis shows that the QLocx container could have similar affects as a CLC but depending on the smaller size it is not possible to store a large amount of materials there. However, the Qlocx can decrease lead-times for the project since materials can be delivered to the container at any time and the receiver can pick it up when they need the delivery or are just passing by the container. The analysis of the Qlocx container also decrease some of the waiting time connected to receiving deliveries and the time it takes to receive deliveries and therefore indirect increase productivity on site. Previous research connected to the effects of the container, indicated that the time connected to receiving, answering questions and phone calls connected to deliveries was decreased almost 3 hours per day for that study. However, those number are analysed not to be directly applicable on the studied project in the case study, since it is unknown how much time the supervisor or construction workers spend planning for or receiving deliveries. Analysis shows that it is possible to save time by using a delivery container.

### **5.4.3 Role 3: Enhanced standardised principles**

As mentioned earlier, previous theory claim that one familiar aspect is the connection between standardisation and SCM. It is analysed if increased standardisation could be beneficial in the construction industry by contributing to more stable supply chains. One way to increase standardisation is to move towards more prefabrication in construction. During the case study it was discovered that they have a high degree of prefabrication at Mandolingatan. Even tough prefabrication should increase productivity on site, the experiences from the case study indicated that it also led to a challenge for the project. The supervisor on site however claim that this was due to bad planning, rather the something connected to construction logistics. The third of Vrijhoef & Koskela (2000) roles are focusing on moving activities from the construction site to supply chain. If activities are moved to the supply chain it is analysed that it is possible to increase the productivity of those activities that are occurring on site, leading to enhanced performance overall of the construction project. Figure 5.9 shows a construction project where prefabrication is implemented as an activity in the supply chain.



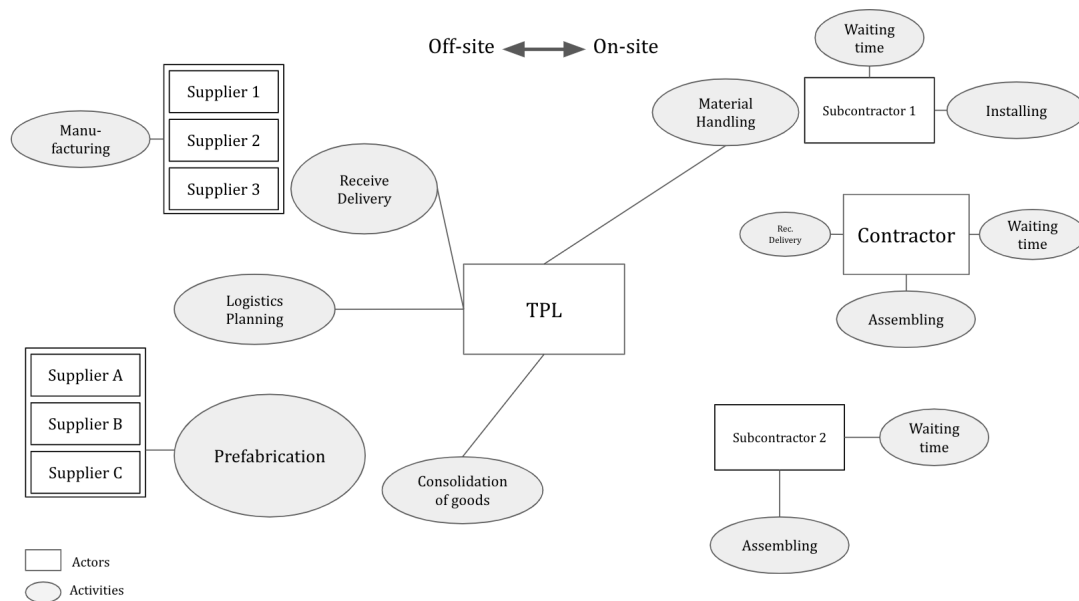
**Figure 5.9:** Moving activities from the construction site to the supply chain.

For the third role, the TPL-company in itself does not offer any services as the initiatives does not directly consider logistical aspects. The analysis of the third focus area has contributed to moving activities from the construction site to the supply chain and compared to the previous the amount of the off-site activities and actors in the figure above has increased. The case study processed some issues regarding prefabricated materials and one situation where prefabrication actually decreased the productivity on the studied case, with regards to the previously mentioned issue of mounting of shell walls. One should have in mind that it is a question regarding experience of the people working with the delivery planning in that case. An analysis is that the issues with the walls never would have occurred if someone else was responsible for the delivery planning. However, it could also be an issue of the experience of the involved people as someone with experience from production might have detect the issue, while someone with less experience might not have seen it as an issue. By using prefabricated elements, activities that used to occur on site is instead taking place off site instead. For this case, it is visualised by removing the casting from on-site activities to an off-site activity called prefabrication instead.

#### 5.4.4 Role 4: Achieving construction supply chain management

Continuing on standardisation, Vrijhoef & Koskela (2000) last and fourth role, focus on standardising process even further and mentioning sequential- and open building as examples. From the theory it is mentioned that the main goal is to replace temporary supply chains with permanent ones and to subsume the supply chain with the production on site. Other initiatives regarding this role are design-build arrangements which is also discussed by the Swedish government in the Lind & Song (2012) study as one way to increase productivity. However, that is a question for the client rather than the contractors, who this study mainly focuses of. Despite

this, a suggestion for the fourth role involving TPL is presented in the figure 5.10 below.



**Figure 5.10:** Fully achieved integration of the supply chain with the construction site.

The last and fourth figure of the roles (5.10) of the roles tries to visualise a merging of the supply chain off site and the production on site. Connecting to the first role, the TPL-company can here act as the merging part between the supply chain and the site. But the services of TPL, is not believed to contribute to achieving the goal according to the fourth role. The analysis has investigated if the four roles and TPL can contribute to improve the productivity at the construction site. Implementation of TPL and SCM has contributed to move activities from the site to supply chain and by that letting the construction workers, supervisors and site manager and so on, focus on direct value adding activities instead. The figures connected to the four roles (5.6,5.8,5.9 and 5.10) has trying to visualise the result of the different implemented processes and services. An analysis of the figures shows that the fewer activities that are executed on site the more room for productivity among the workers on site.

## 5.5 Increasing productivity by rearranging activities

If the principles of SCM is fully implemented and adapted at the construction project at Mandolingatan, the supervisor could spend less time solving problems or plan for logistics and instead focus on value-adding activities. During the three days of observations, some activities were identified that could be categorised as waste, or in other words as non-value adding. These activities are listed in table 5.2 below. The activities have been categorised as waste based on two reasons. The first reason

is that they are not considered to either bring the production forward or bring any value to the end product. Furthermore, the second consideration was done based on what services CS Logistics could offer the project. The reason for this is to try to move activities from the site to the supply chain but also to increase the productivity on site. If activities are moved from the construction workers and the supervisors on site, they are able to focus on other activities that will help bring the production forward. Construction workers and subcontractors are also able to focus on their core competencies and not spend time to either look for or move materials to their workstations.

**Table 5.2:** Identified non-value adding activities performed by a supervisor at Mandolingatan during five days

Identified waste	Performed by	Duration
Meeting regarding placement of construction elevator	Supervisor, Site Manager and Supplier of construction elevators	0.75h
Updating of construction site plan	Site Manager and Construction Engineer	0.5h
Looking for areas to store materials	Two Supervisors	1h
Moving materials on site	One supervisor	16h
Delivery of container	Two Supervisors	0.5h
Delivery Planning and Subordering	Supervisor	2-3h
		= Approx. <b>22h</b>

The first activity in the table, the meeting regarding construction elevator, is identified as waste because that should have been planned earlier. When CS Logistics is involved as a TPL-actor in a construction project, they can plan for placement of construction elevators and that is usually done earlier in the process of a project. The second activity is the updating of the construction site plan. During the observations it was discovered that the construction site plan was poorly updated. The courtyard was used for temporary materials storage which the supervisors was critical against and claim that the courtyard would be a safety risk in the end. If the construction site plan was well updated and detailed, space for material storage could be discovered and it would be clear for everyone at the project where they should store their materials. Materials that were stored temporary at one place at the project had to be moved to another place in order to be able to build scaffolding. This activity demanded two working days and one supervisor. If the construction site plan was updated, the placement of the scaffolding would be shown on the plan and the materials would probably not been stored at that location in the beginning. However, according to the consultants at CS Logistics for a smaller project like this it is beneficial that the personnel on site do the construction site plan. The people working on site a better aware of the production and the occurring activities on site.

The end of the first observations day ended with the two supervisors searching the site for potential areas where they could store construction materials. They also went around a look for a pallet truck that only one of the supervisors were aware of existed on site. At that time material was stored everywhere and there was no order regarding where to material should be stored. If the case was that a TPL-solution was used on site, it is assumed that it would have been more order regarding storing of materials. Between the first and the second observation, the site was cleaned and materials was moved from one part of the site to the parking garage. The plan was to store materials there in the first place, but since the parking garage was delayed that was not possible. Moreover, if the parking garage was not delayed, would the site still look like it did during the observations? Would the supervisors have to spend this time and the two days it took to move the materials? Which is leading us to the fourth identified activity, moving materials on site. At the second observation, it was obvious that materials on site had been moved and the supervisors mentioned that it took them around two days to move all these materials. In addition, they also had to rent one machine to help move the materials.

The two last identified non-value adding activities are connected to deliveries. The first of them, included helping the subcontractors with a delivery of a container. If the project had a working construction site plan, the supervisors probably would not have to participate in that activity since the placement of the container would have been clear from the beginning. The last activity is the delivery planning that one of the supervisors is responsible for and puts a lot of effort in. The supervisors spend a lot of time both planning for deliveries and to do the subordering of elements. The supervisor thought that approximately 2-3 hours, two times a week are spend working with the delivery planning. Compared to previous theory arguing that a supervisor spends 17.5 % of their days executing non-value adding activities during their working days.

For this case study it was discovered, based on the identified hours in table 5.2 above, that during a period of five working days, one supervisor spends 22 hours on activities equalling waste. 22 hours during a week containing of five working days indicates that one supervisor spend 50 % of their time performing activities that does not increase the productivity at the project in any way. This does not mean that the activities are completely unnecessary, in most cases they have to be done. Instead, it is suggested that they bring in support from a TPL-actor, for example CS Logistics, that are experienced in working with construction logistics. Several authors agree that construction logistics needs more attention (Thunberg & Persson, 2014; Hulthén et al., 2017). The theory state that if more attention is paid to the supply chain it is also possible to save 5 % of the total costs. For a project in the size of Mandolingatan, 5 % is corresponding to approximately 14 million SEK. However, since the industry is not aware of its costs connected to logistics it is difficult to identify when and where it is possible these cost savings exist.

The analysis of the study has reach to a consensus that it is possible to move activities performed by actors on site to the TPL-company and as an effect make

it able for the supervisors to perform other activities. One important aspect that can affect the productivity of a construction project is planning. According to the regional manager at Veidekke, planning is the key to increased productivity. The observations made it possible to find that one supervisor at Mandolingatan spend 22 hours during one working week at activities that can be outsourced to a TPL-company. The same identified activities and duration may not occur every week but is an indicator that the supervisors can be relieved from some activities. If the 22 hours could be reduced from the supervisors working weeks, they would have time to do other value adding activities that can increase the productivity of the project. According to the regional manager at Veidekke, the supervisors can use this time to plan for future activities. The logistics can be planned in detail and the risk of unforeseen problems will be reduced. Less amount of problems can increase the productivity, since problems can be costly and take time to solve. Planning is one aspect that is discovered to be very important and closely connected to productivity. If the supervisors are able to plan more in detail, an analysis is that people working with managing construction projects would dare to remove some of the “air” (time buffers) in the production schedule. By doing so, the whole duration of production schedule could be decreased.

### **5.5.1 Utilising TPL-services to create stable construction supply chains**

During the thesis, the potential effects of outsourcing logistics to a TPL-company for a construction project is investigated. One goal is to show effects that will motivate the contractors and project managers to use the offered services by not seeing them as costs and instead focus on what the effects could bring to the project. For this case study, both Veidekke and its affiliated company, CS Logistics has been explored to identify potential effects. Analysing the two companies, one should further investigate what it means that Veidekke owns a TPL-company and how they can take advantage of that by using CS-Logistics to improve their own supply chains. The analysis shows a lot of benefits and positive effects of outsourcing logistics at a construction project. Depending on Veidekke’s situation with CS Logistics it is considered if it is possible for the construction company to customise TPL-services to fit their construction projects. If it is possible to increase standardisation by customising their services to the supply chains in Veidekke’s construction project, project performance can increase. By analysing the supply chains connected to Veidekke’s construction projects it should be possible to identify what kind of customising that is needed for their supply chains. In a best-case scenario, it should be possible to create more permanent and stable supply chains.

For example, all projects in a region where a CLC is located, could use the CLC and JIT-deliveries and an effect will be decreased inventory levels and lead-times since all projects will be able to store their materials at the terminal. If all project would utilise that service, the productivity it is possible to increase productivity at all those projects. Another analysis suggest that standardisation can increase among

all of Veidekke's construction projects if the same personnel and processes from the TPL-company is used on all of their construction project. The personnel will then be familiar with Veidekke's process, which in turn can decrease planning time since processes are repeated from project to project. Lastly, it is also assumed that the logistics analysis can help CS Logistics understand how Veidekke executes projects and based on that, help them achieving SCM in construction and improving overall performance of their construction projects.

# 6

## Conclusions

In this chapter, the findings connected to the research questions are summarised and recommendations for the case company are presented. Lastly, some suggestions for further research are described.

### 6.1 Improving project performance

The aim of this thesis is to investigate how outsourcing logistics can improve the performance of the construction supply chain, as one way to increase the productivity in a dense city construction project. In order to fulfil the aim, this chapter presents the conclusions made throughout the analysis and connected to the answering the research questions.

#### **Solving challenges in urban areas by outsourcing logistics**

One conclusion is that the main challenge connected to logistics in a dense city construction project is the lack of space at the construction site. The construction sites in urban areas are dense, leading to that there is no room for material storage on site. At the same time, urbanisation is increasing which will lead to even smaller construction sites in the future. Additionally, construction projects located in urban areas need to adopt to the conditions set by the surrounding environment. At Mandolingatan, there are four projects constructed parallel with each other and there is one road available for transport of deliveries. This means that the road is heavy utilised which can lead to a risk for creating a bottle neck effect. Another challenge connected to logistics in dense city construction projects are that many actors and stakeholders are involved in the project, sharing the limited space. The communication between every actor must be well-managed in order to avoid consequences such as lack of directions on where to store materials at the construction site. It is concluded that most of the challenges are in some way caused by the lack of space at the construction site.

In this study, it has been discovered that a typical TPL-arrangement mainly consist of following services: delivery planning in an IT-system, delivery containers, intransport, JIT-deliveries and construction logistics centres. It is concluded that most of the services is contributing to decrease the amount of material storage on site. The TPL-services can contribute removing non-value adding activities from workers and supervisors on the construction site. A conclusion is therefore that TPL-services

can coordinate the different actors involved in a construction project and contribute to well-managed communication between them.

### **Outsourcing of logistics to facilitate for construction supply chain management?**

SCM was to a large extent absent at the studied construction project. Based on the four focus areas of SCM in construction, only SCM-principles connected to the third role was identified. However, what was discovered was that some of the principles of SCM was requested at the construction project due to challenges encountered on site, as JIT-deliveries. The third role of SCM, suggests increased standardisation and prefabrication as initiatives to achieve SCM. The degree of prefabrication at the studied project is high, but could be increased even further by using more prefabricated elements or for example modular kitchens. This leads to the conclusion that SCM was only present to a small extent in the current construction supply chain at the project, since only initiatives connected to the third role could be identified. The study also explored if outsourcing of logistics to a TPL-actor could have an impact in achieving construction supply chain management with the goal of improving the overall performance of a construction project. The research contributed to identify beneficial effects with the TPL-services. The effects of applying TPL was then discovered by applying different TPL-services within each one of the four roles of SCM. The analysis consisted of figures to help visualise that the four roles and outsourcing of logistics can help move activities and actors to the supply chain. When activities is moved to the supply chain and logistics is outsourced, it is concluded that the performance on site can be improved by increasing the amount of time the construction workers and the supervisors can focus on value-adding activities. The TPL-services could help facilitate the principles within the first two roles but for the last two, the TPL-actor or its services could not contribute to fulfil the aim of those roles.

## **6.2 Recommendations for Veidekke**

Based on the findings in this thesis, the suggested recommendations for Veidekke is presented below. Firstly, due to the poor performance in the construction industry it is suggested that Veidekke outsource logistics to an actor specialised in logistics, a TPL-company, to improve project performance. During the observations, it is identified that 22 hours of activities during a total of 5 days could be moved or eliminated from the supervisors by outsourcing construction logistics. Some activities are non-value adding for the production, materials handling as an example but is necessary and can instead be outsourced to a TPL-company and therefore removed from the workers on site. The supervisors still need to plan for deliveries but with support from a TPL-company, the time for executing this activity can be shortened. Findings from the empirical study suggested that these hours instead could be used to plan for future events. If the supervisors are able to plan future activities more in detail, the risk that unforeseen problems will occur can be reduced. Today, a

part of the schedule includes unutilised time, added as a safety buffer if unforeseen issues occur that can delay the production. By giving the supervisors more time to plan, this safety buffer will not be necessary and as a result, the duration of the schedule can be shortened. The study also identified that if materials handling is outsourced to a TPL-company it is possible to decrease one hour of work every day for the construction workers. The case company should try to use these identified hours as a base when planning for future projects to decrease the amount of “air” in the production schedule to shorten the total duration. Further, it is recommended that keeping the construction site plan updated is prioritised in dense city construction projects. The main challenge in these projects are the lack of material storage on site and by updating the construction site plan often, it becomes more obvious where to store the materials and misunderstanding can be avoided.

This study confirms that outsourcing logistics as early as possible in the process give the greatest effects. One recommendation to the case company is therefore to involve TPL-services already in the planning phase of the project. If the planning phase is extended, the production phase can be shortened. As one approach to this, it is suggested that Veidekke utilise the opportunity that they have an affiliated TPL-company, CS Logistics, to plan for the logistics. Veidekke should investigate how and if it is possible to use their TPL-company to improve the performance of their construction projects’ supply chains. Using CS Logistics in combination with the four roles of SCM, it is possible to produce more stable and permanent supply chains and therefore improve the productivity. The last recommendation for Veidekke suggest that the process of planning projects should be reviewed to make it possible to decrease project duration, partly based on the findings in this study.

### 6.3 Further Research

It is suggested that the identified hours of waste is used as a base for further research. One should try to identify more accurate numbers comparing the effects of a construction project that handles the logistics of their own compared to a project where it is outsourced. By doing so, it is possible to identify quantitative measurements that could motivate the usage of the services. Moreover, it is suggested that further research should try to identify what the lack of well-planned logistics actually costs for a construction project. Following, one should try to find appropriate calculation methods including how to calculate for the TPL-services for projects in the tendering phase. Furthermore, it is suggested that the study is developed to a larger context to make it more applicable on other construction projects as well.

# References

- Agapiou, A., Clausen, L., Flanagan, R., Norman, G., & Notman, D. (1998). The role of logistics in the materials flow control process. *Construction Management & Economics*, 16(2), 131–137.
- Akintoye, A. (1995). Just-in-time application and implementation for building material management. *Construction Management and Economics*, 13(2), 105–113.
- Allen, J., Browne, M., Woodburn, A., & Leonardi, J. (2014). A review of urban consolidation centres in the supply chain based on a case study approach. In *Supply chain forum: an international journal* (Vol. 15, pp. 100–112).
- Azambuja, M., & O'Brien, W. J. (2008). Supply chain modeling: Issues and perspectives. *Construction supply chain management handbook*.
- Bankvall, L., Bygballe, L. E., Dubois, A., & Jahre, M. (2010). Interdependence in supply chains and projects in construction. *Supply chain management: an international journal*.
- Basu, R., & Wright, J. N. (2012). *Quality beyond six sigma*. Routledge.
- Behera, P., Mohanty, R., & Prakash, A. (2015). Understanding construction supply chain management. *Production Planning & Control*, 26(16), 1332–1350.
- Bell, E., Bryman, A., & Harley, B. (2018). *Business research methods*. Oxford university press.
- Bengtsson, M. (2016). How to plan and perform a qualitative study using content analysis. *NursingPlus Open*, 2, 8–14.
- Bertelsen, S. (2003). Construction as a complex system. In *Proceedings for the 11th annual conference of the international group for lean construction* (pp. 11–23).
- Bostad2021. (n.d). *Bostad 2021 - en del av jubileumssatsningen*. Retrieved 2020-04-28, from <http://bostad2021.se>
- Briscoe, G., & Dainty, A. (2005). Construction supply chain integration: an elusive goal? *Supply chain management: an international journal*.
- Brunge, K. (2013). *Förbättrad logistik för byggmaterial i norra djurgårdsstaden: Metodutveckling för utvärdering av miljöbelastning*.

- Carlsson, C.-M., & Janné, M. (2012). 7. sustainable urban distribution in the øresund region. *Rethinking Transport in the Øresund Region*, 113.
- CS Logistics. (n.d.). *Tjänster*. Retrieved 2020-02-04, from <http://cslogistics.se/#tjanster>
- CSCMP. (n.d). *Cscmp supply chain management definitions and glossary*. Retrieved 2020-02-19, from [https://cscmp.org/CSCMP/Academia/SCM\\_Definitions\\_and\\_Glossary\\_of\\_Terms.aspx?hkey=60879588-f65f-4ab5-8c4b-6878815ef921](https://cscmp.org/CSCMP/Academia/SCM_Definitions_and_Glossary_of_Terms/CSCMP/Educate/SCM_Definitions_and_Glossary_of_Terms.aspx?hkey=60879588-f65f-4ab5-8c4b-6878815ef921)
- Dahmström, K. (2011). Från datainsamling till rapport-att göra en statistik undersökning. *Studentlitteratur AB, Lund, Sverige*.
- Dubois, A., & Araujo, L. (2007). Case research in purchasing and supply management: Opportunities and challenges. *Journal of Purchasing and Supply Management*, 13(3), 170–181.
- Dubois, A., & Gadde, L.-E. (2002a). The construction industry as a loosely coupled system: implications for productivity and innovation. *Construction management & economics*, 20(7), 621–631.
- Dubois, A., & Gadde, L.-E. (2002b). Systematic combining: an abductive approach to case research. *Journal of business research*, 55(7), 553–560.
- Dubois, A., Hulthén, K., & Sundquist, V. (2019). Organising logistics and transport activities in construction. *The International Journal of Logistics Management*.
- Ekeskär, A. (2016). *Exploring third-party logistics and partnering in construction: A supply chain management perspective* (Vol. 1753). Linköping University Electronic Press.
- Ekeskär, A., & Rudberg, M. (2016). Third-party logistics in construction: the case of a large hospital project. *Construction management and economics*, 34(3), 174–191.
- Fernández-Solís, J. L. (2008). The systemic nature of the construction industry. *Architectural Engineering and Design Management*, 4(1), 31–46.
- Gao, S., & Low, S. P. (2014). Lean construction management. *From Lean Production to Lean Construction*, 27–48.
- Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Methods of data collection in qualitative research: interviews and focus groups. *British dental journal*, 204(6), 291–295.
- Halinen, A., & Törnroos, J.-Å. (2005). Using case methods in the study of contemporary business networks. *Journal of business research*, 58(9), 1285–1297.
- Hulthén, K., Sundquist, V., Gadde, L.-E., & Eriksson, V. (2017). *Logistikens roll i effektiva byggprocesser*. Sveriges Byggindustrier.
- Janné, M. (2018). *Construction logistics solutions in urban areas* (Vol. 1806). Linköping University Electronic Press.

- Josephson, P.-E., & Hammarlund, Y. (1999). The causes and costs of defects in construction: A study of seven building projects. *Automation in construction*, 8(6), 681–687.
- Josephson, P.-E., & Saukkoriipi, L. (2007). *Waste in construction project: call for a new approach*.
- Koskela, L. (2000). *An exploration towards a production theory and its application to construction*. VTT Technical Research Centre of Finland.
- Koskenvesa, A., Koskela, L., Tolonen, T., & Sahlsted, S. (2010). Waste and labor productivity in production planning case finnish construction industry. In *Proceedings of the 18th annual conference of the international group for lean construction* (pp. 477–486).
- Landin, A., & Oberg, M. (2014). Productivity and efficiency in the development of the swedish construction sector. *American Journal of Industrial and Business Management*, 2014.
- Lind, H., & Song, H.-S. (2012). *Dålig produktivitetsutveckling i byggindustrin: Ett faktum eller ett mätfel*.
- Lindén, S., & Josephson, P.-E. (2013). In-housing or out-sourcing on-site materials handling in housing? *Journal of engineering, design and technology*.
- MyLoc. (n.d). *Logistics for construction companies*.
- Persson, F., Bengtsson, J., & Gustad, Ö. (2009). Construction logistics improvements using the scor model–toronet case. In *Ifip international conference on advances in production management systems* (pp. 211–218).
- Pettersson, A. I., & Segerstedt, A. (2011). Performance measurements in supply chains within swedish industry. *International Journal of Logistics Systems and Management*, 9(1), 69–88.
- Qlocx. (2019). *Bygglogistik*. Retrieved 2020-03-30, from <https://www.qlocx.com/bygglogistik>
- Révai, E. (2012). *Byggstyrning. 4: e upplagan*. Liber förlag AB. sid.
- Sandberg, E. (2015). *Logistik och strategi: för lönsamhet och tillväxt*. Studentlitteratur AB.
- Shirazi, B., Langford, D., & Rowlinson, S. (1996). Organizational structures in the construction industry. *Construction Management & Economics*, 14(3), 199–212.
- Spillane, J. P., & Oyedele, L. O. (2017). Effective material logistics in urban construction sites: a structural equation model. *Construction Innovation*.
- Strandberg, J., & Josephson, P.-E. (2005). What do construction workers do? direct observations in housing projects. In *Proceedings of 11th joint cib international symposium combining forces, advancing facilities management and construction through innovation* (pp. 184–93).

- Sullivan, G., Barthorpe, S., & Robbins, S. (2011). *Managing construction logistics*. John Wiley & Sons.
- Sundquist, V., Gadde, L.-E., & Hulthén, K. (2018). Reorganizing construction logistics for improved performance. *Construction management and economics*, *36*(1), 49–65.
- Thunberg, M., & Persson, F. (2014). Using the scor model's performance measurements to improve construction logistics. *Production Planning & Control*, *25*(13-14), 1065–1078.
- Tommelein, I. D., & Li, A. (1999). Just-in-time concrete delivery: mapping alternatives for vertical supply chain integration. In *Proceedings iglc* (Vol. 7, p. 97).
- United Nations. (2019). World urbanization prospects: The 2018 revision. *New York (USA): United Nations Department for Economic and Social Affairs*.
- Veidekke. (2019). *Veidekke bygger för framtiden byggutveckling*. Retrieved 2020-02-12, from <http://veidekke.se/om-oss/nyheter-och-media/pressmeddelanden/article29888.ece>
- Veidekke, y. . n. u. . h. u. . . , title = Fakta om Veidekke. (n.d.).
- Vrijhoef, R., & Koskela, L. (2000). The four roles of supply chain management in construction. *European journal of purchasing & supply management*, *6*(3-4), 169–178.
- Xue, X., Li, X., Shen, Q., & Wang, Y. (2005). An agent-based framework for supply chain coordination in construction. *Automation in construction*, *14*(3), 413–430.
- Xue, X., Wang, Y., Shen, Q., & Yu, X. (2007). Coordination mechanisms for construction supply chain management in the internet environment. *International Journal of project management*, *25*(2), 150–157.
- Ying, F., Tookey, J., & Roberti, J. (2014). Addressing effective construction logistics through the lens of vehicle movements. *Engineering, construction and architectural management*.
- Ying, F., Tookey, J., & Seadon, J. (2018). Measuring the invisible. *Benchmarking: An International Journal*.

# A

## Appendix - Interview Questions

### A.1 Third Party Logistics: Set 1

#### **The company**

Please start by telling us about your background, your role at the company and what you work with today.

What kind of logistics services does Prolog offer?

In what stage of a project does Prolog usually get involve?

- Does this differ if its an individual programme or a for example a city development programme?

Is it the client or the contractor who takes the initiative to outsource logistics?

- Is there any difference depending on who took initiative?

- Is there a difference in what knowledge the customer has about building logistics, depending on whether it is a contractor or a client?

#### **Construction Logistics**

From your experience, how do you feel that the construction industry is working with logistics?

- Is there any difference between how different actors (client, contractor, subcontractors, consultants, suppliers) are working with logistics?

In what way is construction logistics involved in the planning of a project?

What effects (and for who) do you experience when a TPL is responsible for the logistics on a construction project?

- Is there any actor who is more beneficial and some who is less beneficial from the usage of TPL in a project?

How do you experience that the construction logistics has changed in the industry?

- Is companies putting more or less resources to handle logistics today than before?

Which construction logistic services are the easiest and most effective to implement?

What factors could improve the conditions for effective construction logistics?

In 10 years, how do you think that the management of construction logistics will look?

Which are the largest challenges that is met when implementing and using TPL?

How do think that you can increase the motivation to use construction logistic services in construction?

- Do you think that the client should demand the services?
- How can you motivate the contractor without demands from the client?

### **Economy**

To motivate the usage of TPL further, where do you think that the contractor can lower their costs, corresponding to the costs of the TPL?

How does your employer company charge for your services? Set price? Current account?

### **Measuring Logistics**

Do you measure logistics in any way today?

### **Urban Environments**

How has the construction logistics in urban areas developed?

From your experience, what have you experienced are the biggest challenges of building in dense cities today?

### **Connections between sustainability and construction logistics**

Construction logistics deals a lot with getting the right material at the right time to the construction site. This can in turn infer more half full transports.

- How do you think that this stands contrary to the “sustainability-thinking” that exist today?
- Is there any other aspects regarding sustainability to have in mind when it comes to construction logistics?

Finally, What is your dream scenario with construction logistics?

## A.2 Third Party Logistics: Set 2

### The Company

Please start by telling us about your background, your role at the AFRY and what you work with today.

What kind of logistics services does AFRY offer?

Which is the most common logistics service that you offer?

- Do you offer some kind of standard solution with services?

In what stage of a project does AFRY usually get involve?

Is it the client or the contractor who takes the initiative to outsource logistics?

- Is there any difference depending on who took initiative?

- Is there a difference in what knowledge the customer has about building logistics, depending on whether it is a contractor or a client?

Please tell us about your project at Norrlands University Hospital.

- You mention savings between 10-15%, where do they exist?

- Is it possible to save these amount at more “typical” construction projects as well?

### Construction Logistics

From your experience, how do you feel that the construction industry is working with logistics?

- Is there any difference between how different actors (client, contractor, subcontractors, consultants, suppliers) are working with logistics?

- Is logistics more considered in a particular kind of projects, for example large complex projects?

Which construction logistic services are the easiest and most effective to implement?

Are there some parties that benefits more from using TPL-services and some that are less beneficial?

Which are the largest challenges that is met when implementing and using TPL?

How do think that you can increase the motivation to use construction logistic services in construction?

- Do you think that the client should demand the services?

- How can you motivate the contractor without demands from the client?

### Measuring Logistics

Do you measure logistics in any way today?

### Connections between sustainability and construction logistics

## A. Appendix - Interview Questions

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Do you think there are any connections between effective and well-planned construction logistics and sustainability?

### **A.3 Third Party Logistics: Set 3**

Which is the most common logistical solution that you offer?

- Why is that one the most requested?

What are the main benefits you see using TPL in construction projects?

How do you motivate the usage of TPL?

What is included in your logistical analysis and what factors are the most important to take into consideration?

Of all your services, which one do think would have the most effect (save time) if it was applied on a “typical” housing project?

Do you experience that there are some kind of logistical challenge that the contractors face more often?

- If yes, which ones? Or do they differ from project to project?

Do you measure the effects of your logistics services?

How do you charge for your services?

## A.4 Mandolingatan - Supervisor: Set 1

### The role as a supervisor

Please start by telling us about your background.

- For how long have you worked in the construction industry?
- For how long have you worked as a supervisor?

What is the best part about your job?

What is most challenging?

Who do you have contact with at the site and in the supply chain?

- Do you have contact with other functions at Veidekke?

What do you think is included in the role as a supervisor?

- What occupies most of your time?
- Does that differ between project to project?

### Construction Logistics

Of all your tasks, which would you say are connected to logistics and in what way?

Do you experience that you often have to solve unexpected problems?

- What kind of problems and why do these occur?
- How much of these would say are connected to logistics?

What do you consider to be the biggest problem when it comes to logistics at this project?

- Is it some problem that is reoccurring from project to project?

How have you planned for the logistics at this project?

Do you have any experience regarding TPL from other projects?

How do you think your working tasks would have changed if a third party was responsible for all logistics at the project?

- What pros and cons with a potential change?
- If the logistics was handled by an external part and you for example had one more hour a day to do anything value-adding, what would you do?

### Scheduling and disturbances

How, by who and when have this project been planned?

How is the detailed planning done?

How do you think that the production is following the schedule at this project?

- Compared to other projects?

What kind of disturbances makes you depart from the schedule?

How common is it with replanning?

- What makes you need to replan?
- What consequences can occur due to replanning?

Does long-term planning work? for example five weeks rolling schedule.

### **Deliveries**

Does often waiting time occur during the days? For example that you have to wait for material, late deliveries, occupied crane?

What happens if a delivery arrive earlier than planned?

- What requirements are sent to the supplier?
- How long in advance do you have to book delivery of materials?

Does it happen that your deliveries sometimes collide with deliveries to the subcontractors?

- Since the delivery plan is visible to everyone, do you feel that everyone involved in the project is actually aware of the deliveries? Do they take the other's deliveries into account?
- Do you have any requirements for you subcontractors regarding deliveries?

Can you explain the sequence of events when a delivery arrive at the site?

- How often does deliveries come to the project?
- How long does it generally take to receive a delivery?

What do you think would have been beneficial if you had the ability to store material at a terminal?

### **Other questions**

Do you try to use as much prefabricated elements as possible? Or do you prefer to mount on site?

How does the collaboration work between the different projects at Mandolingatan?

- Are you as a supervisor involved in that?

## A.5 Mandolingtatan - Supervisor: Set 2

### The role as a supervisor

Please start by telling us about your background.

- For how long have you worked in the construction industry?
- For how long have you worked as a supervisor?

What is the best part about your job?

What is most challenging?

What do you think is included in the role as a supervisor?

- What occupies most of your time?
- Does that differ between project to project?

### Construction Logistics

Of all your tasks, which would you say are connected to logistics and in what way?

Do you experience that you often have to solve unexpected problems?

- What kind of problems and why do these occur?
- How much of these would say are connected to logistics?

What do you consider to be the biggest problem when it comes to logistics at this project?

- Is it some problem that is reoccurring from project to project?

How have you planned for the logistics at this project?

Do you have any experience regarding TPL from other projects?

How do you think your working tasks would have changed if a third party was responsible for all logistics at the project?

- What pros and cons with a potential change?
- If the logistics was handled by an external part and you for example had one more hour a day to do anything value-adding, what would you do?

### Scheduling and disturbances

How do you think that the production is following the schedule at this project?

- Compared to other projects?

What kind of disturbances makes you depart from the schedule?

How common is it with replanning?

### Deliveries

Does often waiting time occur during the days? For example that you have to wait

for material, late deliveries, occupied crane?

Can you explain the sequence of events when a delivery arrive at the site?

- How often does deliveries come to the project?
- How long does it generally take to receive a delivery?

Do you receive deliveries every day?

Do you think that you could have increased the productivity at this project?

- Can you see any potential improvement areas?

## A.6 Mandolingtatan - Site Manager

### **The Project and planning of the project**

Please start by telling us about your background and your role at the project.

- When were you involved in the project?

How was the project planned? And by who?

- When was the planning done? (the rough “planning” and the main schedule)

- Who was responsible for the planning, especially with regard to the construction site plan and the schedule. Experiences among the responsible?

- How do you take unforeseen events into account?

How does involved planning according to VDC work?

- Was it used when planning this project?

- How do you feel that it can affect the productivity at the project?

Was there something that should have been considered during that planning phase that was missed?

Are you collaborating in some way with the other projects at Mandolingtatan?

- Is there any joint deliveries to the different projects?

How was logistics taken into consideration during the planning phase (before starting the production)?

- Was TPL or any other form of logistics services ever considered?

How do you follow up and convey how the project is working out? (Including subcontractors)

How do you follow up the planning process after the project is completed?

Do you measure logistics in any kind of way?

- For example that deliveries arrive on time or that the delivery plan is followed?

How does it affect the project that you and the subcontractor work according to piece rate?

### **Logistics**

Which have been the biggest challenges in general and with regards to logistics at this point in the project?

Where do you think that the biggest logistical improvement of exist for this project?

Do you have any experience from working with TPL from previous projects?

- If yes, positive or negative?

What do you think could have been the largest effect of using TPL at this project?

Do you think that you could have increased the productivity at the project by using more prefabricated elements or modular kitchens? (In other words, move activities from the site to the supply chain)?

How do you think that the logistics at the project would be affected if you had the ability to store material somewhere else?

Do you collaborate with your supplier to improve the flow of materials?

- Does the suppliers have any improvement suggestions?

What do you think is the most important with regards to logistics in the supply chain?

- For example: packaging, JIT-deliveries, co-loading?

### **Construction Site Plan**

How often is the construction site plan updated during the production phase?

- Is it updated as much as it should?

Does the construction site plan involve a pre-decided area for storing of materials?

What do you feel could be a disturbance that affects the schedule?

- Are disturbances commonly occurring?

- Compared to previous projects?

Do you think that TPL could have any effect on the main schedule at this project?

- If yes, what activities would have been affected?

## **A.7 Mandolingtatan - Client perspective**

Please start by telling us about yourselves and the projects at Mandolingtatan.

What did you see as the main logistical challenge?

What was the reason for hiring a consultant responsible for the logistics?

What was included in consultant's assignments and when in the project was he involved?

Have you as a client set any demands regarding logistics to your contractors?  
- If yes, was those included in the tendering or conveyed later on?

How does the collaboration between the projects work?

What would you say is the key for well functioning collaboration and logistics at Mandolingtatan?

# B

## Appendix - Duration of activities from observations

### B.1 Mandolingatan - Observation: Supervisor A

Table B.1: First observation

<b>Time</b>	<b>Activity</b>
06.45-07.10	Daily Meeting
07.10	Control before concrete casting
08.00	Control of casting process
09.50-10.35	Spontaneous meeting
10.35-11.35	Continued meeting
11.35-12.20	Meeting regarding construction elevator
12.30	Check for possibilities to cast one day earlier
14.25	Order new tools/machines
14.40-15.40	Check for possible areas to store material

### B.2 Mandolingatan - Observation: Supervisor B

Table B.2: Second observation

<b>Time</b>	<b>Activity</b>
09.30-10.10	Late breakfast
10.10-10.20	Return rental machines
10.20-10.35	Control the deliveries from the morning
10.35-10.55	Check the project
11.05-13.00	Office duty and delivery planning
13.45-14.00	Communicate the delivery plan
14.00-14.40	Check the project
14.40-15.10	Prepare the schedule
15.15-16.00	Suborder of shell walls

## B.3 Mandolingtatan - Observation: Supervisor B

**Table B.3:** Third observation

<b>Time</b>	<b>Activity</b>
06.45-06.55	Daily Meeting
07.00-08.10	Team leader meeting
08.10-08.20	Talk with subcontractors
08.20-09.10	Check project
09.10-09.40	Delivery of container
09.40-10.10	Breakfast
10.10-10.40	Unidentified activity
10.50-12.35	Planning meeting
13.10-14.00	Economy meeting
14.15-14.40	Check the site; update construction site plan
14.40-15.45	Check the project



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