CHALMERS
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Construction Consolidation Centers: A compilation on how implementation can be carried out

A study on early stages engagement and driving forces in the context of Gothenburg city

Master's thesis in Design and Construction Project Management

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Abstract

Today the construction industry can be held accountable for a third of the total urban transports. With this comes complications such as environmental impact, citizen safety as well as traffic interference. To make matters worse cities are growing at a rapid pace, from 2018 at 55%, the urban population are expected to grow to 68% by 2050. Construction logistics play a central role in addressing these issues, where one way of addressing these are through the implementation of a Construction Consolidation Center (CCC). The purpose of this study was to investigate the early stages of establishing a CCC, who are the key stakeholders, as well as providing a stepping-stone as to how a CCC can be implemented in relation to the context of Gothenburg and its challenges related to construction logistics. This is accomplished through a literature review, drawing upon the strengths, weaknesses and examples from the industry accompanied by a thorough empirical study, consisting of qualitative interviews with industry actors. To condense the theoretical and empirical findings, the findings were evaluated and analyzed with a designed evaluation method. Resulting in a compilation of four scenarios centered around establishing a CCC, of which all take different perspectives depending on the desired outcome. Concluding for these scenarios is that there is a clear division between considering financial gain or societal gains, where the selection of scenarios is highly dependent on urban characteristics and existing TPL-providers. In the context of Gothenburg and the city's existing environmental goals, scenario 1 and 2 are found to align with these the most. Finally, the future intent of these scenarios is to provide a general understanding to which they can serve as a foundation for analyzing CCC implementation in specific projects.

Keywords: Construction logistics, construction consolidation center, sustainable urban development, stakeholder engagement.

Bygglogistikcenter: En sammanställning av hur implementering kan utföras
En studie av tidiga skeden och drivande faktorer med fokus på Göteborg stad

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Sammanfattning

Byggbranschen kan idag sägas vara ansvarig för en tredjedel av den totala mängd urbana transporter. Detta bidrar till komplikationer som miljöpåverkan, medborgarsäkerhet och trafikstörningar. I samband med detta utvecklas städer i en hastig takt, 2018 var den urban befolkningen 55% och förväntas växa till 68% till år 2050. För att hantera dessa frågor spelar bygglogistik en central roll, där en av metoderna att adressera dessa problem är genom implementeringen av bygglogistikcenter. Syftet med denna studie var att undersöka de tidiga skedena av att etablera ett bygglogistikcenter, vilka de viktigaste aktörerna är, samt att ge en grund för hur ett bygglogistikcenter kan implementeras i relation till Göteborgs kontext och dess utmaningar relaterade till bygglogistik. Detta uppnås genom en litteraturstudie, där styrkor, svagheter och exempel från branschen tas upp tillsammans med en noggrann empirisk studie, bestående av kvalitativa intervjuer med branschaktörer. För att sammanfatta de teoretiska och empiriska resultaten utvärderades och analyserades resultaten med en designad utvärderingsmetod. Detta resulterade i en sammanställning av fyra scenarier centrerade kring etablering av bygglogistikcenter, varav alla tar olika perspektiv beroende på diverse faktorer. Slutsatsen för dessa scenarier är att det finns en tydlig uppdelning mellan att överväga ekonomisk vinning eller samhällsvinster, där valet av scenario är beroende av de urbana förutsättningarna och existerande logistik tjänster. I relation till Göteborg och stadens miljömål är scenario 1 och 2 de som överensstämmer mest. Slutligen är avsikten med dessa scenarier att ge en allmän förståelse för vilka de kan tjäna som grund för att analysera en implementering av bygglogistikcenter i specifika projekt.

Nyckelord: Bygglogistik, bygglogistikcenter, hållbar urban utveckling, nyckelaktörer.

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This master's thesis represents the culmination of five years of civil engineering studies at Chalmers University of Technology. It was conducted at the Department of Technology Management and Economics in Sweden during the spring of 2024.

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"Don't fear failure. Be afraid of not having the chance. You have the chance!"

- Sally (Cars 3)

Filip de Boer and Emma Sahlberg, Gothenburg, June 2024

List of Acronyms

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

CCC	Construction Consolidation Center
CLC	Construction Logistics Center
CLP	Construction Logistics Plan
CSCM	Construction Supply Chain Management
EV	Electrival Vehicle
HGV	Heavy Goods Vehicle
JIT	Just In Time
SCM	Supply Chain Management
TPL	Third Party Logistics

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1
Introduction

The following chapter describes the background of how logistics in the construction industry have presented itself historically, presently and what future impacts it may impose. In addition to this, the purpose of the study as well as its delimitations and research questions are be presented.

1.1 Background

In the world of logistics, Supply Chain Management (SCM) and logistics are often intertwined. SCM is most commonly defined as the discipline that encompas ses the planning, implementation, and control of processes, from their origin at the supplier, up until their final destination at the consumer [Cooper et al., 1997]. Logistics on the other hand as a subcategory of SCM, can be defined as the management of the flow of materials, tools, and equipment from their point of origin, up until installation and point of delivery [Almohsen and Ruwanpura, 2011]. There are many perceptions of how they relate, but the more commonly accepted among scholars is the unionist view; where logistics play a part in what SCM encompasses [Larson and Halldorsson, 2004, Sweeney and Edward, 2005].

In the dawn of rapid urban densification, the greater urban areas have grown significantly in the last decades [Guerlain et al., 2019]. With this comes a greater demand for the construction of dwellings and infrastructure. Consequently, there has been a large increase in the number of Heavy Goods Vehicles (HGV) transporting materials as well as the lack of space for warehousing construction materials in urban areas [Janné, 2018]. The construction industry is facing many challenges, be it environmental, economic, or social. To address these challenges, construction logistics may be part of the solution, most notably in the fields of economic and environmental sustainability. Today construction accounts for 30% of the total freight transports in the urban space, and even more in terms of pollution [Guerlain et al., 2019]. In addition to this, the share of population living in urban areas is expected to rise from 55% to 68% by 2050. The rapid increase in the urban population creates a higher demand for urban construction and without preemptive measures the construction industry will continue to put stress on the environment and the shortcomings of the industry will loom.

In a study by Shakantu et al. (2003) it was found that transports related to construction account for up to 58% of the total logistics cost where the logistics

account for upwards of 10% of the total project cost. Additionally, there seems to be a relationship between the purchase price of materials and the logistics cost of the material safely reaching its intended location [Vrijhoef and Koskela, 2000]. Furthermore, Sundquist et al. (2018) concluded that in the field of material purchasing, the extra costs imposed by poor logistical management could vary as much as 40 to 250% of the purchase price. This becomes a question of where the money is best spent since the transportation of goods and materials is a cost that is "hidden", resulting in it disappearing between the lines or if logistical solutions should be adopted [Sundquist, 2023].

Continuously, the construction projects taking place in the urban area pose a problem to the external stakeholders and other occupants of the public space as well. As mentioned, the construction industry is responsible for a large part of the freight transport passing through the cities, bringing unwanted consequences such as detours and road closures, both of which contribute to an even more congested urban center [Janné, 2018]. Additionally, the external stakeholders may experience socioecological consequences affecting the health and quality of life due to the large amount of construction-derived HGVs in the urban center, some of the consequences are dust and heavy metal oxide emissions as well as noise pollution to name a few [Gilchrist and Allouche, 2005].

Furthermore, the industry is also facing criticism for its inefficiencies and low levels of innovation [Dubois and Gadde, 2002a]. The construction industry is highly complex and custom, there is no project like the other and each project could be viewed as a pilot on its own [Ekeskär and Rudberg, 2016]. This is explained by the common occurrence of custom parts and designs, each with its prerequisites, resulting in every project facing different challenges, both externally and internally [Gao and Low, 2014, Ekeskär and Rudberg, 2016, Ying and Tookey, 2014]. Additionally, construction projects can be argued to be one of the most complex operations to carry out, partly because of its many custom components included and also due to the multifaceted nature of the industry with many actors involved [Dubois and Gadde, 2002a]. This is further emphasized by the common occurrence of loose couplings in the industry, creating a problem for long-term collaboration, further creating barriers for logistical solutions to prevail. Continuing, the construction supply chain is characterized by having large amounts of waste occurring, both material and time waste. This in turn results in the project delivery being late, and perhaps more expensive than first anticipated when procured [Vrijhoef and Koskela, 2000]. This is one example where the industry has fallen behind in terms of eliminating waste and streamlining its processes such as the manufacturing industry, which tends to work towards a more lean approach. This waste-eliminatory approach may not only serve as a means to save money but also resources in terms of material, promoting a more environmental approach to the construction processes [Gao and Low, 2014].

1.1.1 Addressing the challenges through logistical solutions

This is where construction logistics could offer a helping hand in addressing the previously presented problems. Historically, in the construction industry, logistics is something that has been lacking as compared to other industries and often is taken for granted, resulting in it not being utilized to its full potential [Sullivan et al., 2011]. The logistics in the construction industry are characterized by its low innovation and knowledge adoption from other more successful industries, repeating the same mistakes repeatedly [Janné and Fredriksson, 2022].

The main objective of construction logistics is to minimize urban interference in construction projects without compromising efficiency and project delivery. To accomplish this a set of logistical solutions can be used which include both actions taken on-site or off-site. The on-site solutions often include measures that increase the efficiency of the contractor and allow them to make full use of their labor hours. These solutions may be off-hour material movements, checkpoint systems, and transport scheduling. In contrast to this, the off-site solutions often aim to decrease the number of transports going to the site through the consolidation of goods. This is where the introduction of a CCC could alleviate some parts of the problem. The main intent of establishing a CCC is to consolidate construction transports outside of the city center, thus reducing the total number of HGVs in the most urban areas, reducing their interference with other stakeholders, and minimizing traffic disturbances as well as noise pollution [Janné, 2018, Sullivan et al., 2011]. Additionally, another purpose of establishing a CCC is to reduce the need for warehousing space on-site which often in urban projects is a valuable commodity, resulting in an increase in on-site performance as well. This is accomplished through transport scheduling, where the HGV transports are sent to deliver the construction materials JIT, with the following consequences of waste reduction, faster project delivery, and increased on-site safety due to less movement [Ghanem et al., 2018]. Furthermore, a CCC can be utilized as a central hub for multiple projects, allowing for larger volume purchasing, which in turn may yield higher project margins.

1.1.2 The context of Gothenburg

In the context of Gothenburg, there has been a large movement of urbanization in the past decades, and with the [U.N., 2018] predicting the urbanization trend in the city to continue to above 90% by the year 2050 there are no signs of it slowing down. In addition to this growing population trend, the city of Gothenburg has initiated a few large-scale projects, both residential and infrastructure, resulting in the city is becoming even more void of space than before, with more stakeholders needed to be taken into consideration. Furthermore, with the ambitious environmental goals of the municipality to have all of their emissions related to transport reduced by 90% of 2010's value, an oversight in construction logistics plays a crucial role in reaching these goals until 2030 with the current emissions derived from construction transports being as high as 5% of the total emissions [Sundquist, 2023]. Given that urban freight related to construction accounts for 30% of the total freight movement, the leverage the construction industry could have in reducing total emissions through

more efficient logistical solutions is immense [Guerlain et al., 2019].

1.2 Purpose & Aim

The purpose of this master thesis is to explore and compile how an implementation of a CCC can effectively be established in larger cities. In addition to this, in Gothenburg with the prerequisites it presents within the context of logistical challenges in the construction industry and urban densification. Further, the study seeks to find and explore the key stakeholders and their responsibilities during the initiating phase of establishing a CCC, examining aspects such as financial investment, regulatory compliance, and operational management. Additionally, it aims to map the multiple obstacles and benefits associated with CCC implementation held by key stakeholders to identify possible risks and opportunities. Drawing lessons from successful CCC implementations in other major cities, the thesis aims to provide an accurate compilation of CCC implementation scenarios, which also can be used as a stepping stone when analyzing the needs of specific projects and development areas.

1.3 Delimitations

To limit the scope of the master thesis, the focus is set on the context of Gothenburg, and will not capture the challenges faced by other cities or regions with different urban characteristics, including opportunities and challenges, while still highlighting some that may be general and not exclusive to only Gothenburg. In addition to this, the study will be limited to investigating the implementation of CCC solutions that span multiple projects and can function over a long-term perspective. Furthermore, it does not delve into historical trends or future projections beyond the current context and contemporary challenges of Gothenburg. The research primarily examines the early stages of CCC implementation within the construction industry, including its logistics and SCM aspects, while excluding in-depth exploration of other sectors. The study relies on qualitative research methods, such as interviews, literature, and case studies, excluding quantitative approaches. Moreover, while the perspectives of many stakeholders are considered, certain viewpoints such as property developers, contractors, CCC providers, and municipalities, are prioritized based on their direct involvement in CCC implementation. Finally, the focus lies on the key stakeholders' needs for a CCC to function properly as well as the external CCC requirements. Therefore the internal operation of a CCC will only be mentioned briefly to be able to contextualize the challenges.

1.4 Research questions

1. Who are the key stakeholders during the initiating phase of establishing a CCC and how can the responsibilities of these key stakeholders differ in terms of financial aspects, regulatory compliance, and operational management?

2. What are the potential risks and challenges associated with implementing a CCC and how can they be mitigated or managed effectively?

3. How can the implementation of a CCC be introduced in to a metropolitan context?

    - How can lessons learned from CCC implementations in major cities be applied to the context of Gothenburg?

    - How can the gathered information synthesize into proposed strategy for an implementation in accordance with the prerequisites of Gothenburg city?

2
Theory

The following sections are based upon the literature findings and gives a theoretical foundation for this study. The theory chapter takes the wide-to-narrow approach, initially explaining the overarching concepts of SCM, proceeding down to the details of construction consolidation centers and key stakeholders.

2.1 Supply Chain Management

SCM is the concept of managing the multitude of relationships between different actors, both upstream, and downstream in a supply chain [Lambert and Cooper, 2000]. These relationships create a network of linkages of which SCM is most commonly defined as the discipline that encompasses the planning, implementation and control of processes, from their origin at the supplier, up until their final destination at the consumer [Cooper et al., 1997]. It is often a thin line distinguishing the difference between logistics and SCM, where there are many perceptions of how they relate, but the more commonly accepted among scholars is the unionist view; where logistics play a part of what SCM encompasses [Larson and Halldorsson, 2004, Sweeney and Edward, 2005].

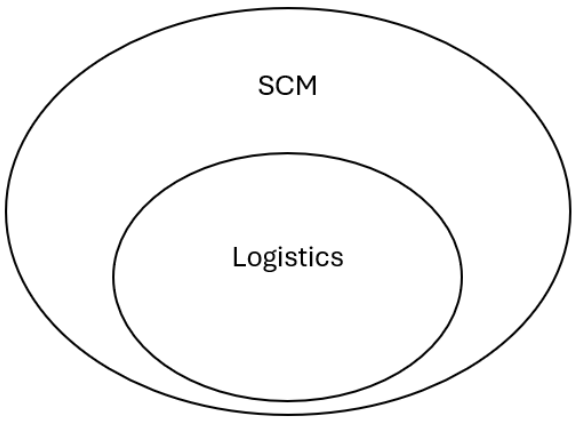

Figure 2.1: Depiction of unionist view.

2.1.1 Construction Supply Chain Management

Construction supply chain management (CSCM) is the part of SCM that solely focuses on the supply chains related to the construction industry. Additionally, CSCM is unique in the sense that its progress in using SCM as a tool to emphasize productivity has historically been lackluster [Vrijhoef and Koskela, 2000]. Comparing the efforts in addressing the supply chain-related issues in the construction to the manufacturing industry the progress differs a lot [Cutting-Decelle et al., 2007]. While the manufacturing industry is the pioneer in SCM with its Toyota production system, the construction industry has a lot to learn in terms of accomplishing JIT and reducing overproduction [Koskela et al., 1992].

These issues that currently present themselves in the construction industry can be derived from three reasons, firstly, the large amount of resource waste, secondly, the difficulty of addressing the waste-creating processes in time and finally, many of the waste and problems occurring in the industry are caused by the poor control of the respective supply chain [Vrijhoef and Koskela, 2000]. The consequences of neglecting the previously presented issues may be lacking productivity, project delivery delays and cost overruns with as much as 10% [O'Brien, 1999]. Additionally, another issue that can be attributed to the lackluster performance of CSCM is how the temporary aspect of a construction project hurts the strong relation upon which a functional SCM is funded [Vrijhoef and Koskela, 2000]. This forces each project to re-invent itself to some extent in regards to establishing the supply chain channels each time a new project is initiated [Koskela et al., 1992]. Continuously, in other industries where the SCM progress has reached further a common denominator is the usage of standardized parts [Dubois and Gadde, 2002a]. The construction industry in this case does not use standardization to the same extent due to its highly custom and complex nature, making each construction project a highly complex undertaking. Additionally, due to the multifaceted nature of the industry with many actors involved, a highly custom and highly competitive industry has evolved [Pryke, 2009]. This has resulted in the industry becoming more opportunistic and self-interested, consequently influencing the overall performance and innovation in the industry [Cox and Townsend, 1998].

2.2 Construction logistics in urban areas

As mentioned previously, logistics is often considered a subcategory of SCM and is commonly defined as the management of the flow of materials, tools, and equipment from their point of origin, up until installation and point of delivery [Almohsen and Ruwanpura, 2011]. Logistics is a crucial component of every well-executed project delivery, especially with the growing complexity of supply chains in the modern age construction projects [Sullivan et al., 2011]. In the construction industry, logistics is something that has been lacking as compared to other industries and often is a service taken for granted, resulting in it not being utilized to its full potential and falling short in its reach. There have been various attempts made to try and address the issues that the complexity of logistics presents, where many

solutions have had various levels of success.

With a growing urban population, the cities are growing at an ever faster rate spurring a need for new construction in an even denser climate [Guerlain et al., 2019]. Consequently, there has been a large increase in the numbers of HGV transporting materials as well as the lack of space for warehousing construction materials in urban areas [Janné, 2018]. The result of this great increase in the number of HGVs may bring unasked-for consequences such as traffic congestion, resulting in both an increase in traffic, as well as an increase in interference, adding up to 22% of the urban transports being construction related [CivicProject, 2018, Lindholm and Browne, 2015, Sezer and Fredriksson, 2021]. Additionally, with roughly 50% of the construction freight arriving before 09:00 on weekdays, and no transports on weekends, this problem of construction freight traffic interference is condensed into a small time-frame [Sezer and Fredriksson, 2021]. Given that urban freight related to construction accounts for 30% of the total freight movement, and an even larger part in terms of pollution, this will further necessitate the need for improved construction logistics [Guerlain et al., 2019]. With the prognosis of urban centers accommodating as much as 68% of the world's population by 2050 these issues that construction logistics are facing will only continue to grow if measures are not taken.

2.2.1 Construction's external interference in an urban environment

In the urban context there are many different stakeholders involved when transporting materials, interfering with traffic and perhaps re-directing roads or walkways. This interference that construction brings into the urban environment may bring social costs for the ones involved, which is categorized into the following four classifications [Gilchrist and Allouche, 2005].

- *Traffic*
- *Economic activities*
- *Pollution*
- *Ecological/social health*

Within these different categories traffic is the one category that directly affects the flow and congestion of vehicles as a consequence of less mobile HGVs passing through the urban centers. Additionally, a construction site in the city center can impose detours or even road closure, reducing the road space and further promoting a congested city center which may induce problems for the general public [Janné, 2018]. Continuously, the increase of construction freight also impacts the environment in the sense that 30% of the total tonnage transported in the urban center can be attributed to the construction industry, resulting in air pollution from emissions [Guerlain et al., 2019, Gilchrist and Allouche, 2005].

The economic disturbances that urban construction projects may infer are loss of income due to restricted accessibility of businesses, while this is in most cases com-

pensated for it still may harm businesses on a short-term horizon [Gilchrist and Allouche, 2005]. Additionally, the construction project may hurt itself economically through congestion by having a harder time accomplishing JIT or running the risk of having scheduling failures, pushing the project timeline further which may impose fines or loss of revenue [Guerlain et al., 2019].

Furthermore, a socioecological consequence of the construction interference is how it affects the quality of life of urban residents and visitors by emitting dust and heavy metal oxides from the heavy-duty processes [Gilchrist and Allouche, 2005]. In addition to the transports causing a disturbance the construction site itself can be considered guilty of the vibrations and noise pollution caused by heavy machinery, commonly perceived as one of the more annoying disturbances caused by construction.

2.2.2 Current logistical challenges

The construction industry is as previously mentioned characterized by its project-based, temporal organization and fragmentation, and with this comes challenges [Dubois and Gadde, 2002a]. Firstly, the lack of understanding of what are the costs of logistics contributes to the problem of trying to implement and financially motivate logistical solutions, as historically, logistics has often been a "hidden" cost or "included" in the price [Sundquist et al., 2018]. Additionally, it is common that the relation between material pricing and total logistics costs for the material to reach its intended location is that the lower the material purchase price, the higher the logistics cost to handle it [Vrijhoef and Koskela, 2000]. This extra logistical cost is often shown as inefficient labor on-site where contractors spend as much as 15% of their working hours in handling logistics [Sezer and Fredriksson, 2021].

Furthermore, the construction industry is commonly referred to as being slow and conservative while also being the industry constantly reinventing itself as each project is unique to the other [Kadefors, 1995]. Additionally, the industry can be described as a loosely coupled system, with many actors involved in the temporary setting of a construction project [Dubois and Gadde, 2002a]. These two combined make it difficult to facilitate organizational learning and foster innovation as well as long-term collaboration [Gambatese and Hallowell, 2011]. Furthermore, implementing logistical solutions requires great communication between different stakeholders, minimizing waste, and optimizing the supply chain [Dave et al., 2016]. To successfully address the logistical challenges of the construction industry, all of the aforementioned challenges must be dealt with.

2.2.3 Current logistical solutions

In today's day and age, construction logistics is gaining traction as a concept that can help reduce costs, increase productivity, and thus reduce the time of project delivery. Many logistical solutions can be utilized, which are often categorized as off-site and on-site logistics where they face different problems to excel [Sullivan et al., 2011].

The problem that is faced in the topic of off-site logistics is that the transports going in and out of the construction site with deliveries or waste may cause an external interference with traffic, creating congestion [Sundquist, 2023]. In addition to this, the large number of inbound material transports is something that needs to be addressed in terms of environmental concerns. The following solutions seek to address the logistical issues before them reaching the construction site [Sundquist, 2023, Lindholm and Browne, 2015]:

- Consolidate material transports to reduce number of veichles.
- Formulate a detailed Construction Logistics Plan (CLP) in advance to detail the site disposition plan, rules, safety measures, costs, area coding etc.
- Alternate forms of transports, utilize water/rail if the context allows.
- Utilizing Construction Freight Partnerships (CFP) to optimize transports.

In contrast to the off-site logistics, on-site logistics faces problems in terms of space, material coordination, material damages, material movement, all of which may be contributors to waste [Sundquist et al., 2018, Sezer and Fredriksson, 2021]. Additionally, insufficient planning was a main contributor in terms of waste-occurrence where many of the solutions had to be carried out *ad hoc*, resulting in schedule interference and further future disturbances [Ying and Tookey, 2014]. Some of the solutions that seeks to address these issues in advance before they cause disturbances are presented following by Sullivan et al. (2011):

- Off-peak hour distribution to avoid congestion at the construction site.
- Delivery control and transport scheduling to have a stable inbound material flow.
- Optimize tower crane and lift usage.
- Off-hour material handling to optimize the work hours of contractors and reduce unnecessary material movements and spread out the usage of lifts.
- RFID to track and sort material deliveries.
- On-site waste management

2.3 Defining the CCC

Distribution centers have been popular in many other sectors it is only during the 21st century the idea has started to be implemented within the construction sector [Muerza and Guerlain, 2021]. While CCCs have been adopted in some successful projects they are still by no means a norm in the industry which makes you ask why [Lundesjö, 2018]. One reason may be that the focus has been on improving logistics *on* site rather than *to* site. Finally, projects that implemented a CCC have been very contrasting, but the concept and methodology of maximizing logistical efficiency whilst minimizing disruption are the same.

CCCs, also called construction logistic centers (CLC) in some literature, are distribution facilities used to manage logistics and channeling material deliveries to and from construction sites, see Figure 2.2 [Sullivan et al., 2011, Lundesjö, 2018].

Suppliers or haulage companies deliver the material to the CCC, where they are stored briefly in a warehouse away from the site (often no more than 50km away), and by adopting a JIT basis a logistic team working from the CCC delivers the material to the site. Even though a lot of the material handling should go through the CCC, direct delivery to the site can happen simultaneously if necessary. Furthermore, to ensure safe handling and storage, the CCC should follow a palletization strategy where all consignments arrive on pallets or in a stillage. A time limit on the material stored should be set to ensure an efficient use of storage (ideally around 10-14 days). The scope of a CCC therefore includes storing, consolidation, handling of material, transportation, and a high level of cooperation between the construction project and CCC in terms of logistical plan. In addition to this, other services can be provided by the CCC to offload the logistical challenges of the construction project.

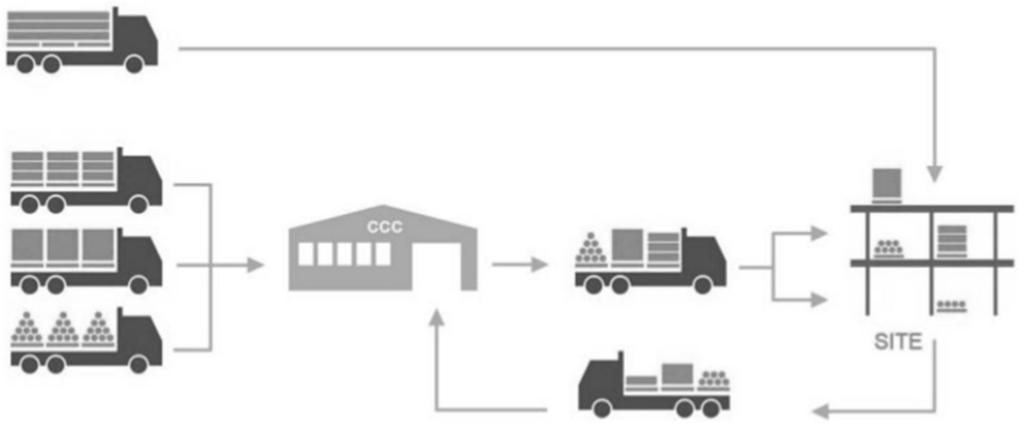

Figure 2.2: Supply chain of a CCC [Muerza and Guerlain, 2021].

2.3.1 Types of CCC

Implementing a CCC solution into a construction project can occur in many different ways and the application can be very flexible [Sullivan et al., 2011]. The concept can be adapted to serve a single project, multiple projects by a single contractor (within a region), or even multiple projects involving collaboration among different contractors. CCCs are customizable to meet specific site needs and can be managed by either the principal contractor or a specialized logistics contractor, depending on procurement, the size of the CCC, or the number of sites it serves. Furthermore, how a CCC is run can also depend on for example ownership of material or contractual agreements within the project, this will be discussed later. Below are three different types of CCCs suggested by Sullivan et al. (2011).

1. **The concealed consolidation center** - This type of CCC is typically operated by the site's principal contractor and is located within the boundary of the site hoardings. It is a basic form of CCC that provides short-term buffer storage to reduce congestion, potential theft or damage, and inconvenience

when otherwise transported directly to the site and stored. It is a site-based temporary warehouse unit with limited storage capacity and uses ten principal contractor logistics employees.

2. **The communal consolidation center** - This type of CCC is located away from the construction site and is used to manage logistical constraints associated with construction work. It is particularly useful for inner-city construction projects where there is a lack of storage space and facilities. The communal CCC is typically operated by a specialist logistics contractor and provides short-term buffer storage to reduce congestion and inconvenience when otherwise transported directly to the site and stored.

3. **The collaborative consolidation center** - This type of CCC requires collaboration between different clients and contractors and is the largest of the three options. It is the most likely to receive government funding. The collaborative CCC is intended to serve multiple sites simultaneously over a wide geographical area and is operated by a specialist logistics contractor. It receives its name from the collaborative nature of its shared use between different clients and contractors.

Furthermore, Greger Lundesjö (2018) lists a few variations on how a CCC have been set up in previous projects:

- Heathrow Consolidation Center (HCC) was set up in 2001 to serve the ongoing construction at Heathrow Terminals 1-4. The CCC was implemented by the contractor Mace, but run by a construction logistics specialist.
- The logistic center set up for Hammarby Sjöstad in Stockholm was instead initiated by the Stockholm City Authorities and is run by a construction logistics specialist.
- Londons CCC was similarly initiated by the authorities but is differently run by a partnership between, Transport of London, developers Stanhop PLC, the construction firm Bovis Lend Lease and logistics company Wilson James (operates the facility).

2.3.2 Resources and facilities of a CCC

The facility of a CCC is compared to other modern warehousing operations very simple and easy to set up [Lundesjö, 2018]. It does not require complicated in-house solutions for moving material used in for example postal logistics or more urban distribution facilities. The purpose is receiving bulks of material which are stored and then delivered upon order from the site. The importance within a CCC therefore lays in the process of consolidation instead of the physical facility. Continuously the volume of these resources of course needs to be adapted to the project or projects the CCC will serve and in comparison to warehousing in other industries they are neither large or complex due to the focus on consolidating. Lundesjö (2018) presents that the ideal resources for a functional CCC includes the following:

- *A small or medium-sized warehouse. At a minimum an open floor is all that is needed for storage; larger operations will include some pallet racking and shelving areas.*
- *Preferably a covered area where vehicles can be offloaded/loaded in the dry.*
- *Outside hard standing for large items and materials not vulnerable to the weather.*
- *A waste/recycling area for packaging materials and other waste.*
- *Forklift truck(s) for vehicle loading and handling in the warehouse.*
- *Vehicle(s) for delivery to site.*
- *Personnel such as a warehouse operative(s), administrator, and driver(s).*
- *Some kind of warehouse management system.*

Example numbers on the volume of resources are that larger projects, such as hospitals and residential apartments, may demand a warehouse area of 10,000m^2, whereas smaller projects can suffice with an area as small as 650m^2 [Lundesjö, 2018]. For instance, the London Consolidation Center, spanning 10,000m^2 accommodates three to six projects concurrently. In contrast, the Sainsbury consolidation, reuse, and recycle center, covering 6,000m^2, caters to numerous smaller projects and recycling needs. Vehicle requirements also differ, with large projects may utilize flatbed lorries, cranes, LWB transit, and multiple forklift trucks, while smaller projects typically only uses a transit van, flatbed lorries, and just one forklift truck.

2.3.3 Benefits of a CCC

Implementing a CCC offers a range of significant benefits for construction projects [Guerlain et al., 2019]. In the beginning, one main reason for introducing CCCs was to reduce traffic and congestion in urban areas, leading to reduced noise and emissions of adverse pollution. Further benefits are that a CCC provides short-term buffer storage, reducing congestion on construction sites, which can lead to improved site safety, reduced vehicle movements, and less disruption to local communities. Additionally, materials stored in CCCs are less susceptible to theft and damage compared to being stored directly on construction sites, resulting in cost savings for contractors and clients, as well as improved project timelines.

Moreover, CCCs contribute to improved health, safety, and welfare standards on construction sites and improve the organization of materials, thereby helping to reduce the risk of accidents and injuries. Furthermore, CCCs facilitate waste reduction and the reuse/recycling of packaging materials, leading to cost savings and reduced environmental impact. By providing just-in-time delivery of materials and equipment, CCCs can maximize productivity on construction sites, reduce downtime, and improve project timelines [Sullivan et al., 2011, Guerlain et al., 2019].

In addition to these operational benefits, implementing CCCs can increase accountability and enhance the image of the construction industry [Sullivan et al., 2011].

By improving the organization and management of materials, CCCs can help to improve the reputation of the construction industry and increase client satisfaction. Furthermore, CCCs help in reducing damage to equipment and materials by providing secure storage and reducing the need for on-site handling. Lastly, CCCs can lead to better use of the trade contractor's skilled trades workforce [Guerlain et al., 2019]. By reducing the time spent on material handling and organization, skilled trade workers can focus on their core tasks, leading to improved productivity and project outcomes.

2.3.4 Barriers for implementing a CCC

Implementing long-term sustainable logistical solutions in the construction industry are many times difficult due to the measures affecting conditions not controlled by the actors in charge of the initiatives. Hence, identifying the barriers is necessary for being able to overcome them. Initiating barriers have been identified by the project SUCCESS and are discussed below [Cordis, 2022].

The first barrier identified is the "Difficulty to evaluate the financial sustainability and market for the initiative" [Cordis, 2022]. This barrier underscores the complexity of assessing the financial viability of consolidation centers. It involves challenges in determining the profitability of CCCs, including high implementation costs, uncertain returns on investment, and the need for support from public authorities. Furthermore, it highlights the issue of identifying logistical costs in the construction sector and how it is not linked with the solutions that can be implemented [Sullivan et al., 2011]. Addressing this issue requires a comprehensive restructuring of current contractual agreements among all stakeholders, including considerations for new cost allocations [Cordis, 2022]. Additionally, they emphasize the necessity of clear business models, cost-benefit analysis, and quantification of processes to ensure the financial sustainability of CCCs.

The second barrier covers "planning difficulties" [Cordis, 2022]. It includes the various challenges related to land availability, price, and location. Such as the critical role of securing suitable land at acceptable prices for CCC initiatives. Hence a need for public authorities to intervene to address issues such as high land prices in city centers, which may hinder the profitability of CCC initiatives. Furthermore, the lack of integrated supply chains, planning, and coordination is identified as a significant barrier, leading to congestion, parking problems, and inefficiencies in scheduling, storage, and equipment sharing. Addressing these planning difficulties is important for the successful implementation of construction logistics optimization measures.

The third barrier discusses the "operational difficulties" [Cordis, 2022]. This barrier focuses on the resistance to innovation and the adoption of advanced technologies in the construction sector and is also discussed by Sullivan et al. (2011). It highlights the need for innovative solutions and the integration of Information and Communication Technology to optimize construction logistics. Additionally, private actors many times feel that the promotion of innovation should come from the authorities

since such change will impact procurement processes and related contracts. Further challenges related to outsourcing are identified, emphasizing the need for specific framework agreements, databases of qualified suppliers, JIT deliveries, and the implementation of the Supply Chain Operations Reference Model are also identified as operational difficulties and need to overcome.

The last barrier describes the issue of "Construction logistics as a niche topic" [Cordis, 2022]. It reveals that construction logistics is still considered as a niche topic and that most authorities lack knowledge and understanding of the importance of the subject. This leads to insufficient information in policy and planning documents. Overcoming this barrier therefore requires active engagement with stakeholders, raising awareness about the importance of construction logistics optimization, and fostering collaboration among diverse actors in the construction supply chain.

2.4 Preexisting CCCs in the construction industry

In this section some of the already existing or previously CCCs are exemplified, highlighting the stakeholders, services as well as potential accomplishments to provide a basis of understanding to industry practices.

2.4.1 Djurgårdsstaden CCC

The Djurgårdsstaden CCC was implemented to support a large number of constructions in the area of Stockholm Royal Seaport [Bergman, 2016]. Further, it was established to be in line with the environmental vision Stockholm City has of minimizing the impact of the construction industry. The CCC was established in May 2013 and aims to decrease transportation, increase load capacity, enhance accessibility by facilitating co-distribution with eco-friendly hybrid vehicles, and take care of some waste disposal. It is located close to the construction area to minimize transportation distance.

The CCC was introduced and established by the city of Stockholm which also took responsibility for the procurement process of warehouse suppliers, transportation firms, and gates. A third-party logistic company was hired to operate the CCC through an open proposal procurement process. Servistik was then chosen as a facilitator as well as for the tactical and the operational work in conjunction with Wiklunds Åkeri who is responsible for transports, warehousing, and gatekeeping. 2018 Servistik was replaced by Nobolog, still in collaboration with Wiklunds Åkeri, who still runs the operation and facilitates the CCC today. So, the CCC is owned by the City of Stockholm, and the responsibility is shared among various stakeholders including the City as the client serving the property developers for housing development, the contractors building in the area, and the CCC operator, operating the facility. The operator is responsible for the progress and coordination of all services at the CCC, while the City is responsible for the planning and building of the facil-

ity. The CCC coordinates several resources and services that are beneficial to the City, property developers, and contractors in the area.

The CCC offers a range of services aimed at optimizing resources and logistics needs for the property developers and contractors within the geographically limited area [Bergman, 2016]. These services include coordinated transport management from arrival at the project area to the work site, shared perimeter protection, coordinated waste management, construction site information, consolidating material transport, crane coordination, development phase coordination, summer and winter road cleaning, as well as physical management services such as unloading, receiving of goods, terminalisation, and coordinated distribution to the respective construction sites.

The project is still running but some positive outcomes already established by Bergman (2016) are a reduction in transport to the construction site and the amount of waste, leading to lower costs than estimated in the project. Furthermore, enhanced safety, cleanliness, and resource efficiency were found, as well as improved coordination. However, there have also been challenges and negative outcomes, including teething problems during the initial 18 months of operation, as well as difficulties in finding a balance between the costs carried by property developers and contractors. These challenges have required continuous improvement and adaptation of the CCC's operations.

2.4.2 Uppsala CCC

Uppsala municipality started the CCC to address the growing challenges with accessibility in the city as a result of increased population and many simultaneous large construction projects [Eriksson, 2018]. Further, they had seen the success of Djurgårdsstaden CCC and took inspiration from their solution. One big change Uppsala made is that they chose the location of the CCC close to the E4 highway instead of next to the construction site, this leads to good access to roads as well as the opportunity for multiple projects to use the CCC. The goal of the CCC was to coordinate and streamline construction transport, which is expected to reduce the number of construction transports to current projects by 45% and reach a consolidation number of 75%. Meaning that 3/4 of transports to the city are now only going to the CCC, and not into Uppsalas urban central area.

The monopoly of building permits and roadkeepers is held by Uppsala municipality, hence they are the initiators of addressing these challenges [Eriksson, 2018]. They procured the operation of the CCC and chose Wiklunds Åkeri AB as the operational contractor. The procurement involved a contract period from March 2018 with the possibility of annual extensions until 2032 [UppsalaKommun, 2023]. The municipality of Uppsala mainly funds the CCC through the construction companies' connection fees to the center, which is mandatory for companies operating in the designated areas to meet the city's sustainability goals.

The CCC contains of two main parts: one physical consolidation center and one digital delivery planning service [Eriksson, 2018]. Contractors are responsible for scheduling transports to the CCC as well as directly to project sites (direct transports are only approved if the transport meets the requirement of a minimum of 13 articles/pallets or a filling grade of a minimum of 80%). A consolidation service operates from the CCCs collection point, where the deliveries are consolidated and transported to the project sites. Every contractor is assigned an area at the collection point, tailored to the projects' needs.

Positive aspects include an efficient consolidation effect and a strategic location near the E4 highway to facilitate transportation as well as allowing for a communal consolidation center [UppsalaKommun, 2023]. A key insight from similar initiatives in Stockholm Royal Seaport CCC emphasized the importance of location, which has been integrated into the design of Uppsala CCC to avoid transportation challenges within the city. Furthermore, the long contract duration until 2032 allows for sustainable investments, including Wiklunds' sling trucks operating with 100 percent renewable fuel [Eriksson, 2018]. Increased digitization for monitoring goods flows also enhances visibility and supports other traffic measures, such as environmental zones.

Challenges include decentralized waste management, with contractors having the option to purchase services from Wiklunds [UppsalaKommun, 2023]. Ongoing challenges involve managing concerns and skepticism from stakeholders [Eriksson, 2018]. Therefore effective communication with stakeholders is crucial for addressing concerns and ensuring user-friendly system understanding. Increased digitization for monitoring goods flows enhances visibility and supports other traffic measures, such as environmental zones. A user-friendly system implementation is therefore highlighted as key to a successful operation.

2.4.3 London CCC

The London Construction Consolidation Center (LCCC) was a solution proposed for the increased demand of construction of housing, business, and infrastructure putting a high demand on managing the construction logistics efficiently [TfL, 2016]. The LCCC was started in 2005 and operated by Wilson James with the goal *"to deliver in the safest and most efficient manner possible the right materials to the right site at the required time in active partnership with trade contractors and project managers.* The objective of its implementation was to accomplish a JIT delivery schedule while reducing the number of transports going to the construction site through consolidation, resulting in reduced traffic congestion.

The project cost a total of £3.2 million and was a partnership between Stanhope PLC, Bovis Land Lease, Wilson James, and Transport of London. The different actors in the partnership had different roles where Stanhope PLC was the site developer, Bovis the contractor including project management of the construction, Wilson James was the actor responsible for the operation of the CCC with its ex-

pertise and its trucks, and Transport of London collected data and promoted the usage of the CCC through its various channels. The requirement for financing this project was to determine the financial viability of implementing one such solution and tracking the saved costs within the construction supply chain. This project spanned two years from 2005 until 2007 and intended to serve four office projects in central London. The operations were configured in such a way that a contractor would make bulk orders to a supplier, which is set to pass through the CCC and then can be called off by the same contractor to achieve JIT deliveries.

The CCC offered a wide range of solutions and services in line with its objectives of increasing productivity and reducing the interference of the four construction sites the CCC intended to serve. The services the LCCC offered were directly connected to the aims of the CCC where reduction of traffic congestion and air pollution was a consequence of the consolidation effort performed at the CCC. Additionally, the CCC served the function of being the single point of contact regarding deliveries, making the deliveries less prone to change in schedule through simple communication. Continuously, the CCC made use of reverse logistics, where materials and components that were abundant and not needed at the construction site could be sent back to the supplier through the CCC or recycled.

To track the success of the initiative a few goals were set up, focusing on reducing the amount of freight journeys by 40, reducing the journey time of supplier deliveries to contractors on site by 30-60 minutes, and accomplishing a delivery reliability of 97%. All of these goals were accomplished or even superseded by a great margin where the amount of freight journeys was reduced to 60-70% of transports passing through the CCC and 40% directly to the construction site. Additionally, the journey time was reduced by 120 minutes, doubling the expected reduction set by the goal. The delivery reliability reached the goal of 90% reliability. The lessons learned from this project that spanned two years were many, positively highlighting the immense impact one such solution could offer. However, the LCCC wasn't considered fully successful due to its low take-up of construction projects, only serving four projects with the possibility to serve ten. This makes the argument that the CCC was not used at full capacity and could thus reach even further in its achievements.

2.5 Early stages in construction projects

The construction project is divided into several critical stages from project initiation to project delivery often referred to as the project life cycle [PMI, 2016]. This section will focus on the early stages of a construction project and what decisions and tasks they encompass, ranging from project initiation, up until the procurement of labor and materials [Al-Reshaid et al., 2005]. A construction project consists of separate phases where different actors have different responsibilities [PMI, 2016]. It is worth noting that these different responsibilities may vary with what type of contract is being executed.

1. **Project initiation**: In the initiating stages of a construction project, PMI 2016 states that there are various tasks to be determined, starting with as little as an idea and evaluating the feasibility of this idea. This phase might be the most important since it lays the foundation for the success of the whole project. Some of the critical tasks to be handled in the initiation of a project are to determine the scope of the project, its goals, and the preparation of contractual documents. Additionally estimating the resources, cost, and deliverables required to carry out the construction project is a key activity in this phase [Ismail et al., 2013].

2. **Design**: The design stage consists of developing the design of the project further in accordance with what is requested from the client [PMI, 2016]. In this phase the design schematics are created, providing a basis for how much resources, and material would be required to carry out the project and a closer approximation can be reached. Continuously, the design stage is where the project road map is determined when each of the deliverables is due.

3. **Procurement**: In the procurement stage, all the material, labor resources, and equipment are due to be procured. This is the stage where long-term planning could result in great benefits to the construction project accomplishing great cost reduction in inventory purchasing [PMI, 2016]. There are various ways to approach the question when procuring these resources, in terms of material, the construction project could choose a buffer storage approach or a more lean approach, depending on the prerequisites of the project. When procuring resources in terms of labor and personnel a decision must be made as what and how many should be involved and, whether the project requires external solutions such as TPL-services, which tend to be perpendicular to the project complexity [Ekeskär et al., 2022]. It is in this procurement stage where a well-designed CLP could map the activities and material flows to best avoid unforeseen incidents driving cost and delays [Serra and Oliveira, 2003].

2.6 Stakeholders mapping of a CCC

Paying close attention to who has a stake and of what order of magnitude is highly relevant in evaluating such a case of the initiation process and governance structure [Janné and Fredriksson, 2019]. The nature of a construction project is that the end-product is constructed at the place of consumption, resulting in all equipment and materials needing transport to its intended location [Fredriksson et al., 2021]. As described by Guerlain et al. (2019) these construction transports in the urban environment account for a third of the total urban transports and consequently involve the external environment as well as the internal environment of the construction site. In a study conducted by Janné & Fredriksson (2019) focusing on the Stockholm Royal Seaport as a case it was concluded that the different stakeholders in a CCC can be divided into three levels of governance. These levels of governance are the strategic level, In the following table the respective stakeholder at the respective level of governance is depicted:

Strategic	Public authorities	Developer	Contractor
Tactical	TPL-provider	Contractor	
Operational	TPL-provider	Contractor	

Table 2.1: Stakeholder's level of governance [Janné and Fredriksson, 2019].

Adopting the levels of different stakeholders presented by Janné & Fredriksson (2019) and the commonly reoccurring ones presented in the examples from London, Uppsala and Stockholm, they can be sorted according to Table 2.2. The table is structured in the way of highly relevant, relevant and less relevant stakeholders.

Different stakeholders categorized according to relevance for CCC implementation	
Highly relevant	Contractor Client TPL-provider Authorities Developer
Relevant	CFP Suppliers Businesses in close proximity Landowners Residents in close proximity
Less relevant	Public transport Bikes & Pedestrians

Table 2.2: Key stakeholders in establishing a CCC.

In the following subsections, the highly relevant stakeholder's roles and expectations will be described. The relevant and less relevant stakeholders will not be described. While they are important to take into consideration, they are not essential for the implementation and core functions of a CCC.

2.6.1 Public authority & Client

In many cases related to a successful implementation of a CCC, the client is often from the public authorities and plays a significant role in the implementation of CCCs [Sullivan et al., 2011, Cordis, 2022]. They address planning challenges related to land availability, pricing, and location and can ensure suitable areas for CCC initiatives through urban planning and zoning regulations. Financially they can also provide support and investments, particularly in the initial stages, to mitigate implementation costs associated with CCCs as well as contribute to their long-term sustainability. Furthermore, public authorities are responsible for developing regulatory frameworks and policies that can support the establishment of CCCs. Their facilitation involvement can also extend to coordinating stakeholders, influencing

public procurement processes to incorporate CCC requirements, and actively raising awareness about the benefits. By fulfilling these responsibilities, public authorities can contribute to the successful implementation of CCCs, leading to improved urban logistics.

2.6.2 Contractor

The contractor, representing the construction company overseeing a project, is also a key stakeholder for the success of CCCs [Cordis, 2022]. They can identify the need for a CCC by assessing potential benefits and analyzing logistics processes to pinpoint opportunities. Further, they musy engage with public authorities, requiring collaborative efforts to find suitable land and address planning challenges. Financial viability can be assessed through a cost-benefit analysis and business model development. Contractors should also actively participate in the planning and coordination of the construction supply chain, incorporating technology for logistical solutions, and collaborating with stakeholders to ensure efficient material delivery. If the contractor owns the CCC, they manage its operation, ensuring efficiency and profitability. Alternatively, if the CCC is outsourced, the contractor ensures that they still are involved in the process for effective CCC management. In summary, the contractor's role spans optimization identification, collaboration with authorities, financial evaluation, supply chain coordination, and direct CCC operation if ownership is involved.

2.6.3 Developer

The developer is the company that develops the project and then later procures a contractor to carry out the construction. In addition to this, the developer could also be a public authority, and in larger companies, the developer and contractor could be the same entity [Fredriksson et al., 2021]. There are many similarities between the developer and the contractor and it is important for them as well to engage with the public authorities to discuss the possibilities of developing new projects, what challenges there may be, and finding solutions that meet the criteria of the authorities. The key interest for this stakeholder is to reduce the production cost through the higher efficiency a CCC solution could help promote thus resulting in higher profit margins. The objective of the developer in a CCC is to reduce the risk of project delay, through the productivity increase a CCC could offer [Cordis, 2022]. Additionally, the developer seeks to minimize the disturbances caused to third parties in close proximity to the project [Fredriksson et al., 2021].

2.6.4 TPL-provider

The TPL-provider can either be managed by the project contractor or outsourced to a third-party logistics company [Sullivan et al., 2011]. Whereas the latter is typical with collaborative consolidation centers. The TPL-provider is responsible for ensuring that the CCC is efficiently and effectively managed and that logistics processes are optimized to generate profit. This can include providing logistical services, ensuring compliance with all relevant regulations and standards, and developing a

business model [Cordis, 2022]. It is also crucial that the TPL-provider collaborates with the other urban logistic stakeholders by establishing communication channels and partnerships. Finally, they can provide information and training to construction companies and organizations to attract interest in the CCC solution.

3
Methodology

The following chapter describe the methodology that this study is following to reach the aim of the thesis as well as to present how the study is being carried out. Due to the investigative nature of the study, a qualitative research process including a literature review, interview study, and site observation has been used to gather information from literature and empirical standpoints. Finally, the quality of the research and ethical considerations are discussed.

3.1 Research approach

This thesis takes an abductive approach to answering the aim and research questions. This approach is beneficial since the interplay between theory and empirical studies can be used to continuously modify the theoretical framework [Dubois and Gadde, 2002b]. The possibility to go back and forth between theory and empirical studies also makes it possible to find things otherwise missed as well as get a larger understanding of the research area. The interplay for the abductive approach, or in other words a systematic combining is illustrated below in Figure 3.1.

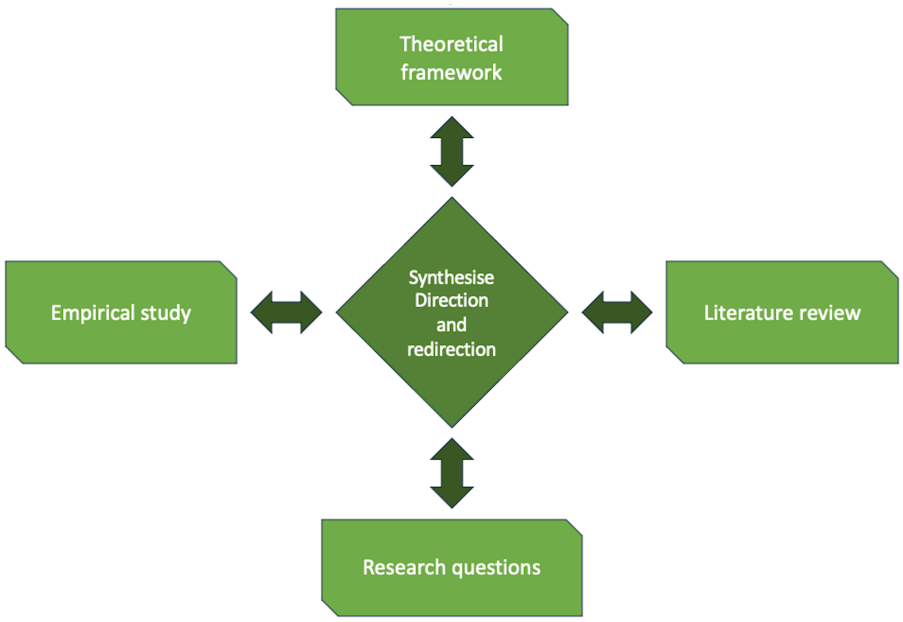

Figure 3.1: Interplay for abductive approach.

To achieve the aim of this study a qualitative research process focusing on interviews and verbal descriptions is used to understand the industry's perception. Interactions and needs between the key stakeholders, of which are Göteborg stad, contractors, and CCC provider, for implementing a CCC are to be examined. When "understanding the social world through an examination and interpretation of that world by its participants" [Bell et al., 2022] the current needs of the different parties can be found. Preliminary understanding and data collection of the current situation are generated from existing literature and then broadened by conducting several interviews to get a holistic view of the case. This approach may uncover additional aspects of the study, leading to a potential redirection of the theoretical framework as well as rephrasing the research questions. The results from the interviews will be summarized and analyzed with the theory to draw conclusions and synthesize the results.

3.2 Literature review

A literature review is conducted in the early stages of the study to generate a relevant theoretical frame of the case. The review aims to gather the important main ideas and current situation in the study [Bell et al., 2022]. It is an essential part of the research since it will give a general overview and understanding of the subject area as well as find possible gaps in the literature. The first part of the review was carried out before the first interviews and has its focus on the current situation as well as challenges regarding the implementation of a CCC found in the literature. Since the study takes an abductive approach the literature review have an iterative process during the whole research study as suggested by Dubois and Gadde (2022b). The results of the interviews and research therefore have an impact on the literature review and guided the development of the approach and angles of the study.

Academic databases such as Google Scholar and lib.Chalmers were used to search for literature by using relevant keywords. These keywords include logistics, construction, consolidation center, and implementation. In addition, books and literature used in courses at Chalmers University of Technology were used in the research. To sort out relevant information the abstract and keywords were examined to find literature related to the aim of the thesis. A critical evaluation of the sources was performed to find contemporary literature. Finally, the study is carried out within a Swedish context but the literature used in the thesis is both international as well as local.

3.3 Empirical study

Interviews are in qualitative studies one of the most commonly used methods to acquire adequate data [Bell et al., 2022]. Moreover, interviews can be flexible and focus on the interviewees' opinions regarding the research area. For this interview study, a semi-structured nature are used where some questions have been prepared to guide the interview. Although, flexibility still existed, where follow-up questions

around or outside the topic was explored. This is preferred with an iterative process since the semi-structured interviews can lead to new thoughts and realizations can be further researched in literature. The prepared questions are based on the research questions as well as findings in the literature. The questions varied to some degree depending on the interviewee since the interviewees represent different stakeholders in the industry and have non-identical roles.

Since CCCs are not systematically used in the construction industry the knowledge regarding the solution among the respondents varied. The goal was to have at least two interviews with representatives from each key stakeholder to be able to confirm similar needs or find differences in implementing a CCC. By having at least two representatives the goal was to create a result that are more trustworthy. Additionally, logistical experts was interviewed to get a holistic perspective of the needs and challenges. To create similar conditions for all interviews the process for all interviews was the following:

1. *Finding relevant interviewees:* Contacting companies which have an interest and knowledge about CCCs.
2. *Developing interview questions:* Preparing an interview guide to be used during the interviews.
3. *Performing the interviews:* Approximately 1 hours interviews were notes are taken and if allowed by the interviewee also recorded.
4. *Summarize the interviews:* Summarizing the notes as well as complementing with additional information from recordings.

3.3.1 Summary of interviewees

This section provides a summary of the interviewees, including current position and relevant previous employment. In the table below a summery of the interviewees representing stakeholders can be found.

Stakeholder	Name	Role	Date of interview
Public authority	Per Bramfalk	Site manager CCC	2024-02-01 2024-02-14
TPL-provider	Elin Pettersson	Sales manager	2024-02-15
Freight forwarder	Martin Mattsson	Site manager CCC	2024-02-15
Public authority	Jasmin Ahnfors	Business manager	2024-02-16
TPL-provider	Jon Svensson	Logistic manager	2024-02-20
TPL-provider	Fredrik Friblick	Logistic consultant	2024-02-21
Contractor/developer	Jonas Åslund	Project Manager	2024-02-26
Public authority	Magnus Jäderberg	Research manager	2024-02-29
Contractor	Daniel Nielsen	Site manager	2024-03-05
TPL-provider	Christoffer Johansson	Regional manager	2024-03-07
Contractor	Fredrik Balkåsen	Project manager	2024-03-07

Table 3.1: Summary of interviewees.

Per Bramfalk has since 2018 been the site manager for Djurgårdsstaden CCC in Stockholm, facilitating the CCC for Stockholm stad. Previously he has been working with construction logistics since 2010 and before that, he was the marketing manager for a logistics company working with production supply within the engineering industry. In 2012 he was involved during the procuerement process of the current Djurgårdsstaden CCC as well as in the startup of the operation. Between 2012 and 2018 he consulted on many logistical projects and has helped the public authorities with these kind of questions. Furthermore, he was an advisor for Uppsala municipality during their process of establishing their CCC.

Elin Pettersson is today the sales manager for Ahlsells logistical solutions, including the consolidation terminal in Gothenburg. She has previous experience with construction logistics at Serneke where she was the logistic manager in the project Karlatornet in Gothenburg. Here she facilitated the day-to-day activity of logistics which included planning for the usage of Karlatornet CCC established for supporting the construction of Karlatornet.

Martin Mattsson is the operation site manager for Uppsalas CCC managed by Wiklunds Åkeri. He is originally a trained electrician who has worked on many construction projects. He later came in contact with logistic work through the distribution of hall carpets where he took care of the route optimization. Finally, he came to Wiklunds Åkeri where he worked for 14 years with their freight forwarding services, and with his current role at Uppsala CCC for the last 4,5 years.

Jasmin Ahnfors is the operational manager representing Uppsala municipality in regards to Uppsala CCC. She represents the municipality towards the construction companies and makes sure that the relation operations work smoothly. Previously she has been involved with the stage coordination for the progress of the expansion projects in Uppsala.

Jon Svensson has the last three years been responsible for the logistics department in Sweden at Ahlsell and is also the one who was responsible for establishing the consolidation terminal in Gothenburg. He has continuously worked with logistics in many industries during his career, including vehicles and clothing. He came in contact with the construction industry in 2010 at Skanska where he worked in their logistics department.

Fredrik Friblick is the CEO of Prolog which is a company working with change management, competence development, and process management within the construction industry. He founded Prolog in 2001 and has worked within the construction industry with its optimization and development for over 20 years.

Jonas Åslund is a project manager at Serneke working with the project Karlatornet. He previously worked at Skanska for several years where he was a production engineer working with infrastructure projects in Sweden. He then became an assistant project manager for the airport project La Guardia in the USA, which had large

logistical challenges. Since 2021 he has worked at Karlatornet and has been closely involved with the logistical solutions in the project, including the consolidation terminal.

Magnus Jäderberg is the research and innovation manager at the land development department at Göteborg Stad and has long experience within the logistical field. He has previously worked at both IKEA and Tetra Pack with logistical optimization. Since 2007 he has been working with logistics at Göteborg stad in various roles. Currently, he researches different logistical solutions that can be applied in Gothenburg in different industries, one being a CCC for large construction project.

Daniel Nielsen is the site manager for a land remediation project at Ropsten in Stockholm City executed by PEAB. The project is part of the development area Djurgårdsstaden which means that it is connected to Djurgårdsstaden CCC. Previously in his career, he has worked as a leader and manager in an industry not connected to construction.

Christoffer Johansson is the regional manager for western Sweden for the logistical solutions at Lambertsson. Since graduating with a civil engineering degree he has worked with construction logistics. First at Svensk bygglogistik for 7 years in various roles, and later at PEAB where he worked until 2022 with the logistical solution for the project Platinan in Gothenburg.

Fredrik Balkåsen is the project manager representing Zengun, which currently building a commercial building in the development area Djurgårdsstaden and is also connected to Djurgårdsstaden CCC. Since working at Zengun he has worked with the logistical challenging projects Urban Escape and Sergelshuset, located at Stockholms urban center. Giving him a good knowledge of construction logistic solutions.

3.4 Site visit

To get a greater understanding of the operation and functionalities of a CCC, a site visit at an operational CCC in Uppsala was performed. This site visit involved an overview of the services offered at the CCC, as well as a description of the supply chain extending to and from the projects connected to the CCC, and the internal operation at the CCC. The visit also included a business insight into the daily operations and its challenges and difficulties. Overall, the information gathered from the site visit provided a deeper understanding of CCCs and facilitated more precise research outcomes.

3.5 Evaluation method

In this section, the method for developing and evaluating a compilation of different ways of implementing a CCC is presented. Inspiration are drawn from the EU initiative on research related to CCCs called SUCCESS . The method in this research for evaluating the feasibility and suitability draws contexts from theory and empirical findings and contains of a general SWOT analysis on CCCs, assembly of scenarios, and finally framing the CANVAS business model on the CCC scenarios. To conclude the findings the scenarios are then analyzed and discussed. This process is illustrated in Figure 3.2 where each of the steps will be explained in the following subsections.

Figure 3.2: Illustration of evaluation method.

3.5.1 SWOT analysis

A SWOT analysis was made for the implementation of a CCC in Gothenburg city to highlight the possible strength, weakness, opportunity and threats that exist. A SWOT analysis is a strategic planning tool that stands for Strengths, Weaknesses, Opportunities, and Threats [Gürel, 2017]. By identifying and evaluating these four elements you can understand the internal and external factors that can impact the success of a project or situation. The elements are further described below:

- **Strengths:** Internal factors that give an advantage or competitive edge.
- **Weaknesses:** Internal factors that pose challenges or areas that need improvement.
- **Opportunities:** External factors that could be advantageous to the objective.
- **Threats:** External factors that may present obstacles or risks.

The SWOT analysis in this research provide a structured approach to understanding the situation Gothenburg city will be in by implementing a CCC. The qualitative nature of the analysis allows for a deep understanding of the unique challenges and opportunities specific to logistics [Wang et al., 1711].

3.5.2 Assembly of scenarios

With the gathered information from theory and empirical study, four different scenarios were produced with a systematic approach. The scenarios encompass the various factors and conditions that influence the scope and business model of a CCC. The scenarios were later used as a foundation for using the CANVAS business

model. The four scenarios were created through a number of steps.

1. The first step, choosing the type of CCC, was partly decided by CCCs currently existing and operating well, as well as with the help of Sullivan et al. (2011) flow chart which aims to guide the choice of future application of a CCC which is shown in appendix 1.
2. In the second step, key drivers that will influence the establishment of CCCs were identified. These could include economic conditions, regulatory changes, stakeholder engagement, and environmental considerations.
3. In the third stage, a narrative for each scenario was developed that describes the conditions for establishing the CCC, which includes, among other things, initiators, stakeholders, and if requirements are at hand.
4. Lastly, the scenarios were compared and adapted, making sure that they easily could be differentiated as well as leading to various outcomes.

3.5.3 CANVAS Business model

The CANVAS Business model is a template model for developing or analyzing pre-existing business models in relation to nine different parameters [Osterwalder and Pigneur, 2010]. In these nine different parameters, the business model being evaluated aims to map the different constituents, presenting an overview of requirements, needs, and potential trade-offs within the evaluated model to see how a company intends to make money or value. Following are the nine different parameters the CANVAS Business Model is built upon:

- **Customer Segments:** Who and what organizations is the intended audience?
- **Value Propositions:** What bundle of services are offered to each respective Customer Segment?
- **Channels:** How is communication to the Customer Segments performed?
- **Customer Relationships:** What relationship is established with each respective Customer Segment?
- **Revenue Streams:** How is revenue attained?
- **Key Resources:** What assets are required for the model to function properly?
- **Key Activities:** What actions are required for the model to function properly?
- **Key Partners:** How is the supply network structured?
- **Cost Structure:** What are the operational costs?

This model has successfully been used in cases of urban logistic projects many times, such as TURBLOG, SMILE, and CITYLOG [Cordis, 2022], hence why the model is adopted in this research as well. In this study, the use of CANVAS business model aims to highlight key items that are important to take into regards in the implementation phase of a CCC. Furthermore, how such a CCC can create value for Gothenburg city.

3.6 Ethical considerations

To minimize ethical risks it is important consider ethics, especially when conducting an interview study [Bell et al., 2022]. Bell presents the following four key ethical principles based on Diener and Crandell (1978):

- Avoiding harm to participants
- Securing informed consent
- Ensuring participant privacy
- Preventing deception

These principles underscore the importance of participant well-being, obtaining consent, and maintaining transparency in research practices. These principles will be taken into consideration during the interview study. All participants will be asked if they want to be anonymous and if it is okay to record the interview. Furthermore, to ensure correct understanding of the interview the respondents will get the opportunity to review their contribution before publishing. Finally, following GDPR, all the notes and recordings from the interviews will be deleted after publication.

3.7 Quality of the study

To ensure a study with high quality, four criterions for evaluating the validity and reliability of qualitative research have been used [Bryman and Bell, 2011]. The following criterion need to be met to ensure trustworthy research:

- Credibility - How trustworthy are the results?
- Transferability - Are the results applicable in different environments?
- Dependability - Is it probable that the results are applicable at other times?
- Confirmability - Has the researcher acted objectively?

For ensuring *credibility*, the thesis uses a qualitative research approach, incorporating interviews, literature reviews, and case studies to confirm findings through data triangulation. Furthermore, the use of a qualitative method allows for in-depth understanding and exploration of the topic, while the iterative process ensures the possibility to continuously change and include more depth in the research, which further bolsters credibility. Finally, all respondents were, before published, contacted to verify that their understanding of the questions was correctly understood and utilized in the empirical study.

Regarding *transferability*, the study's focus on Gothenburg may limit generalizability to other cities with different urban characteristics. However, detailed descriptions of the research context, method, and stakeholders, offer insights applicable to similar urban settings facing construction logistics challenges.

Transparency in methodology, including the evaluation process and SWOT analysis, supports the *dependability* of the results. Clear illustrations enable future researchers

to understand and potentially replicate the study, enhancing dependability. Additionally, the method has been reevaluated multiple times during the study by the researchers, and supervisor, and opposed by an opponent group.

Reflexivity and objectivity maintenance throughout the research process contribute to *confirmability*. Qualitative methods include and consider multiple perspectives, further supporting confirmability. Overall, the thesis meets the criteria for credibility, dependability, and confirmability, though transferability to different environments may be somewhat constrained by its focus on Gothenburg.

4
Empirical Findings

In the following section, the findings gathered from interviews are presented. Including current usage of CCC solutions in Sweden, lessons learned from CCC usage, and key stakeholders' interests and responsibilities, as well as found driving forces in the early stages of construction projects when implementing a CCC.

4.1 Current usage of CCC solutions in Sweden

In Sweden today, some established CCCs exist and are used in construction projects. Additionally, services resembling the ones provided by a CCC have been brought up. Information gathered during the interviews about these CCCs and services is presented in the sections below.

4.1.1 Djurgårdsstaden CCC

Djurgårdsstaden CCC is owned and established by the city of Stockholm in 2009. Per Bramfalk explains that the usage of a CCC was necessary for the city to accomplish its environmental goals in terms of urban transport emissions. The CCC is also quite exploratory and they provide much more services than other more traditional CCCs. Besides consolidation, storing, and transporting material, one extra service is perimeter protection, where the city has bought gates, lights, and fences which the CCC centrally organizes and reuses on all the individual projects. The CCC is also responsible for electricity supply and alarms which are not traditional CCC services. Per believes that this is beneficial in this specific project since it will run for many years, and they could reuse many of the materials they have bought, such as the gates and fences, instead of the city needing to rent these.

Per Bramfalk describes that the CCC is mandatory for all property developers to use if they want to build in the project area. The current business model is an all-inclusive model where companies pay a connection fee when construction starts and then all of the services the CCC has is provided. The current model is not profitable for the city income-wise, but many societal benefits as previously mentioned have already been noticed, which was one of the goals for the implementation of the CCC solution. Per Bramfalk thinks the setup of a connection fee is a good solution if you can include it in the early stages of planning. The benefits that the city has seen from using this kind of solution have been many, including the reduction of construction-related transport. There have also been additional positive outcomes

such as the CCC providing safety and security to each of the construction sites connected to the Djursgårdsstaden CCC. This has resulted in the citizens in close proximity to the construction projects being offered a higher level of security and safety, something that Per heavily emphasized. Additional benefits for the citizens of Stockholm have also been a reduction in emissions and noise pollution, not only as a consequence of the reduction in the number of transports but also through the usage of electrical freight vehicles.

4.1.2 Uppsala CCC

With many similarities to Stockholm, the question of establishing a CCC arose when plans for large-scale urban development were being conducted simultaneously. The CCC drew much inspiration from the Djursgårdsstaden CCC and Per Bramfalk was consulted as an expert when the initiation of Uppsala CCC began. Per described the main reason for building the CCC was that the time plan of the development areas was tight, resulting in a high intensity of construction transports. Leading to a high level of emissions in the urban center which could not be tolerated by the city since it was reaching emission caps. On the other hand, it was implied by Jasmin Ahnfors that the sole reason why the CCC was required by the development area was that it would not be possible to handle the logistics otherwise.

Martin Mattson describes that the services the CCC provides are the traditional ones and include consolidation, transportation, unloading, and loading, but also the opportunity to use their system, Promate, to coordinate logistics planning. Similarly to Djurgårdsstaden CCC, the business model is set up as an all-inclusive solution with a connection fee being paid before construction starts. Jasmin Ahnfors mentions that the municipality has priced the service on a level that the contractors and developers often find to be expensive, at the same time the municipality loses money. In some cases, this loss of money can be counted as a social or environmental benefit where air pollution is reduced with less transport. Furthermore, Martin describes that the cost-benefit relation between the cost of operating the CCC at a loss and the benefit on a greater scale is hard to estimate without precise calculations. However, the savings on highway tear and maintenance costs as well as environmental savings may justify the cost of operating the CCC to some extent. On the other hand, the current solution is very expensive for Uppsala municipality and an investigation on the future of the CCC is ongoing at the moment.

Operationally, the consolidation of material has seen great success according to Martin Mattson, and during 2023 a reduction of around 3000 transports into the city center was made. Furthermore, they have seen that companies connected to the CCC are getting better at consolidating and planning their transport to maximize the service. He notices that all actors benefit from the solution, both the ones with limited construction areas but also the ones with larger ones since the workers focus less time on material handling.

4.1.3 Karlatornet CCC

Karlatornet CCC was established and owned by Serneke but operated by Ahlsell. The CCC was a part of Sernekes' solution for being able to build Karlatornet and it would not have been possible without it due to the site area and complexity of the project. Jonas Åslund further explains that Serneke covered all costs surrounding the CCCs and the solution was therefore required for all sub-contractors to utilize in exchange for them streamlining labor efficiency as a trade-off. Serneke chose this setup due to the CCC being mandatory for all contractors to use and making it possible for Serneke to control all logistical flows to the site. Elin Pettersson was the logistics manager representing Serneke in this project establishment. She explains that during the project all transport went through the CCC, except full trucks that could meet a set slot time at the site. The CCC covered many services besides warehousing and consolidation of materials, such as Myloc services for deliveries as well as communication platforms for all companies. Additional services such as the logistical planning including time and consolidation planning were run by Serneke themselves to gain an oversight of the operations. The future of the terminal is currently uncertain, but Serneke will not keep operating a CCC from the location after the Karlatornet project completion.

4.1.4 TPL-provider

Ahlsells was originally a distributor of installation products, tools, machines, and supplies for sectors including industrial, construction, real estate, and the public sector. Besides this, they have begun providing other services such as logistics, one being a consolidation terminal operating in Gothenburg city. Elin Pettersson describes that this terminal is being rented by Ahlsell and is also operated by them. The terminal includes a space of $35000m^2$ with both inside and outside storage, and it currently serves around 40 projects in the Gothenburg area with mainly consolidation and storage of materials. This includes projects outside the construction sector since they serve other sectors as well. Jon Svensson further explains that they aim to reach an effective delivery plan where it is not only JIT to the gate but throughout the whole supply chain. In comparison to CCCs managed by the public sector Ahlsells terminal does not consolidate materials on trucks that will deliver to several projects in one round. This mainly depends on their high degree of filling as well as that it creates uncertainties with JIT delivery.

Jon Svensson further describes that the terminal was established since they saw a shortage of service in Gothenburg, and Ahlsell could meet this need. Currently, they still see a large demand for this kind of service and are looking to expand it further. Even though there are no requirements set by authorities, Ahlsell manages to operate a profitable terminal that companies frequently choose to use in new projects. This is something that other stakeholders believe is not possible which is interesting and creates the question of why this is. Elin Pettersson describes that their business model intends to keep it as simple as possible to make it clear for the clients what they get. The baseline is that clients pay per $100m^2$, hourly for truck drivers, per transportation as well as daily rent if flatbeds are left at the site. Additionally, the

clients can pay for other on-site solutions if they want those services as well. The simplicity in their business model is something that Jon Svensson also thinks is a reason why their solution is profitable. Elin Pettersson also implies that profitability depends on the terminal consolidating and storing materials from more industries than only construction. For example trains for Trafikverket. This allows them to fill up the terminal during a recession as well.

Lambertsson, a provider of all sorts of construction-related rentals, as well as TPL solutions, has also been using CCC-resembling solutions in projects, as explained by Christoffer Johansson. He describes that they have utilized terminals for consolidation purposes during construction with the intention of JIT deliveries. One example was during a project in Borås where they rented space from a storage company that had experience with temporary storage of construction materials. Additionally, the material was kitted and delivered after construction hours to maximize efficiency. Furthermore, he explains that the public authority in Borås is very progressive with logistical thinking and that it was them that wanted JIT deliveries. However, it was Lambertsson who suggested the CCC-resembling solution of consolidating material at a terminal.

4.1.5 Freight forwarders

Besides operating the Uppsala CCC and Djurgårdsstaden CCC, Martin describes that consolidation of materials has been offered by Wiklunds Åkeri and many other freight forwarders for several years. Although they call it by other names such as warehousing or storage consolidation. Many freight forwarders own big warehouses, and thus use them for different purposes depending on the needs of the companies they serve. Sometimes these services can be very similar to what a CCC offers and provides. Martin therefore implies that certain CCC solutions are not revolutionary and new but rather well-established within freight forwarders. Why these warehouses are not called CCCs are because they are not only a CCC since their services change over time. A CCC also often provides many other services, such as waste management, sling trucks, and application services. In conclusion, there are not many established CCCs, but many freight forwarders offer certain CCC solutions in Sweden today, which also are widely used in the construction industry by several different actors.

4.2 Lessons Learned

Shown below are the lessons learnt from experiences in working with CCC solutions and additional considerations that should be made for future solutions.

4.2.1 Djurgårdsstaden CCC

Djurgårdsstaden CCC was established from an experimental point of view and the CCC solution has evolved throughout the years. One large lesson learned explained by Per Bramfalk is the CCCs business model. The initial business model aimed to

charge for transactions. The more deliveries, the more expensive it became. They also charged for storage and various other services the CCC offered. These charges were also controlled by for example "number of times a gate was opened". This created problems where contractors tried to avoid charges by leaving the gates open since this only showed as one delivery. Finally, when discussing with the main contractors about these issues, they realized that their goal was to deliver a positive experience of a CCC, which was the main argument for changing the business model.

The concept for the new business model was an all-inclusive solution, where there was a higher connection fee for the builder, but once paid, almost everything was included in this solution, removing the incentive to "cheat." Among other things, 12 days of free storage was introduced along with several security solutions. Now, the collaboration begins on entirely different terms. There is no need to discuss costs in the same way, which benefits a better relationship. The goal today is for these companies to have such a positive experience that it creates demand elsewhere. Which was not the case with the first business model. Per comments that this business model works well for Djurgårdsstaden but it should not be replicated in other major cities but more inspired by, since every city has its prerequisites. Overall the newer business model works a lot better than the previous and it can be a good starting point for establishing new CCC in other major cities.

4.2.2 Uppsala CCC

In Uppsala the question of whether a CCC should be implemented or not was raised by a local freight forwarder and was later evaluated and procured by the public authority. This posed a problem since the investigation of introducing a CCC took a long time and construction of the development area had already been going on for a short while. Both Jasmin and Martin described this to be problematic for the contractors being forced to later adopt the CCC solution, after their contract had been procured, resulting in a change of project scope and approach. The lesson learned from this instance in Uppsala CCC was that every developer and contractor should be contractually bound to use the solution before the project starts, removing the occurrence of alterations or contractual misunderstandings.

Additionally, in Uppsala, they have run into the same issue as Djurgårdsstaden CCC, where the business model is not entirely meeting the requirements that they had wished for. The current business model being used in Uppsala CCC is based upon a connection fee for the developer, just like the one previously explained in Djurgårdsstaden. The issue described by Jasmin and Fredrik Friblick was that when the business model was created, it was not configured to handle dynamic volumes of flows, resulting in high operational costs when the economic situation alters the building rate. To try and address this issue, they are currently reiterating the business model. Another issue, further complicating the development of a suiting business model with a connection fee is described to be due to the fee being too low, although its users experience the cost to be too steep. Uppsala municipally chose a lower price to avoid contractors not wanting to build in the area. However, Magnus

Jäderberg discusses that the extra costs of logistical solutions are minimal when comparing it to the whole project and that contractors should not have a problem paying for such solutions. Hence, the lesson is to carefully choose a profitable business model, break even, or at the very least, operate at a small deficit that can be motivated by project complexity or societal benefits.

4.2.3 Karlatornet CCC

Since Karlatornet CCC was established to serve one project only as well as Serneke paying for the solution, the main lessons learned according to Elin Pettersson was about optimizing the usage and communication. She explains that from the beginning an overall logistical plan existed for coordination provided by Serneke while the sub-contractors were responsible for their material and planning when it would get delivered to the CCC and to the site. Initially, the sub-contractors were not used to the system Myloc but as it was stipulated contractually, they had no choice but to adjust their workflows accordingly. As the project proceeded the logistics management at Serneke, including Elin Pettersson, started to plan the consolidation and transportation more thoroughly to ensure the constraining time-plan as well as reducing the margin for errors. Jonas Åslund explains that even the time for carrying in all material was estimated by the minute to be able to optimize the number of transports to site and into the building. Elin Pettersson continues by stating that planning every little detail precisely was key for succeeding with the operations and time plan of the project. The lesson learned is to make sure that a detailed plan for consolidation, transportation, and hitting slot times exists to ensure the project delivery. This gains even greater significance during intense construction periods where large amounts of materials are being delivered every day.

Another issue brought up by Jonas Åslund with the Karlatornet CCC is that the CCC was planned to be used for the whole development area of Karlastaden, but because Serneke needed to sell certain areas of the development area due to inflation and the rise of material costs the future of the CCC is now unclear. The return on investment will be decreased due to the CCC not servicing the whole development area since the cost of the CCC will be distributed among fewer projects. In the case of Karlatornet the CCC was necessary for building the great building and Serneke sees no financial loss with the CCCs shorter lifespan. However, in other projects, a shortening in a CCC lifespan can have an extensive effect on the project budget. Hence, the lesson learned both is that having an extensive plan in terms of adaptability and unpredictable events is important, as well as that the cost of a CCC can be distributed more with long-spanning usage than short-spanning.

4.2.4 Summary of lessons learned

A summary of the experiences from Djurgårdsstaden, Uppsala, and Karlatornet CCC which offer valuable lessons and considerations for future CCC implementations are listed below.

- An **adaptable business model** is highlighted as important to ensure that the business strategies meet the evolving nature of construction projects. A flexible and adaptable business model will ensure that the CCC can meet the needs of new projects and stakeholders, as well as emphasize the need for tailored approaches based on local prerequisites.

- **Early stakeholder engagement** when introducing a mandatory CCC connection is crucial for contractual understanding and project efficiency. Ensuring that all actors are onboard and able to prepare from the beginning of a project can mitigate issues such as resistance and try to avoid demands.

- **Balancing costs** becomes important in publicly financed CCCs where operational costs are weighed against social benefits. The temptation to minimize charges to encourage participation must be carefully weighed against the financial sustainability. This balancing act requires an investigation of the cost-benefit dynamics to ensure financial stability in the CCC.

- **Planning and communication** between involved actors is critical for ensuring efficient usage of a CCC, particularly evident in the Karlatornet experience. Emphasizing the importance of comprehensive planning, especially during peak construction periods, is a key takeaway for effective CCC operations.

- **Long-time planning** for the CCC is of high importance for being able to adapt to unforeseen events and changes in project scope.

- The **lifespan of a CCC** is important due to the financial benefits of long-term usage lead to a more effective distribution of costs.

Overall, the lessons learned speak to the importance of adaptable and inclusive business models, early and clear stakeholder engagement, careful balance of costs and benefits, and meticulous detail in planning and communication. By incorporating these insights, future CCC projects can navigate challenges more effectively and optimize their operational efficiency.

4.3 Key stakeholders

In the following section, the key stakeholders identified by the interviewees are presented in terms of their interest and responsibility for establishing and utilizing a CCC. The public authority was identified to mainly consider climate and social interests, contractors and private developers are grouped due to their common interest of financial and productivity gain as well as utilizing the solution, and finally TPL-providers with the interest of facilitating CCCs and acting as providers of the solution.

4.3.1 Stakeholder interests

When observing the question from the **public authorities** point of view, they highly emphasize the reduction of transport, and the positive consequences of reducing emissions and disturbances to the urban population, described by Per Bramfalk to be one of the contributing reasons to establishing Djurgårdsstaden CCC. Continuously, Magnus Jäderberg describes that these wished-for consequences can be addressed through various requirements stated by the municipal actors. In contrast to the focus lying on the environment and civilian population, Jasmin Ahnfors states that the reason for Uppsala CCCs' existence is not primarily to address this, but rather that the project development areas would not be buildable without this kind of solution, and the environmental and civilian safety gains were welcomed consequences. With this in mind, Martin Mattson states that if a public agent were to provide a CCC solution, they can calculate the gains of the environment, wear, and safety as economic gain, although hard to measure as opposed to if a private actor were to provide it.

Furthermore, when observing the interests of the **contractor and private developer**, Per Bramfalk describes that the CCC initiative in Djurgårdsstaden had affected the construction industry positively through the services that it offers, with many actors leaving their finished projects with a positive understanding of the possibilities of a CCC. However, as private developers in the area of Norra Djurgårdsstaden are stipulated to connect to the CCC to be allowed to develop, they are described to start with a negative view of its applications and possibilities and the relation starting *"..on the negative side.."*. But in the end, after project completion, they do acknowledge that the CCC had benefited them enormously.

The ultimate accomplishment is described to be actors of the industry understanding and marketing the solution for others to understand the potential it may have for project delivery and structure, all of which may have economic benefits to the actors, something Jonas Åslund implies is the bottom line for every private actor. Consequently, resulting in every decision boils down to whether the solution poses an economic advantage or not. It is implied by Jon Svensson that the difficulty of convincing contractors that there is an economic gain in utilizing logistical solutions is one of the greatest challenges. This is further exacerbated by Jasmin Ahnfors when it was described that the CCC in Uppsala has allowed projects to be completed earlier than first anticipated, yielding a productivity boost. Something that Jasmin wanted to emphasize more is to communicate the potential of a CCC in *"their language"* tying back to this economical perspective previously described. Additionally, Martin Mattson confirms this notion of users not understanding the potential until it has been shown in their project performance. Some of the productivity increases that can be derived from the CCC are less material waste, better on-site conditions, and higher levels of JIT. These effects were described to be appreciated to such an extent that actors that were not contractually obliged to connect to the CCC wanted to connect as well.

The interest of the contractor in utilizing a CCC solution is described by Jonas Ås-

lund to only be a means to reaching higher productivity goals, as previously stated, this may be due to the project complexity, requirements or it being economically advantageous. Daniel Nielsen describes that there may be other instances where the contractor would be interested in the services that a CCC can provide. In the case of Djurgårdsstaden CCC, has have been the additional service of project coordination, alleviating the contractor of the complex task of dealing with other projects in proximity to their project which Daniel Nielsen acknowledges as a success for the project. When asking Fredrik Balkåsen whether the usage of Djurgårdsstaden CCC was beneficial for the project, it was mentioned that it both had and had not, this is then explained that they are in the initiating stages of construction, not making consolidation very necessary due to the already high filling rate of inbound transports. In addition to this, his project does have a large site layout, located on the very edge of the development area, allowing for on-site storage to some extent. He makes the argument that while he does acknowledge the benefits of the CCC, he would like to decide when to use it due to some stages in the construction process are more logistically intensive than others. While the CCC offers great benefits to the contractor it is mentioned by Jonas Åslund that a voluntary implementation would only be considered as a viable option to the contractor if it facilitated a lower tendering offer of the project. In contrast to this, Christoffer Johansson states that there have been cases where a CCC solution had been implemented as a way to show the holistic planning of the project.

Continuously, the **TPL** is only the facilitator of the CCC, and providing this kind of solution may pose great economic benefits, given that there is a request. When discussing this matter with Elin Pettersson and Jon Svensson, they describe that there already is a market demand for logistical solutions, but for its possibilities to have an impact of scale, the challenge of creating the awareness previously described persists. They strictly believe that they as a private actor should be the facilitator of these solutions given their expertise, something acknowledged somewhat by Magnus Jäderberg, stating that a municipal agent will never be an expert in construction logistics. There is an interest from TPLs in a demand that is artificially created by stimulus from imposed requirements, as stated by Jon Svensson. Currently, the demand is high enough for it to be financially sensible to operate this solution from a private perspective, however, with this artificial demand, the possible gains would be even greater.

4.3.2 Stakeholder responsibilities

When conducting the interviews many common denominators were found in which stakeholders were mentioned as pivotal to the success of a CCC. All interviewees as previously described have mentioned the public authority to possess a central role in this question, whether it be providing the solution or providing the *"playing field"*. Additionally, they all do mention that the private developer or the contractor plays an important role, this is due to them being the users of the CCC services and its functions.

When interviewing Jonas Åslund, representing the contractor and private developer perspective, it was described that there may be a large underlying issue in how things are procured concerning how construction logistics is favored. He describes that in both private and public procurement lowest price tenders are often the ones awarded the contract, and adding the extra costs of introducing construction logistics generally disfavors the tender proposed by the contractor or private developer. This is due to the productivity gains that the CCC solution may offer a project is spread across all actors involved in the construction project, allowing subcontractors to save labor hours and the cost savings not being realized until project completion. This could be described as some sort of imbalance where the subcontractor would be the largest benefactor of the CCC solution. On the other hand, the contractor is described to be the hardest actor to convince into using a CCC due to the risk of them carrying the economic burden, while not receiving the full benefits of it. For this function properly the subcontractors would be required to put realistic tenders, reflecting savings on labor from the productivity gains of the CCC solution. Jonas acknowledges that this is a complex estimation to make due to the high uncertainty of exactly how large this gain could be.

Jonas Åslund describes that for CCCs to gain traction and be used more widely by contractors, their benefits must be fully realized. This is complicated since all interviewees describe the entry into understanding the benefits of using a CCC is through using one, creating a step into uncertainty for an already conservative industry. This is where some actors, such as Per Bramfalk, Jasmin Ahnfors, and Martin Mattsson agree that the public authority should create a solution which forces industry actors into coming in contact with the logistical benefits a CCC would offer. Oppositely, Jonas Åslund, Elin Pettersson, and Jon Svensson do recognize the need for public agents to drive the interest of the industry in a certain direction. However, they describe that there would be a more suitable approach to letting specialized actors operate within their field of profession, meaning contractors focuses on construction, public authority focus on municipal management and TPL-providers focus on the logistical solutions. Overall, when discussing this topic with the interviewees from the public authorities and contractor perspective, they acknowledge that the responsibility of increasing awareness of CCC solutions must be burdened by the public authority since they are the ones who mandate requirements. In addition to this, the interviewees agree that the construction industry may be a little too comfortable and habitual, complicating changes but perhaps necessitating requirements to drive this change.

4.4 Driving forces in early stages of CCC implementation

All interviewees agree that the implementation of a CCC is a good solution to mitigate the large number of construction-related transports in urban centers. There are various interpretations and descriptions of who should be a driving force in realizing this solution, as well as how. Simply put, they agree that some sort of

requirement is necessitated for the development and establishment of these solutions to prevail and gain traction. All parties do agree that these requirements should be put in place by the public authority governing the area, however, there seems to be a lack of alignment of who should be the one being the provider of the solution. Hence, this section concludes the interviewees' thoughts on how stakeholders can act as driving forces in the early stages of implementing a CCC, as well as reflections on who should be the provider of the solution. Like the previous section, the key stakeholders are categorized due to their similar opportunities to act as a driving force.

4.4.1 Public authority

When interviewing the public authorities, they all seem to agree that requirements are essential to the success of a CCC. Both the representatives from Uppsala and Stockholm agree that these requirements should be formatted in such a way that when developing in the respective areas, connecting to the CCC is compulsory. They describe the public authority to be the sole actor that could achieve this, and drive the usage of CCCs forward through providing great examples of its benefit to private developers and contractors. Jasmin, Martin, and Per all hope that through providing this good example, their satisfied customers will find similar logistical solutions necessary for the future success of their projects and stimulate a demand, which in turn may develop a market for the CCC solution.

Furthermore, when consulting Fredrik Friblick on what he sees are the requirements for the success of a CCC he does acknowledge the need for the public authority to create the regulatory boundaries of which the industry is to follow. This may be a simple task if the municipality is the one selling the plot of land, in which requirements can be established, something that Per Bramfalk also mentions as an opportunity. This becomes a difficult task if the land being developed has been owned by the private developer since earlier, and suggests that overarching requirements would be a suitable solution due to their versatility in reaching both of these situations. Something Fredrik Friblick stressed was that if a public actor was to set requirements, it is also important for them to provide support in how to reach them. In the case of CCCs, if these overarching requirements were to be implemented, they would most likely spur a need for CCCs and consequently, there would be a requirement for some actor to distribute this service. Fredrik does not see the problem with incorporating the CCC as a solution to fulfilling the previously stated requirements, however, he underscores the importance of using supplementary solutions as well, which may accomplish the same effect.

The TPL-providers Jon Svensson and Elin Pettersson instead describe the decision of what requirements being put in place to be a fundamental driving force in how a CCC could and should be used for the benefit of the public authority. Jon suggests that rather than the public authority being the provider of the solution, they should create the *"playing field"* in which the industry can fit and adapt their business models and solutions, something that Fredrik Friblick describes as overar-

ching requirements, targeting the industry as a whole instead of individual projects. Jon Svensson states that there may be a reason why the initiatives of publicly procured CCCs have not spread further than the ones seen in Uppsala and Stockholm and implies that maybe this is a case where the industry would be better off taking the risks and perhaps rewards. He emphasizes this further when describing what the *"playing field"* should look like and describes that the public authority should look into setting requirements for how the city should be operated as a whole, suggesting requirements such as maximum number of arrivals, size of transports and time slots of when transports are allowed to happen. In addition to stating these suggestions, he describes that there are risks with making requirements and that they may bring unwanted consequences where the industry may try to be exploitative to some extent, and therefore requirements must be carefully considered.

The challenges that the public authority is facing are described by both Magnus Jäderberg and Per Bramfalk to partly originate from the split political interest of how and where resources should be prioritized. While all politicians have a common interest in reducing transport and environmental impact while increasing safety for their citizens, they describe the efforts to accomplish this to be split. This is further complicated by the possibility of the political current changing and perhaps run the risk of disfavoring the CCC solution and prioritizing resources on different efforts. Furthermore, the understanding of what a CCC may offer to the public may not be fully understood, not even internally. Magnus Jäderberg describes that there is a lot of convincing that is necessary to create an understanding of the idea of implementing a CCC among other municipal departments. Additionally, the public authority is strictly bound to the law of public procurement, while it creates equal opportunity for all actors fulfilling the stated requirements, it may impact the expected quality as cost is what decides the ultimate solution.

Overall, the interviewees procured by, or representing the public authority emphasize the need for the public authority to be the guiding light in the development of CCC-usage in the sense that they do not believe a private actor could stimulate the demand in solitary. However, they do recognize that they can not be the sole actor providing the CCC solution and wish for this demand to sprout from their successes in promoting the possible benefits of a construction project by using a CCC. In contrast to this, among the interviewees representing the private actors, there were disagreements about what had been stated by the public authority. They recognize the need for the public actor to have a central role in creating rules and regulations that the industry needs to adopt and provide solutions. Continuously, the private representatives do not necessarily agree that the public actors need to be this guiding light in creating a demand since they have already succeeded in establishing a profitable solution as demonstrated by Ahlsell.

4.4.2 Contractor/Private developer

The interviewees highlight that there are various levels of understanding of construction logistics among contractors and private developers. The interviewees agree that there is a large conservatism within the industry with a negative attitude to change, further complicating the idea of introducing construction logistics as a solution to address the productivity of construction projects. This attitude towards construction logistics has been described to have changed among contractors, private developers and even subcontractors when the solution has been mandatory, and they have been forced to utilize the CCC solution. This is described by Martin Mattson and Per Bramfalk to in some cases have resulted in higher project productivity, creating an economic incentive for contractors and private developers to achieve logistical success, something which the CCC is described to contribute to. As stated by Jon Svensson, the economic burden of incorporating logistical solutions such as consolidation or JIT deliveries should not be seen as a burden but rather an opportunity for the contractor to save resources, increasing their potential yield. Therefore the main driving force of why a contractor would consider adopting CCC solutions boils down to whether it poses an economical advantage. Continuously, Fredrik Balkåsen states that the possibility that contractors have in driving the change forward is to provide good examples themselves. As previously mentioned this gain in productivity is prevalent and can have large effects on the project economy. This is something that he and Christoffer Johansson describe the contractors can transmit themselves as a competitive advantage reflecting holistic thinking in their implementation plan.

Furthermore, Daniel Nielsen and Fredrik Balkåsen acknowledge that the challenges that the contractor is facing in terms of adopting CCC solutions in their projects are partly due to this previously described negative attitude to change, but also the fear of losing control of their material flows. The core concept of a CCC is having material pass through the terminal and thus leaving some of the freedom of accessibility to materials can be perceived by some as negative according to Daniel. Another challenge that is mentioned by both Daniel Nielsen and Jonas Åslund is how the common occurrence of lowest-price procurement may leave qualities such as logistical solutions among others out of projects due to how the tendering process works in the construction industry.

4.4.3 TPL-provider

The TPL-provider can be a driving force in such a way that they provide a CCC solution as well as good market alternatives and competition. Jon Svensson states that Ahlsell is operating their CCC not only with limitations to the construction industry. He continues, mentioning that the idea of consolidating goods is no new concept and that the TPL in the field of CCCs must try and address the constantly changing nature of construction projects with creative solutions to allow smooth arrivals and distribution of goods for it to be a viable solution. Additionally, Jon emphasizes the need for satisfied customers, if they can tailor their solution to fit the needs of a construction project, they can alleviate the on-site logistical problems and possibly increase the productivity of the construction project. It is implied by

Jon that the consequence of having this possibility to tailor to the needs of a customer is important in creating conditions for the CCC solution to gain traction and increased utilization.

The challenges that the TPL-providers are facing in terms of using a CCC is that the prerequisite of its economical viability is that it is being utilized close to maximum capacity at all times as described by Jon Svensson. If there is any occurrence of overcapacity, this tends problematic for the actor financially responsible for the operational cost. As highlighted by Jonas Åslund, the CCC established for Karlatornet had seen great success whenever the productivity rate was high, but when this falls, so does the viability of using a CCC, and it may not prove as great a solution as first anticipated. Fredrik Friblick describes that aiming for more dynamic and tailored solutions such as checkpoints and other on-site solutions, as opposed to the very static and inflexible CCC may be beneficial in some cases due to their generally low operational costs. Continuously, the TPL-provider may also run the risk of having a low filling rate in their terminal due to low interest or awareness of the solution as well as how market fluctuations may hinder the overall building rate, making projects passing through the CCC more scarce, something Fredrik describes as a risk to consider in today's economic situation.

4.4.4 Requirements as a driving force

As previously explained the public authority can have a great responsibility in the future of CCCs. Many of the interviewees agree with the mandate that public authorities have to promote CCC solutions, by setting requirements in the cities' land development agreement and during the procurement process. To which projects the requirement is applied can differ depending on the requirements outline, but can both include all projects of the development area or only projects above a certain gross area or contract size, as explained by Martin Mattsson. Furthermore, Fredrik Friblick thinks that logistical solutions should be prioritized for ensuring a sustainable future and safe cities. The environmental benefits of including CCCs and other logistical solutions in construction projects are brought up by all interviewees, alongside how it can be used as incitements for setting requirements in cities. In the following sections, three types of requirements brought up by the interviewees for stimulating CCC establishment in Gothenburg are presented below:

- **Transportation requirements** is one type of requirement or regulation the public authority can make in a city. Jon Svensson mentions that these kinds of regulations already exist in Gothenburg, giving the example of the environmental zones in the inner city, which are that in certain parts of Gothenburg heavy transports are not allowed to travel if they do not meet the requirements set. Fredrik Friblick also discusses various requirements that can be adopted in a city, such as only allowing electrical vehicles in urban projects, truck-length regulations, time-slots for transportation, and weight. The possibilities are many and Fredrik also explains that almost all of these requirements can be motivated by sustainability or environmental concerns. The consequence in the construction industry will then be that projects will have to think about

logistical solutions to be able to meet these requirements. Where one solution may be a CCC. However, Jon Svensson also mentions that one downside with transportation requirements might be that other logistical solutions than a CCC are implemented in projects. Implementing other requirements can therefore be more effective if you want to exclusively promote a CCC solution.

Magnus Jäderberg emphasizes the possibility of introducing a requirement on the time-period that transports are allowed to make deliveries. This type of requirement aims to keep heavy transports out of the urban center during peak traffic, around 07-09 in the morning and 16-18 in the afternoon. A transport analysis on when and where these peak hours are must be made before deciding upon locations and periods the requirement will be set. He continues by stating that there is no problem for Gothenburg city to include these requirements in the tendering process for projects they own and that a variation of this requirement most likely will be introduced in forthcoming projects.

- **Consolidation requirements** are also discussed by Jon Svensson as a possible requirement. Meaning that all heavy vehicles or certain transports must go through a consolidation terminal. This can be set up in many ways but the basic idea he mentions is through requirements forcing construction elements that do not reach a certain filling rate to be consolidated at chosen terminals. Furthermore, there can then be requirements such as only using electrical and short trucks for these terminals. To ensure that the terminals are run in accordance with the requirements or chosen sustainability goals the public actors can authorize terminals that are acceptable to use. These terminals can then be run by both public actors as well as private actors. This creates a market for the service where private property developers and contractors can chose who they want to cooperate with.

  Magnus Jäderberg however recognizes a problem with this kind of requirement since it becomes difficult for the public authority to make controls. When setting requirements he explains that there must exist a system to be able to ensure that the requirements are met. Doing a control for consolidation and deliveries is difficult since you must look inside the trucks and check the delivery notes. Controlling transportation requirements is easier since you directly can look at a car and state that it should not be in the area due to the time, size, or type of transport.

- **Compulsory CCC connection** as a requirement is the most effective way to include a CCC in your project according to Per Bramfalk. Especially when having a large development area that is owned by the public authority and it is possible to make a CCC requirement for the whole area. Before setting these requirements, Per Bramfalk mentions that it is important to start the discussion early in the process of the project since it takes time to figure out the scope of the CCC. Per further emphasize the benefit of the public authority setting requirements is that they can motivate the requirements with

environmental backgrounds. Per Bramfalk and Jasmin Ahnfors also explain that in both Uppsala CCC and Djurgårdsstaden CCC the actors setting the requirements are both the owners and providers of the CCC solution. This does not need to be the case but it is recurring that the public authorities are the ones providing the solution when setting mandatory CCC requirements. Jasmin Ahnfors and Martin Mattson both explain that in the case of Uppsala, and probably many others, there are no private actors who can or want to be the driving force for this rather new solution. Therefore only public authorities have the possibility to establish a CCC and also include mandatory CCC requirements at the same time to develop in specific areas.

Additionally, Jonas Åslund and Elin Pettersson explain that private developers also can set these kinds of requirements in projects, as shown by Sernekes CCC. However, the difficulties for private developers when setting requirements are often the economical parts. It is hard to motivate including requirements in projects if there are no huge economic benefits. Similarly to what previously has been stated there are only two times private actors include requirements in their projects, the first being if it is economically beneficial, and the second being if the project cannot be completed without it.

Another discussion brought up during the interviews when setting requirements is who should be the provider of the solution. In this question, a variety of answers have been given and the industry does not agree with each other. Daniel Nielsen likes that the ones setting the requirement are the ones providing the solution since their goal is to accomplish a non-monetary goal to withhold a certain service, and not focus on financial gain. Jonas Åslund agrees with Daniel Nielsen because it is the only way to get a uniform solution where every contractor and sub-contractor uses the same solution and reaches a high level of coordination. Jon Svensson thinks that private TPLs should provide the solution to promote the market for these kinds of solutions, many solutions can then exist on the market free for actors to choose from. Competition between TPL providers can then push prices down. Fredrik Friblick is somewhere in between, he thinks that experts, meaning TPL providers, should provide the solution to maximize efficiency. However, he also emphasizes the importance of a guideline to achieve coordination between projects in cities. So, the solution should be initiated by the one setting the requirements, but must not be given by them. The focus should be on a thoroughly planned coordination plan.

Overall, both Fredrik Friblick and Magnus Jäderberg mention that the possibilities when introducing requirements are almost endless. Requirements can be set for many different reasons and with all kinds of outcomes in a municipality, city, or area. Fredrik Friblick continues by discussing that the challenge is to figure out which requirements should be implemented and make sure that the requirements set will meet the expected outcome. It is difficult for the public authority to know in which directions they should push as well as how the requirements should be designed. Per Bramfalk also says that many investigations must be made to evaluate different problems as well as different solutions. This takes time and is a long

iterative process which is a big problem within public authorities.

In addition to this, stakeholders are affected differently by the setting of requirements. The ones setting the requirements must make sure they are being followed, which as previously explained by Magnus Jäderberg can be difficult. The providers of the solution have to find a profitable business model for the solution if it is not provided by the one setting the requirement. However, all of the TPL providers interviewed are positive towards setting requirements since this most likely will favor their market. The private developers and contractors are mostly affected by how they can execute construction. Neither Daniel Nielsen nor Fredrik Balkåsen sees any huge difficulties when requirements are set since the industry is used to new prerequisites. If the requirements lead to huge changes in routines or a lot of economic responsibility is transferred to the contractors it can be met with negativity, but at the same time, contractors cannot do much about the changes more than accepting them. Additionally, Fredrik Balkåsen mentions that the requirements set are not always the most efficient for all contractors since projects are so different. Especially when the public authority sets requirements over large areas they may benefit some projects more than others.

5
Evaluation of Gothenburg

In this chapter, an evaluation of a CCC establishment in Gothenburg is being conducted. Firstly, an introduction to the conditions of Gothenburg concerning traffic and environment is presented. Secondly, a SWOT analysis for a CCC solution in Gothenburg is made. Thirdly, a description of four scenarios aimed at implementing a CCC as well as their respective business model evaluation is presented. Finally, the CCC scenarios are compared and analyzed, resulting in different proposals depending on the desired outcomes.

5.1 Conditions of Gothenburg

The following sections introduce parameters relevant to CCC establishment in Gothenburg. Focusing on urban characteristics, transport infrastructure, traffic patterns, large-scale construction projects, and environmental goals, they offer insights into the challenges and opportunities facing Gothenburg. Through an examination of these factors, a better understanding of the city's need for logistical solutions can be found, as well as the municipality's interest in terms of sustainable development and improved quality of life.

5.1.1 Urban characteristics

The city of Gothenburg is located on the west coast of Sweden and is the second-largest metropolitan area of Sweden. The urban city has around 600,000 citizens and the greater metropolitan area has a little bit over 1,000,000 citizens. Gothenburg's urban area has expanded, merging with surrounding suburbs to form the metropolitan area of Gothenburg, as defined by Statistiska centralbyrån (2024). This metropolitan area is primarily located within Gothenburg municipality but also includes central areas of Mölndal and Partille municipalities among others. The city covers an area of 721.64 km^2, of which 271.41 km^2 are water.

The city has gone from being an industrial cradle to now being revitalized with many construction projects going on as well as planned for the future, posing a logistical challenge for the city and its inhabitants. With the proximity to the sea, the water has always been an option of transport and Gothenburg holds the largest container port in Scandinavia. Additionally, the city is divided in two by the river Göta Älv pathing straight through the city, with the major part of Gothenburg being located on its southern shores. In terms of transportation possibilities the river can be a

blessing in disguise, while it allows for waterway access to many parts of the central areas of the city as well as shipping, it does pose a problem for road accessibility. Continuously, the city is hilly, resulting in many major highways being located in the valleys, with poor connectivity to each other, necessitating the construction of tunnel networks to bridge this gap.

5.1.2 Transport infrastructure

To cross from one part of the city, north to south or west to east, either a bridge or a tunnel has to be crossed. These are both commonly subject to being congestion nodes where traffic is slowed down due to many lanes converging or diverging. As shown in Figure 5.1 the E6 passes through the city, connecting Gothenburg to the south and the continent and up north to Norway. Continuously, the E20 and E45 both head in a northeastern direction, giving access to northern Sweden and Stockholm. With these major highways passing through or close to the urban center the problem of having large amounts of urban transport arises. In addition to this, it is a hard task to move these highways outside of the city, nonetheless expensive.

Furthermore, Gothenburg has railroad transport possibilities, although this is not often the preferred mode of transport, long-haul transport of heavy goods could be a possibility to consider. Additionally, the water poses a possibility of transporting ballast, concrete, and other large-volume materials. In addition to this, it can also be utilized as storage with large barges for riverfront construction projects. This is already exemplified with the construction of Masthuggskajen, utilizing barges as storage for large prefabricated concrete elements.

Figure 5.1: Overview of the greater metropolitan area of Gothenburg and its road-network [Google, 2024].

5.1.3 Traffic

In Gothenburg there are a few major highways allowing transport from north to south, passing through the city. However, one major problem with the road network in the city is that it has to cross the arguably most congested node in the city center, where west-east meets north-south, posing a problem for efficient pass-through of the city. This congestion is most notable during times when citizens' vehicles, public transport, and industry transport all are using the roads simultaneously at a high degree. A logistical investigation is planned to be performed for Gothenburg city according to Magnus Jäderberg, but when traveling through Gothenburg this peak congestion occurs approximately from times 07.00-09.00 and 16.00-18.00.

To lessen the strain on the urban traffic network it would be favourable to move the major highways outside the city. The geography however does not simplify things, with small possibilities of constructing e.g. a city-ring to avoid heavy freight passing through due to hills as well as poor foundation making it difficult to construct tunnels. To solve the issue of traffic affecting the climate too much in the urban center a climate zone has instead been introduced, see Figure 5.2. In the circled area in the figure, requirements for HGVs (total weight over 3,5 tons) and buses have been set regarding fuel and vehicle age restrictions.

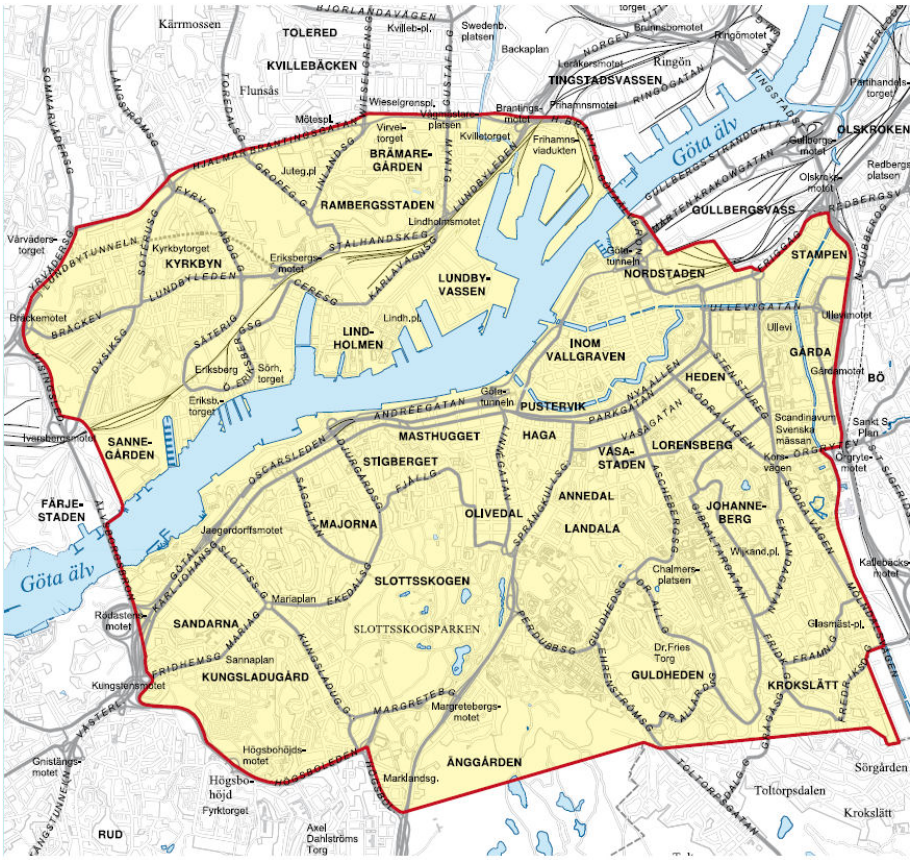

Figure 5.2: Overview of the climate zone in Gothenburg.

5.1.4 Challenges for large-scale construction projects

The city of Gothenburg is growing at a rapid pace, with the large infrastructure project Västlänken underway and several projects planned for the construction program of Älvstranden, the construction intensity will continue to grow. These projects are not only sizeable but are also centrally located within the urban cores of Gothenburg, compounding the logistical pressures on the city. This situation is particularly exacerbated by the high volume of HGVs, the frequent redirection of roads, and the expansive construction sites that increasingly encroach on the living spaces of residents, disrupting daily life and local traffic.

Furthermore, the geological conditions of Gothenburg are that the relatively hilly city has large clay deposits in its valleys. This poses a problem for new construction, necessitating large-scale excavation of masses when developing these large projects to make way for foundation and foundational poles, consequently increasing the footprint and scope of the construction project as opposed to a city with relatively low amounts of clay. These efforts are necessary to clear the way for the foundations and foundational poles that support the structures. Such extensive ground preparation not only enlarges the overall footprint of construction projects but also significantly differs from projects in cities with lesser clay concentrations, where less invasive site preparation might be sufficient. This geological requirement of having to pole larger foundations directly affects the number of transports going to and from a site, both with construction materials as well as removal of masses.

5.1.5 Environmental and climate goals for the city of Gothenburg

Gothenburg City has created an environment and climate program reaching until 2030 which includes several goals in the areas of nature, climate, and the human. Target indicators are set for the sub-goals in these areas as well as an overview of the target. The background for the program lies within the Paris Agreements as well as the EU's goal of Europe being the first climate-neutral continent until 2050. Additionally, Sweden has the climate goal of having a net emission of zero by 2045. In the following sections, the goals which align with the scope of this research study are presented.

5.1.5.1 Transportation emission

In Gothenburg, road traffic ranks as the second-largest emitter of greenhouse gases after refineries. Gothenburg's urban layout facilitates increased public transit and more efficient freight transport, including higher rail and water transport percentages than the national average. The city's compactness also favors walking and cycling. Achieving the goal requires phasing out fossil fuel usage. With around 150,000 car and 25 million truck passages annually in congestion charge zones, Gothenburg aims for fossil-free municipal transport by 2023 and supports Fossil-Free Sweden's challenge for nationwide fossil-free transport by 2030. This encompasses all city-owned, leased, or rented vehicles, including services, to align with local and national climate

targets.

Three indicators are set for reducing Gothenburg's transportation emissions and are listed below:

- **Emission of greenhouse gases from transports**, which are all emission from transports in Gotheburg, including road-traffic, shipping, and work-machines. In 2010 the status was an emissions of 999 990 tons carbon dioxide equivalents per year. The goal for 2030 is to lower this emissons by at least 90%.
- **Roadtrafficwork**, which are all kilometers driven by any road-vehicle, including passenger cars, trucks and busses. The goal is that indicator will be lowered by 25% by 2030.
- **All Gothenburg citys vehicles are fossil free**, which is that all light and heavy vehicles owned by Gothenburg city are fossil free by 2030.

5.1.5.2 Good air quality for the citizens of Gothenburg

In Gothenburg, road traffic is the main contributor to high levels of air pollution, posing risks of cardiovascular and respiratory diseases, especially for children. Their vulnerability stems from their physical development, exposure to outdoor air during peak pollution times, and higher pollutant intake relative to body weight. The goal is to ensure nitrogen dioxide (NO2) levels below 20 micrograms per cubic meter and particulate matter (PM10) levels below 15 micrograms per cubic meter annually, aligning with national air quality targets. Nitrogen oxides (NOx) emitted by traffic primarily consist of nitrogen monoxide (NO) which quickly converts to nitrogen dioxide (NO2), affecting air quality. PM10, comprising inhalable particles from road wear and combustion, includes smaller PM2.5 particles mainly from vehicle emissions and imported pollution. Current nitrogen dioxide levels are mapped to show where concentrations fall below 20 micrograms per cubic meter. In 2015, 70% fell below 20 micrograms per cubic meter and the target is that this number should increase every year.

5.1.5.3 Good noise environment for the citizens of Gothenburg

Ambient noise, primarily traffic noise, affects the majority of Gothenburg residents and can lead to impaired learning, sleep disturbances, and increased risk of cardiovascular diseases. Health impairment due to road traffic noise in Gothenburg amounts to approximately 1,700 disability-adjusted life years lost annually, indicating the cumulative impact on population health. The socio-economic cost of road traffic noise exposure in Gothenburg is estimated at around 1.5 billion SEK. Additionally, the city aims to ensure that the most noise-exposed residences maintain noise levels below 50 dBA on at least one side and provide access to green areas with noise levels below 50 dBA.

The indicator measures noise levels from road and rail traffic for residential buildings constructed in compliance with noise regulations. It evaluates the percentage

of dwellings with noise levels below 50 dBA during the day and evening, aiming to ensure a quieter living environment. Additionally, it assesses the proportion of residents with access to green areas larger than 0.2 hectares within 300 meters, considering noise levels below 50 dBA, to promote peaceful surroundings. In 2020 60% reached the target for residential buildings and in 2018 75% reached the target for green areas. The goal moving forward is a yearly increase in both of these noise environment areas.

5.2 SWOT analysis

In this section, a SWOT analysis of the characteristics of a CCC is conducted. The aim of this is to highlight the potential benefits and drawbacks of the CCC solution provided by both the theoretical and empirical findings while applying this to the Gothenburg context.

5.2.1 Strengths

The strengths of a CCC are wide-ranging and many of its common features have been elaborated in both the theoretical chapter, as well as the empirical findings. Following is a summary of these strengths:

- **Increase the project productivity:** The CCC has the potential to address the on-site complexities of material handling, optimizing the labor time to focus on tasks yielding project productivity. This can be further developed into accomplishing a JIT-schedule and kitting through careful planning and intercommunication between the construction site and CCC. This allows contractors to focus on construction and TPL-providers to focus on logistics, consequently allowing each profession to focus on their field of specialty.

- **Alleviate environmental effects:** The potential positive environmental effects a CCC can address are through the reduced number of transports, consequently benefiting environmental concerns such as noise pollution and air quality. To further increase the gains EVs could be an option to look into when there is sufficient infrastructure. Accomplishing this reduction is key to reaching the environmental goals of Gothenburg city which center around emissions, air quality, and noise pollution derived from transport.

- **Increased safety:** There are various ways that a CCC could address safety. The urban transport reduction is a direct benefit to the safety of citizens in close proximity. Additionally, site safety can also benefit from this, due to fewer inbound transports, perhaps at designated time-slots.

- **Reduced external interference of construction projects:** The reduction of transports also possesses the quality of alleviating the road network. While this can be accomplished with slot-times on off-peak hours in solitary, it can be further developed when combined with the potential a CCC has to offload

interference with traffic and urban space.

- **Placement:** Placing the CCC in the correct location is critical to its success. Having a strategic location is an enormous strength and must be decided carefully to allow for the other strengths of a CCC to come forth.

- **Alternative transportation modes:** The geography of Gothenburg and the proximity to water allow for the water to be used as a transportation mode, where large volumes of materials can be transported via barges. In addition to this, excavated masses and waste can be transported from the site via barges to reduce road transport if this is a service that the CCC considers. This becomes a strength given the proximity to the water that many future large development areas have.

- **Incorporating reverse logistics:** With the implementation of a CCC, this physical location can also serve as a hub for handling or sorting construction waste, incorporating the concept of reverse logistics and waste management into the scope of the CCC.

5.2.2 Weaknesses

The weaknesses of implementing a CCC and the risks it may pose will be explained in the following:

- **High implementation cost:** There is the argument to be made whether the cost of establishing a CCC is worth the financial burden. While the argument of what citizen safety and environment are valued can be stated, there is still an economic factor to consider. This steep cost of setting up a CCC can not always be justified economically and the solution is thus neglected.

- **Reduced level of control:** This is most prominently expressed by the contractors, who see the issue of losing full control of their material flows and the comfort of having everything at hand at all times. Instead requiring additional resource planning, something the industry has been described to not always be sympathetic to, thus it poses a weakness in the success of a CCC.

- **Difficulties in estimating cost-benefit of logistical solutions:** It has been described that there is a large uncertainty of what the costs of logistics are. While benefiting the productivity of a construction project, the implementation of logistical solutions also highlights costs allocated to logistical tasks on-site previously described as "hidden", making the argument that fewer labor hours are required. The weakness is that it is difficult to convince contractors to pay for something "they are already doing".

- **High municipal engagement:** Establishing such a facility requires high levels of municipal engagement in stating requirements to drive a change in the industry or subsidize the solution itself. This becomes a weakness due to the

eventual reliance on another actor for the solution to function properly.

- **Placement:** While the placement could be its strength, a poorly located CCC has the opposite effect and may induce even more construction-related urban transports than before its implementation. As previously described, Gothenburg does not have a ring road allowing transport to pass by the outskirts of the urban center, instead, they cross straight through from south to north. Therefore mitigating as many transports passing through the city must be addressed, and evaluating a strategic placement is of utmost importance.

- **Alternative solutions:** While the CCC offers a range of possibilities it is a static solution. There could be cases where the CCC is not necessitated and approaching the logistical issues with more dynamic methods such as on-site solutions could be more beneficial. This is often a financial question if such an undertaking as establishing a CCC could be accomplished with simpler, more agile methods.
- **Niche application:** The CCC is a large static solution has its highest return on investment when it is being used at maximum capacity, preferably consistently over long periods. Besides when it is necessitated by the project, there are cases where it thrives, such as serving large development areas that take plenty of years to fully construct. This makes the application of the CCC niche, where the viability is put in question.

5.2.3 Opportunities

Shown below are the opportunities that an implementation of a CCC could consequently result in:

- **Legislative development:** The establishment of a CCC has the opportunity of bringing additional benefits such as stricter transportation regulations in both size and schedule, transmitting to other industries in addition to the construction industry. This may overall become an opportunity to address the environmental issues a city is facing concerning transport.

- **Development of urban logistics:** There is an opportunity in how this solution may benefit urban logistics as a whole. While construction logistics is described to be slow and prone to change, addressing this logistical issue through a CCC solution may transmit to other industries.

- **Development of construction industry:** As the industry is known for its conservative approach to change, implementing a solution addressing the productivity of the industry, may generate ripples that induce other industry changes streamlining the construction processes.

- **Market demand:** By providing this type of solution, the intent is to generate such good customer satisfaction to stimulate future demand for similar

solutions. Increasing the symbolic value of the solution and enabling demand-driven markets.

5.2.4 Threats

There are threats to the viability or the operation of CCC which must be considered, these are described in the following:

- **Market fluctuations:** The CCC may be a great solution whenever the building rate is consistently high, but when the building rate drops due to market fluctuations and increased material costs, a CCC may become less beneficial in terms of its financial viability as its often static characteristics heavily rely on high filling rates.

- **Financial risk:** Depending on the scale of the solution, there are financial risks associated with investing in this type of facility. While the public authority can carry financial risk to some extent, the private actors as well as the public must consider that there is enough demand or stimulate this demand through requirements.

- **Lack of utilization:** There may be a risk of the CCC not being used to its full extent as a consequence of the traditionalism of the industry not understanding the full benefits of incorporating logistical solutions in the construction processes.

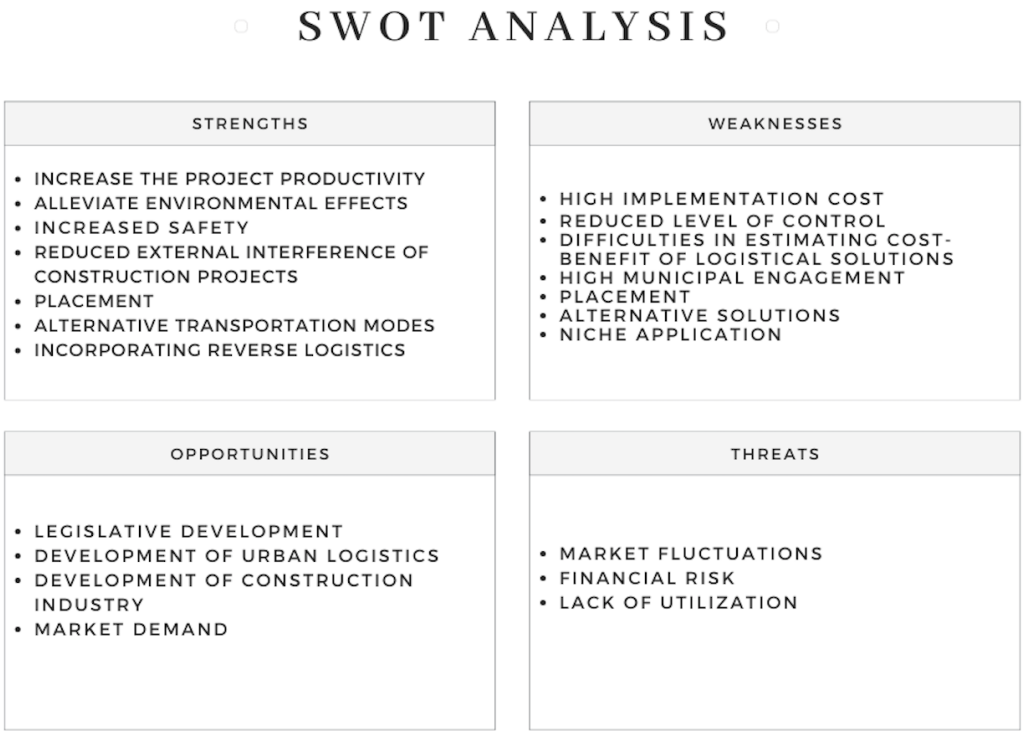

Figure 5.3: Summary of SWOT analysis.

5.3 CCC scenarios

In the following section, four scenarios created using the process found in the method chapter is presented. The first step shows that a multi-project spanning CCC is preferred due to the large scale urban development of the city as well as to the possibility to address Gothenburg city's environmental goals. The rest of the steps differentiate the scenarios and are build upon information from theory and empirical findings. The scenarios consist of both publicly and privately initiated CCCs as well as different business models approaches. The different business model are built upon the information gathered from previously established CCCs as well as the empirical findings.

5.3.1 Scenario 1

Definition of the scenario: Public/private partnership with public ownership.

The first scenario to be assessed consists of one single CCC initiated, funded, and owned by the public land development department. Which has contracted a private logistics company, through open tendering, to operate the CCC over a large amount of time, i.e. spanning over multiple single worksite lifetimes. The CCC provides logistical services to several construction sites managed by several construction companies. Including storage, consolidation, and transportation management, joint logistical software and coordination, and reverse logistical management such as waste management and recycling. The CCC will also provide on-site solutions such as perimeter protection, fences and gates, and construction lights. The public authority has set requirements for a certain development area making it mandatory for construction projects in this area to utilize the CCC. Rules for actors connected to the CCC can be requirements such as filling rate minimums, booking of slot-times to construction sites to reduce the risk of site congestion, and slot-times or transport scheduling to avoid interference with peak-hour traffic. The purpose is to improve the supply chain as well as enhance the positive effects from environmental and social points of view. Further requirements to ensure a positive environment and social outcomes can be set for the CCC, such as delivery times to the CCC to avoid peak hour traffic. Profit is secondary to the purpose.

5.3.1.1 Canvas Business Model 1

The business model for scenario 1 will be assessed from the public authority's point of view as owners. The business model will also be evaluated with two different alternatives as a revenue stream. Where the first will have an all-inclusive approach meaning that a connection fee will be paid at the beginning of the project, and the second will have the approach of the services being paid for individually, meaning only paying for what you are using. Below you will find the Business model Canvas for scenario 1 with the two alternatives for revenue stream.

1. **Customer Segments**
   The CCC only serves construction sites that are located within the specified development area.

2. **Value Propositions**
   The public authority gains a lot of value when incorporating a CCC solution. Including increased project productivity, alleviating environmental, positive social effects, increased safety, reduced external interference, better on-site conditions, ensuring expected material quality, and finally reverse logistical services such as waste management and recycling. The public authority in Gothenburg especially recognizes the social benefits that a CCC solution can bring to all citizens. These positive impacts can serve as a key motivation for investing in such a solution. Furthermore, implementing a CCC can contribute towards reaching Gothenburg's environmental goals, by enhancing air quality, mitigating noise levels, and alleviating traffic congestion.

3. **Channels**
   The public authority includes the CCC establishment in the call for tenders making the developers and contractors aware of the implementation. The change can also be seen in the land development agreement. The CCC may also be promoted in communication campaigns for marketing purposes.

   Continuous communication during operation will occur between public authority and the CCC operators, as well as CCC operators and worksite managers through digital tools as well as oral communication.

4. **Customer relationships**
   Connection to the CCC is mandatory through the land development agreement making it important to have a personal and dedicated service towards the customers before, during, and after operation, to ensure good collaboration.

5. **Revenue streams**
   Since the CCC is a public service to ensure a well-functioning supply chain, financial profit is not necessarily the ultimate goal. The revenue however aims to cover the operational costs during construction. Two alternatives for revenue are presented below.

   Alternative 1 (Connection fee): The developers and contractors pay a connection fee when they initiate construction. This fee covers all services provided by the CCC and is then free to use for the actors.

   Alternative 2 (Dynamic fee): The companies pay according to how much they utilize the services provided by the CCC. However, it is still mandatory to use the CCC according to requirements set in the land development agreement.

6. **Key Resources**
   Resources needed for the CCC are a land area defined by the worksite demand, a warehouse or tent, operational labor for staffing the CCC, handling equipment (forklifts, cranes, etc...), transport vehicles (fossil-free), software application, and security equipment such as fences, gates, and lights.

7. **Key Activities**
   Activities and services provided by the CCC will include consolidation of transports, kitting, JIT deliveries, quality controls of the material, incorporating a sling truck for daily deliveries to the site, perimeter protection, and finally logistics services such as transport coordination for and between projects. Further services can be provided by the CCC if it is found necessary during project planning.

8. **Key Partnership (during operation**
   - Public authority, as CCC initiators.
   - Developers, as main customers.
   - Material suppliers, important to have good relationships to ensure timely deliveries.
   - Freight forwarders, to provide delivery vehicles.
   - Citizens, who need to get information regarding construction for security reasons.
   - Security, to manage security on site.
   - Waste management provider, ensuring good relationships to maximize waste sorting, recycling, and collection.

9. **Cost Structure**
   The cost drivers for establishing and operating the CCC are labor costs, facility costs, transportation costs (sling truck), equipment costs, security costs, and waste management costs.

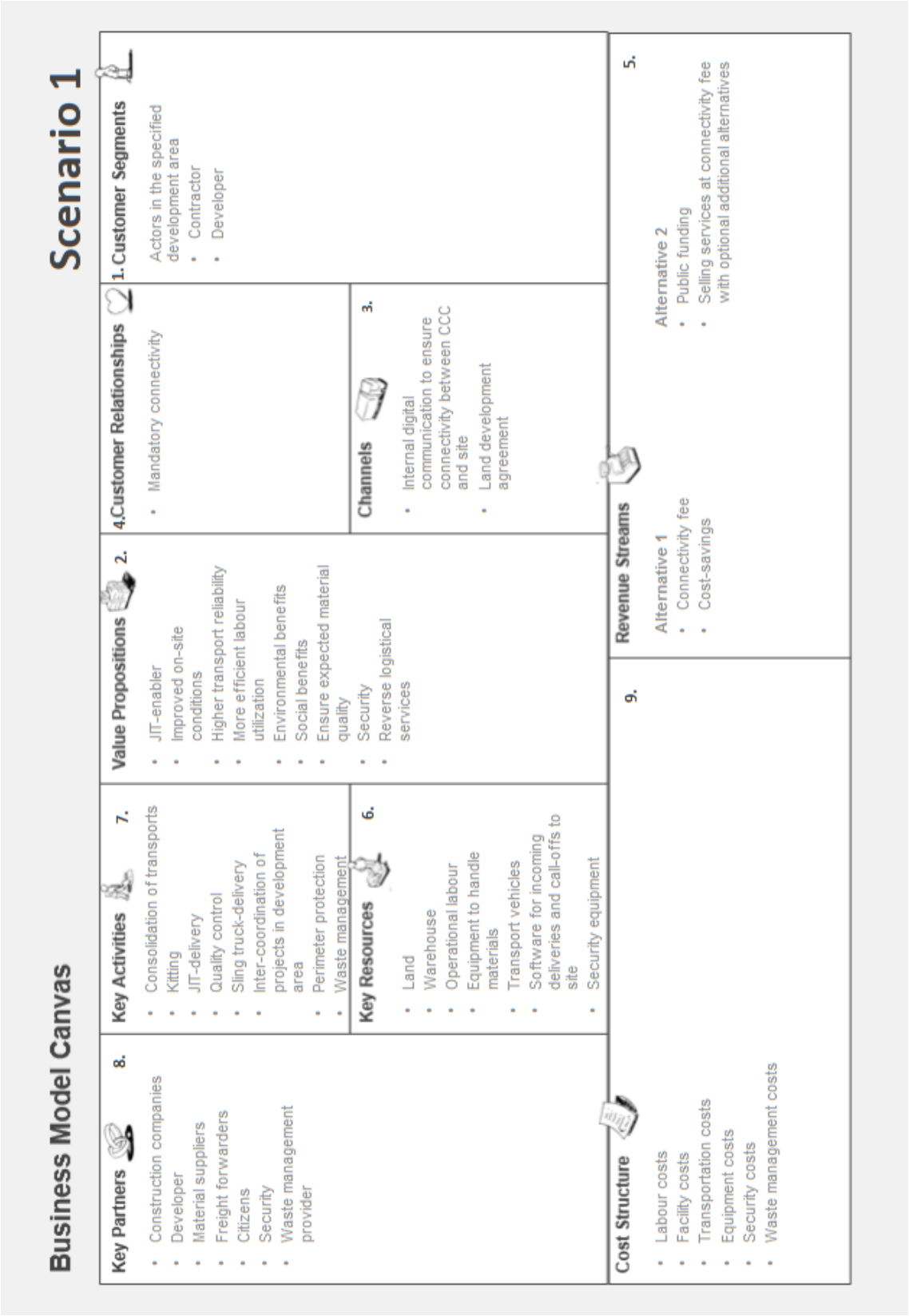

Figure 5.4: Scenario 1 business model canvas.

5.3.2 Scenario 2

Definition of the scenario: Public/private partnership with private ownership.

The second scenario, similar to the first, consists of one single CCC initiated by the public land development department. In contrast to the first scenario, this CCC is owned and established by a private logistic operator through open tendering processes conducted by the public authority. Requirements for certain services will be determined in the tendering request by the public sector to ensure it provides the intended services. Services provided will be similar to the first scenario, including transport schedules, filling rate minimum, storage, and consolidation. The CCC will provide these services for a development area where the public authority has set logistical requirements for construction, including mandatory usage of the CCC. The CCC will therefore provide services for multiple construction sites managed by several construction companies. The TPL-provider and operator's purpose is to improve the supply chain in the area. Additionally, the public authority hopes to get a positive outcome in terms of environmental and social effects. Profit will however be the main aim for the private operators since they are taking a greater risk in this scenario. Collaboration and adaptability regarding the usage and operation of the CCC between the public authority and operator will be important to ensure both parties reach their individual goals. For example, the operator may be allowed to rent and utilize areas of the CCC for private projects if the progression of construction slows down due to unexpected events.

5.3.2.1 Canvas Business Model 2

This business model will be assessed from the logistics company's point of view that operates the CCC.

1. **Customer Segments**
   The CCC only serves construction companies' sites which are located within the specified development area.

2. **Value Propositions**
   The CCC offers great value for the construction sites in the development area. This is important for the logistics company operating the CCC since it is the cause of the establishment. The values proposed are enabling JIT deliveries, improved on-site conditions, higher transport reliability, more efficient labor utilization, reduction of logistics costs, environmental benefits, social benefits, ensure expected material quality, and security.

3. **Channels**
   The logistics company won the open tendering call published by the public authority and got to manage and build the CCC. Requirements for the CCC are established in the land development agreement.

   Continuous communication during operation will occur between the logistics

company operating the CCC and worksite managers through oral communication, digital tools, and reports. Furthermore, software will be applied to manage the logistic process as well as having a place where all information will be shared between worksites and the public authority.

4. **Customer relationships**
   Usage of the CCC is mandatory according to requirements in the land development agreement leading to worksite managers and project leaders having a direct relationship with the logistics company managing the CCC. Together they will co-create the needs found in all development area projects to tailor logistical solutions following the requirements. This allows the logistic operator to understand each site and construct a coordinated supply chain. During operation, the CCC operators will provide personalized assistance to each site.

5. **Revenue streams**
   Since the public authority initiates the CCC establishment the logistics company managing the CCC will get public funding in the initiating stage. During operation, the revenue will come from selling services at connectivity fees with optional additional alternatives.

6. **Key Resources**
   Resources needed for the CCC are a land area defined by the worksite demand, a warehouse or tent, operational labor for staffing the CCC, handling equipment (forklifts, cranes, etc...), transport vehicles (fossil-free), software application, and ability to be flexible.

   The logistics company needs to have properly calculated the average operations to be able to continuously have a high level of activity. This can mean that during peak periods sub-assigning certain tasks to other companies instead of establishing a larger base CCC, running risks of having too high of operational costs.

7. **Key Activities**
   Activities and services provided by the CCC will include consolidation of transports, kitting, JIT deliveries, quality controls of the material, incorporating a sling truck for daily deliveries to the site, perimeter protection, and finally logistics services such as transport coordination for and between projects. Further services can be provided by the CCC if it is found necessary during project planning. Finally, it is important to meet customer experience as contractors and developers may be future clients.

8. **Key Partnership**
   - Public authority, as CCC initiators and the ones setting the requirements.
   - Construction companies, as customers of the service.
   - Developers, as main customers.
   - Material suppliers, important to have good relationships to ensure timely

deliveries.
- Freight forwarders, to provide delivery vehicles.
- Security, to manage security on site.

9. Cost Structure
The cost drivers for establishing and operating the CCC are labor costs, facility costs, transportation costs (sling truck), equipment costs, security costs, and waste management costs. Further consulting costs may occur for establishing great coordination, collaboration, and service to the clients, for future possible projects.

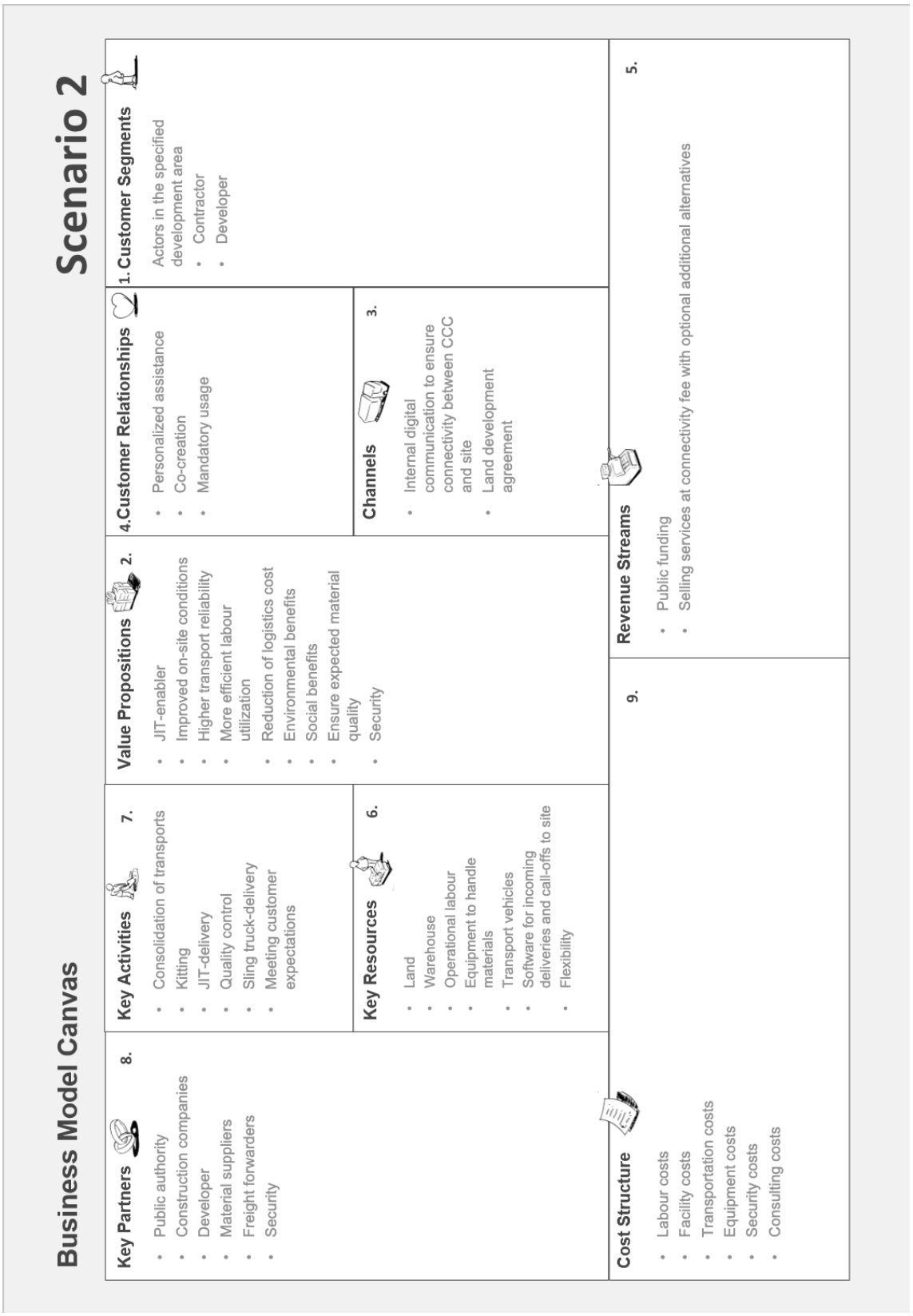

Figure 5.5: Scenario 2 business model canvas.

5.3.3 Scenario 3

Definition of scenario: 100% private ownership and initiative.

In the third scenario, the initiative and establishment of a CCC come from a private logistic operator seeing a market demand for this type of solution. The goal is to sell the CCC solution to all types of construction projects in the Gothenburg area by showing the benefits of including this type of solution in projects. The usage of the CCC is therefore voluntary for companies. Furthermore, the CCC will service multiple construction sites managed by several construction companies. Services provided will be fewer to ensure a high level of usage and will be the baseline of CCC services including consolidation, storage, transportation, and logistical planning. Additional services that could be included are waste management, recycling, and project site coordination. The CCC is operated by the private logistic operator only as a profit center. Finding a tactical placement will be important for ensuring the desired outcome as well as other beneficial outcomes such as climate and social benefits which can be used for marketing purposes. Finally, services provided by the CCC in different construction projects will vary depending on the needs of the projects.

5.3.3.1 Canvas Business Model 3

This business model will be assessed from the logistics company's point of view that initiates, establishes, and operates the CCC.

1. **Customer Segments**
   The CCC serves both contractors and subcontractors who see the benefits of consolidating their materials and having them sent to them whenever required. These are customers who choose this service voluntarily without any requirements driving their initiative.

2. **Value Propositions**
   The values that this solution proposes are centered around making the on-site conditions better through off-site solutions. This is mainly accomplished through the CCC allowing for JIT-deliveries at the same time as it ensures a higher transport reliability. Additionally, the CCC can provide services such as ensuring material quality through inspection, reduction of logistics costs, reduce the number of urban transports, and yielding environmental and social gains. However, these can not be accounted for economically by a private actor and are only viewed as secondary, but appreciated.

3. **Channels**
   External marketing is essential for ensuring clients of the CCC solution. The channels that this solution could communicate its benefits and information through are through calls for tenders, and external marketing highlighting the savings it can generate. Continuously, there are suggestions that this type of private initiative could spread through word-of-mouth or success stories, con-

vincing other industry actors to utilize this solution.

The internal communication channels to ensure connectivity between the site and CCC should preferably be digital to allow for efficient material call-offs.

4. **Customer relationships**
   The relationship between the customer and CCC-provider are that they will receive personal assistance in the sense that the logistical service will be tailored to the requirements of the customer to create an as optimal solution as possible with the help of a specialized logistics team. There is a high emphasis on ensuring customer satisfaction, thus this tailored approach is necessary.

5. **Revenue streams**
   The revenue streams of a privately initiated CCC are strictly bound to the services it provides. These are suggestively priced at a dynamic fee, changing proportional to the amount of warehouse space, the number of transports required as well as how many labor hours are required to handle, consolidate, or kit the materials. In addition to this, there could be added revenue streams from additional logistical services that the CCC may provide.

6. **Key Resources**
   One of the key resources of a privately initiated CCC is the position. Having a strategic placement is critical to the viability of the solution. Additional resources are the plot of land, warehouse, operational staff, handling equipment (forklifts, cranes, etc.), transport vehicles, software applications as well as the ability to tailor to demands and be flexible.

7. **Key Activities**
   The key activities that are crucial to this scenario are the consolidation of materials, kitting, JIT-deliveries, quality control as well as ensuring customer satisfaction.

8. **Key Partnership**
   - Construction companies, customers of the service.
   - Material suppliers, important to have good relationships to ensure timely deliveries.
   - Freight forwarders, to provide delivery vehicles.

9. **Cost Structure**
   The costs that can be derived from the establishment and operation of a CCC are labor costs, facility costs, transportation costs, equipment costs, marketing costs as well as the financial costs consisting of loans and amortization.

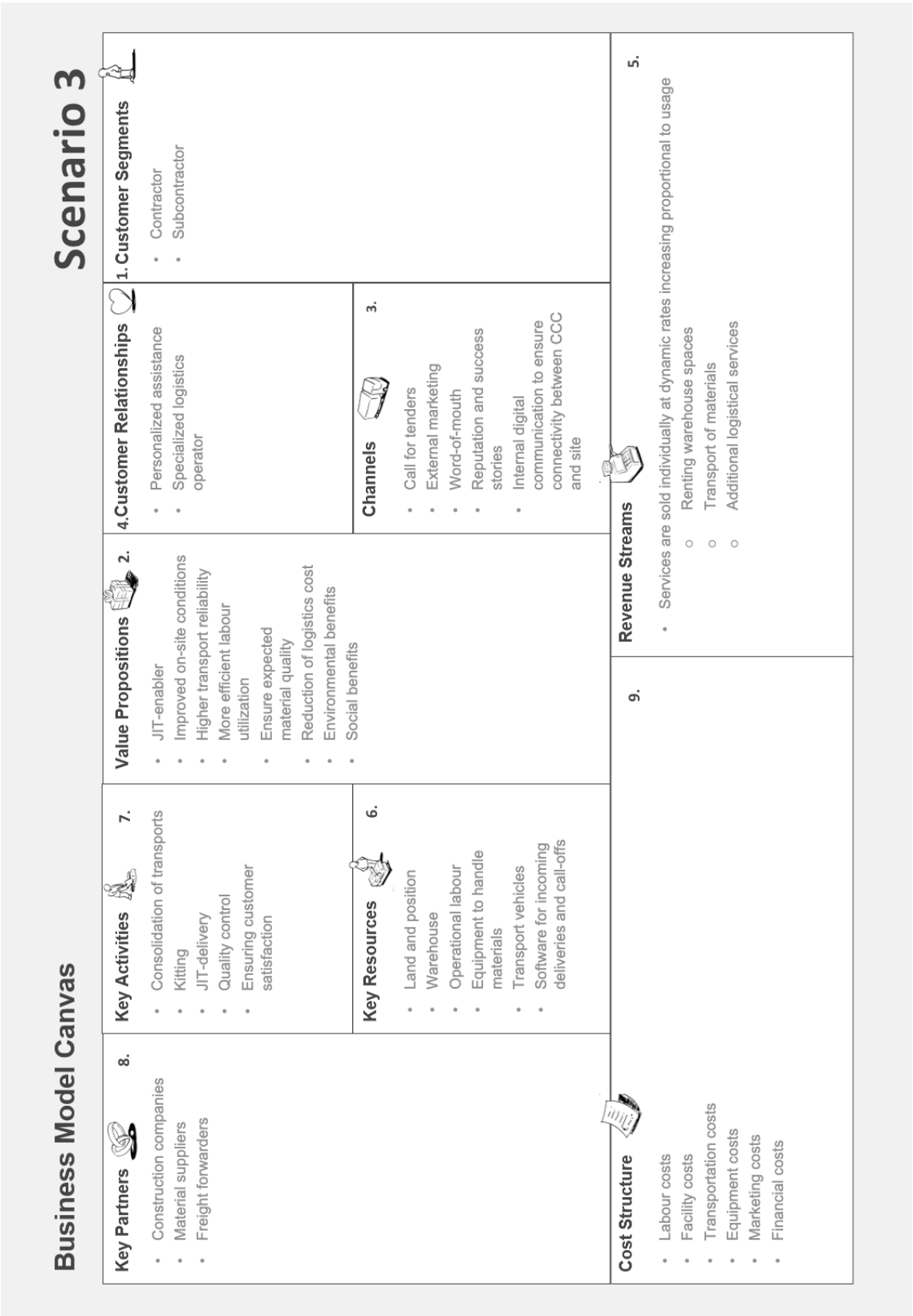

Figure 5.6: Scenario 3 business model canvas.

5.3.4 Scenario 4

Definition of scenario: Private CCC with public support in terms of requirements.

The last scenario is based on the public authority setting requirements on their projects, which will push the construction industry towards needing to implement CCC solutions in these projects. The CCC will be privately owned and established but supported by the public authority through the CCC being advised to use in publicly owned construction projects. Thus creating a market for private logistic companies to establish CCCs. Furthermore, the CCC will serve multiple construction sites managed by several construction companies. The purpose for the public authority in supporting this type of logistical solution by setting requirements is to attain environmental and social benefits, while the private logistic companies aim is to make an economic profit. Open communication will occur between CCC providers and the public authority to ensure that both parties can reach their desired outcome. The CCC is voluntary for companies to use but it will be promoted by the public authority to use for meeting requirements set in the tendering process. However, other logistical solutions than CCCs may be used by developers and contractors to meet the requirements. Finally, services provided by the CCC will differ depending on the needs of the projects and stakeholders.

5.3.4.1 Canvas Business Model 4

This business model will be assessed from the logistics company point of view that operates the CCC.

1. **Customer Segments**
   The CCC serves both contractors and subcontractors that either need this kind of solution according to requirements in projects or see the benefits of a CCC solution. The customers chose this specific service voluntarily but may been advised by public authority to use this kind of solution to meet set requirements.

2. **Value Propositions**
   The CCC offers a lot of great value for construction sites choosing to utilize the solution. Including JIT-deliveries to the site, improved on-site conditions, higher transport reliability, more efficient labor utilization, ensuring material quality through inspections, and reduction of logistical costs. Finally, it is important that the CCC can provide environmental and social benefits through its solution, making sure that the public authority keeps setting requirements on their projects that push the industry to use this kind of solution.

3. **Channels**
   External marketing will be important for ensuring clients of the CCC solution. However, some clients will be directed from public development projects if the CCC can provide an appropriate solution. The channels that this solution could communicating its CCCs services, benefits, and information through

are through calls for tenders and external marketing highlighting the savings it can generate.

Internal communication during operation between the site and CCC could be digital through software as well as oral communication.

4. **Customer relationships**
   The customer relationship between the CCC and managers of the sites will be personal in the sense that the logistical service will be tailored to the requirements of the customer to create an as optimal solution as possible.

   Furthermore, some customers will be directed from the public service. It is therefore important for the CCC to have a continuous dialogue with the public authority to ensure that the CCC can provide services in accordance with the requirements being set.

5. **Revenue streams**
   The revenue streams of a privately initiated CCC are strictly bound to the services it provides. These are suggestively priced at a dynamic fee, changing proportional to the amount of warehouse space, the number of transports required as well as how many labor hours are required to handle, consolidate, or kit the materials. In addition to this, there could be added revenue streams from additional logistical services that the CCC may provide.

6. **Key Resources**
   One of the key resources of a privately initiated CCC is the position. Having a strategic placement is critical to the viability of the solution. Additional resources are the plot of land, warehouse, operational staff, handling equipment (forklifts, cranes, etc.), transport vehicles, software applications as well as the ability to tailor to demands and be flexible.

7. **Key Activities**
   The key activities that are important to this scenario are especially the ones that can provide solutions for possible requirements found in the land development agreement. This could be services such as consolidation of materials, kitting, JIT-deliveries, quality control as well as ensuring customer satisfaction.

8. **Key Partnership**
   - Public authority, setters of requirements in the land development agreement.
   - Construction companies, customers of the service.
   - Material suppliers, important to have good relationships to ensure timely deliveries.
   - Freight forwarders, to provide delivery vehicles.

9. **Cost Structure**

The costs that can be derived from the establishment and operation of a CCC are labor costs, facility costs, transportation costs, equipment costs, marketing costs as well as the financial costs consisting of loans and amortization.

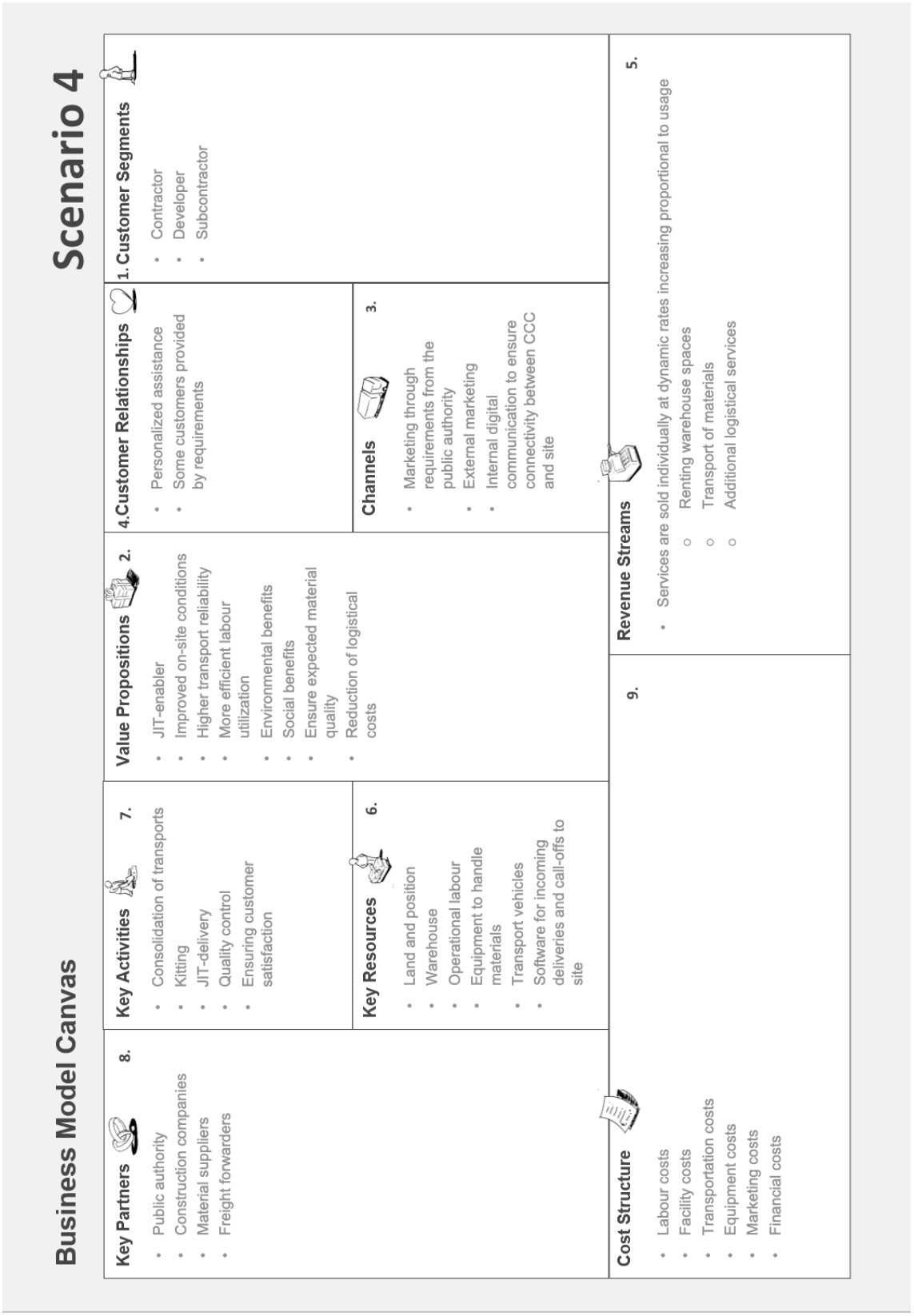

Figure 5.7: Scenario 4 business model canvas.

5.4 Evaluation of scenarios

The final result of this evaluation is four business model canvas' with unique characteristics describing a CCC solution. They are unique in the sense that they have different prerequisites to their initiation and consequently, their scope, as well as revenue streams may differ. The differences are highlighted in the following:

- **Scenario 1:** In this scenario, the public authority is the owner of this solution with the main objective of ensuring that the development area this CCC seeks to address is in line with the municipal requirements in terms of environment and citizen safety and financial profit might not be the ultimate goal, but the benefit of this is that societal profits can be accounted for as well. If developing in this area, this scenario suggests revenue is either collected through a mandatory connectivity a fixed cost, or a dynamic solution where actors pay in accordance to what services are being used where the utilization is still stipulated as mandatory through land development agreements. The benefits this scenario provides are that the public authority who set the requirements are also the ones who provide the solution. By doing this they can tailor the solution to try and address these as best they wish. The ones who benefit from this type of solution are the public authority in the sense that they gain the control of addressing the consequences large amounts of urban transport may have, consequently benefiting the citizens. Additionally, the contractor who is procured by the developer may be the largest benefactor of this type of solution, since they are described to "enjoy" the luxuries of this solution without having to pay for it.

  In contrast to this, the challenge that this solution may face is that the connectivity fee may tend problematic at a fixed price all-inclusive solution. While it makes it very clear and easy to deal with, there may be instances where contractors or developers will not require the full array of services included, and would rather find similar services at dynamic rates more beneficial. This is often rooted in site conditions, and it is harder to motivate this compulsory connectivity if the site is not very limited in terms of space or congestion.

- **Scenario 2:** This scenario is similar to the first one, with the key differences being that it is a CCC owned and operated by a TPL-provider, however, it is established on behalf of the public authority, spurring a need for this solution in a development area. This type of procurement is beneficial in terms of the TPL not having to take the financial risk of establishing the CCC, however, unlike the previous publicly owned solution in scenario 1, the private actors cannot account for the societal gains to the same extent. Additionally, there is the argument that industry professionals should carry out their specialty rather than someone else, making this scenario suitable in the sense that the whole operational aspect is left to the TPL to handle. While the connectivity is stipulated through the land development agreements of the area, this scenario may face challenges in terms of the contractors and developers actively

avoiding utilizing the CCC try and save direct costs. The ones benefiting the most from this type of scenario would be the TPL if there is enough interest in utilizing the solution since they would not be required to pay for the establishment themselves.

- **Scenario 3:** The third scenario presents the option of having the CCC solution entirely provided by the private industry while letting the market answer to a demand is fundamental in a market economy, it tends problematic when there is a low demand. This scenario relies solitary on the principles of providing a good enough service to stimulate demand. The drawback of this is that the scenario solely emphasizes financial profit and societal gains are only secondary since they are difficult to value as a private actor. Therefore the main focus in this scenario lies in creating a tailored solution to the problem of the contractor or developer to stimulate high customer satisfaction generating revenue from the services it provides at a dynamic rate. The challenge that this scenario is facing is that industry professionals might not recognize the need for this type of logistical solution and therefore neglect it, so a high emphasis must be put on marketing and reputation for this to gain traction. Oppositely, the benefits that this could result in are that this high customer satisfaction is withheld and consequently generates a market demand for these kinds of solutions.

- **Scenario 4:** This scenario is similar to the one presented in scenario 3, however, the main difference is that some regulatory bodies have been implemented, putting requirements on actors to reduce their urban transport. This is accomplished through the various requirements previously stated such as slot times to site, transport size, and slot times to avoid peak-hour traffic. The benefit highlighted by this scenario is that the private actors providing this type of solution can expect additional customers due to contractors or developers being forced to adopt this solution through regulations, rather than mandated connectivity. The benefit of this is that the industry actors are free to choose whatever solution fits them, as long as it fulfills the requirements. Additionally, this scenario may be beneficial to the public authority in terms of them not having to provide a solution, saving them the financial burden. The drawbacks of this are that while the requirements are stated, there may be other logistical solutions that accomplish this as well, possibly posing a threat.

5.5 Result of the evaluation

In summary, each scenario presents a different approach to ownership, operation, and regulation of a CCC, with varying implications for stakeholders such as public authorities, contractors, and TPL providers. The evaluation suggests that the choice of scenario involves trade-offs between financial considerations, and societal benefits, and the scenarios rank in the following order what their main objectives are.

Financial considerations:

- **Scenario 3:** This scenario prioritizes financial profit above all else. It relies on market demand and dynamic pricing to generate revenue.
- **Scenario 4:** Although financial profit is prioritized, it may be compliant to provide the services needed to fulfill the requirements aimed at societal gain. Compliance with regulations may also entail costs and complexities for the private industry.
- **Scenario 2:** As it benefits from public authority involvement, some financial risks are mitigated since it still serves the purpose of addressing the public interest. However, as privately owned, it still focuses on financial viability.
- **Scenario 1:** Publicly owned solutions typically prioritize societal benefits over financial gain. While still collecting revenue, this is not the ultimate goal to be profitable, thus ranking lowest in terms of financial consideration.

Societal benefits:

- **Scenario 1:** Public ownership allows for direct consideration of societal benefits and tailoring solutions to address them.
- **Scenario 2:** Public authority involvement in establishing the CCC ensures societal concerns in the required services.
- **Scenario 4:** Regulatory requirements ensure that some societal benefits are considered, albeit indirectly through compliance with these requirements.
- **Scenario 3:** This scenario primarily focuses on financial profit, with societal benefits being secondary and difficult to financially motivate.

Overall, since the setting of requirements is a big factor differentiating the creation of these scenarios, the utilization of the produced scenarios is favorable for the public authority due to the public authority having the mandate of stating the requirements. Hence, when connecting the scenarios to the context of Gothenburg and the environmental goals stated by the public authority, their viewpoint is used, which has a high emphasis on climate and societal benefits, resulting in scenarios 1 and 2 being the scenarios found to address these benefits the most.

6
Discussion

This chapter discusses the evaluation of implementing a CCC in Gothenburg, including the recognized key stakeholders and their role, challenges and risk mitigation, a reflection on the application of scenarios, and finally factors that may have influenced the outcome of the study. The discussion both analyses important factors that influence the implementation of a CCC but also compare different actors' thoughts and experiences.

6.1 Discussion of evaluation of Gothenburg

The problems that Gothenburg is facing are no new task, and examining the prerequisites of the city, there are imminent logistical and environmental challenges ahead further exacerbated by the future or already ongoing large-scale construction projects. For the city to function properly in terms of addressing citizen safety, environmental goals as well as external interference of transport with the large increase in building rate that these projects infer, the CCC solution is viable. This evaluation focuses on providing a general approach to mapping the characteristics of what a CCC implementation means to the city of Gothenburg with different presumptions such as there are these previously mentioned development areas, contributing to to relevance of exploring this idea. Currently, the public authorities in Gothenburg are exploring the idea of establishing a CCC among other logistical solutions and no specific project is fully evaluated. For future actualization, a thorough analysis of the project, project area, and detailed specifications are needed for producing a more specified SWOT and scenarios that can be evaluated. Consequently, what may be lost to having this general approach is the accuracy of the scenarios and how they can be applied in a real context. On the other hand, the general approach can be utilized as a foundation for this more elaborate evaluation of specific projects to rely upon.

The SWOT analysis highlights the potential benefits and drawbacks highlighted by the theory and empirical findings of this study. The SWOT has comprehensive coverage and great alignment with the environmental goals of Gothenburg in terms of what the solution has to offer, indicating the potential synergy and support that this solution may expect. However, it does neglect some of the secondary consequences of implementing CCC solutions such as the limited evaluation of social and financial impact. While the analysis highlights both the benefits and drawbacks of the implementation, it could be strengthened by providing additional insights into

how these benefits and challenges could be achieved or prevailed to capitalize on these opportunities that are presented. Furthermore, there is a possibility that the SWOT analysis could have been more specific if there were more information to be had in regards to the traffic situation of Gothenburg, possibly through investigating the congestion nodes in the urban centers, and identifying geographical strengths and weaknesses as well. However, as this has not been conducted and is not within the scope of this study, there are limitations to how specific this investigation could be and the SWOT analysis conducted serves the purpose of identifying the most prominent features of a CCC solution in the context of Gothenburg could highlight.

It is important to acknowledge that these scenarios may not be the only ones suiting to address the situation in Gothenburg. These scenarios have been evaluated in such a way that they are general and wide-sweeping which may be positive due to them providing a framework that can be reiterated into more specific models. When evaluating the scenarios through the use of the Canvas Business Model, there are similarities between each of them. Firstly, they all rely on the same solution, but the difference among them is how it is enforced, incentivized, and operated and how collaboration is emphasized. In these scenarios, there is a clear difference in ownership structure which may have implications for the success of each of the solutions. The main difference that this highlights is how the financial risks and responsibilities are distributed among actors, with a variance in beneficiaries, influencing their willingness to participate. These differences in ownership structure consequently affect the order in which societal or financial profits are prioritized. These implications are crucial for stakeholders in deciding which scenario aligns best with their goals and values.

The final result states that there is a clear trade-off between the objectives of the suggested scenarios where financial gain and socioenvironmental goals are stood against each other, this in turn impacts the revenue models and the affordability of the solution, creating new challenges such as securing a high utilization rate. What this means for the outcome of the scenarios is that when the context of Gothenburg is applied, with its environmental goals and project-future, scenarios 1 and 2 are most favored. It is however important to acknowledge the financial viability of such an undertaking and the more financially oriented alternatives of scenario 3 or 4 could be less economically burdensome for the public authority, allocating resources to other socio-environmental interests.

6.2 Key stakeholders and driving forces in CCC implementation

Several actors have been identified as key stakeholders in the early stages of implementing a CCC solution for construction projects. These are the public authority, contractors/developers, and TPL-providers. Furthermore, they all have different opportunities and possibilities to affect the implementation of this kind of logistical solution in practice. Each actor therefore can act as a driving force for the estab-

lishment of a CCC.

The public authority has, according to theory, the possibility to provide support for CCC establishment in terms of setting requirements, land use permissions, and in their development area projects [Sullivan et al., 2011]. They play a vital role in facilitating support for setting up a CCC within a city. The empirical findings agree with the theory, where all actors agree that the public authority has the greatest possibility to increase the usage of CCCs as well as other logistical solutions. Especially the possibility of setting requirements is brought up in many interviews, including with Per Bramfalk, Fredrick Friblick, and Jonas Åslund, as an efficient way to drive the solution forward. The public authorities are key stakeholders when demanding a CCC solution in their development projects, but can also be important stakeholders by setting other requirements that push the industry to incorporate CCC solutions in their projects. Additionally, the public authority has the capital to fund innovative solutions, since they can justify the cost with social and climate benefits.

Contractors can, according to theory, be drivers of a CCC by acknowledging the benefits in terms of cost savings and logistical efficiency the solution can provide, and during early stages of project planning promote inclusion of a CCC [Cordis, 2022]. Interestingly, interviewees do not agree with the theory and consider it difficult for contractors to be driving factors. This mainly depends on cost considerations where implementing CCC solutions often requires upfront investments and routine changes. Jon Svensson identifies that contractors may be hesitant to bear these initial costs, especially if they are concerned about the return on investment or the impact on their project budgets. This does not mean that the theory is faulty since contractors do have the possibility to implement a CCC shown by Serneke, it is just difficult for contractors to justify cost increments with time efficiency and other benefits since there always exists big risks with such assumptions. Furthermore, Jonas Åslund describes that the high cost of the solution means that their bids for projects may be higher than competing companies, leading to the company not winning projects. Additionally, the solution is not as profitable for single-use projects because of the high implementation costs. However, contractors and developers are key stakeholders since they most often are the main users of a CCC during project construction.

TPL-providers are directly involved in the operation and management of a CCC. They are key stakeholders since they are the ones providing the necessary services in the operation of a CCC as well as optimizing the logistical processes as experts [Sullivan et al., 2011]. According to both theory and interviewees TPL-providers can act as driving forces by showcasing the benefits of CCC solutions, offering expertise in logistics management, and collaborating with other stakeholders to promote the solution. Although Martin Mattsson does recognize the difficulties TPL-providers have when wanting to establish their own CCC, since TPL-providers seldom have the capital to provide the necessary upfront investment for the solution. Therefore TPL-providers can be drivers for CCC implementation by proposing the solution as expert consultants in large projects, but not as much with establishing the service themselves. While public authority has been shown to operate CCCs in some of the

examples studied. The question is raised as to whether this was a success or not.

6.3 Stakeholder perspectives on setting requirements

During the empirical part of this study, the topic of public authorities' possibilities to set requirements for driving the implementation of CCCs as well as in driving change toward more sustainable and efficient construction projects has become pivotal. Per Bramfalk early stated that by including specific requirements in procurement processes, such as transportation, consolidation, or mandatory CCC usage, public authorities can motivate the adoption of CCC solutions. Magnus Jäderberg and Fredrick Friblick discussed transportation requirements, such as restrictions on vehicle types and delivery hours, and said that they can serve as effective measures to mitigate traffic congestion and reduce emissions, thereby promoting the use of CCCs. However, with these kinds of requirements, it is difficult to balance whether it will promote CCCs exclusively or allow other logistical solutions to emerge. Consolidation requirements, which are that certain transports pass through consolidation terminals, offer another way to stimulate CCC establishment. Magnus Jäderberg answers that while effective in promoting centralized logistics, implementing such requirements may pose challenges in enforcement and control. The last requirement brought up in most of the interviews is the mandatory CCC connection. This requirement is described as the most direct means to integrate CCCs into construction projects, particularly in publicly-owned development areas. This approach not only makes sure of CCC adoption but also aligns with environmental objectives.

Depending on which requirements the public authority may choose to incorporate in their land development agreements, either private or public actors will be more likely to provide the solution. This question on who should provide logistical solutions as well as CCC solutions sparks debate within the industry. While some advocate for public authorities to lead, others argue for private TPL-providers to foster market competition. Therefore the public authority must think about whether they are ready to provide a solution or want TPL-providers to find innovative solutions when setting requirements, as well as providing support for actors affected by the requirements.

Overall, while setting requirements presents opportunities to drive change toward CCC usage, stakeholders' reactions vary. TPL providers generally view requirements positively, as they see a market opportunity, while developers and contractors may face challenges in adapting to new prerequisites and view CCCs as an extra cost. Understanding the unique needs of each project and what everyone involved requires is crucial for making sure these requirements help achieve the goal of more sustainable and efficient building practices. Finally, it is about finding the right balance and making sure everyone is aware of the changes, what the requirements mean, and that solutions exist before projects start.

6.4 Challenges & risk mitigation

Many challenges and risks exist when implementing and establishing a CCC. During the study two main areas were brought up repeatedly, the financial challenges as well as if the solution is the right for the specific problem in projects. Through lessons learned in previous CCC implementations, these challenges can hopefully be mitigated in future projects. The challenges and ways to mitigate these risks are presented below.

6.4.1 Financial consideration

The financial investments needed to establish a CCC are a great challenge, especially for private actors such as developers, contractors, and TPL-providers. High initial costs are the significant barrier, involving expenses for land, facility construction, equipment purchases, software systems, and staffing. These costs need to be carefully balanced with the benefits to ensure a profitable CCC operation. This uncertainty of returns on investment adds to the challenges, where factors like variable construction demand, market conditions and fluctuations, and operational efficiency impact the CCC's financial performance. Additionally, the timeline to reach profitability is often unclear, making initiating stakeholders uncertain of the solution. Many CCC projects therefore depend on external funding and establishment from public authority for financial security, otherwise making managing funds important to avoid financial issues. Additionally, adhering to regulatory, environmental, safety, and possible specific requirement services, leads to extra costs, further adding to the financial load.

Theory and empirical findings highlight key strategies for mitigating these challenges related to finance surrounding a CCC. Developing clear and manageable business models is found crucial as they detail the CCCs and projects' financial condition, including revenue streams, cost structures, and funding. Furthermore, it provides clarity on how the CCC will generate income and cover expenses. Collaboration through public-private partnerships can distribute the financial burdens and risks, leading to greater project sustainability and life span. Lastly, establishing a long-term financial plan is key to forecasting financial needs, ensuring both immediate operational costs and long-term sustainability are accounted for. This is especially important to oversee when deciding on the size of the CCC as well as scope in terms of services provided as a long-spanning CCC must be profitable independently of market fluctuations.

6.4.2 The right solution for the specific problem

A question brought up during the study is if and when a CCC solution is necessary. Two points of view are discussed, where Fredrik Friblick mentions that other solutions may be preferred in many cases, and Magnus Jäderberg emphasizes the need for investigation before implementation to make sure an extensive CCC solution is necessary. Both ideas stem from looking at the project and its needs before thinking

about what solution is necessary, which is a common way of performing projects. However, in terms of reaching sustainability and climate goals, this is not always the approach you take, where methods such as back-casting often are used, where the desired future is established first [Holmberg and Robèrt, 2000]. By finding sustainable solutions first you can then work backwards to find out how this solution can be reached. Therefore it can be interesting for public authorities to first explore solutions in line with their sustainability and climate goals, and then find projects where this solution can be applied.

The question of which solution is the better option to use is common in all parts of a project since continuous comparisons are made during decision-making. In privately driven projects the cost is most often the factor influencing the decisions heavily. However, as previously mentioned, public-driven projects may accept costs if great social benefits exist. However, it is important to compare solutions and make thorough investigations and analyses regarding traffic and project scope to make sure that the chosen solution actually will provide the desired outcome. Extensive investigation of the scope and conditions will ensure that the solution chosen is the correct one. Therefore a CCC will not be the greatest solution for solving logistical problems in all projects. However, as previously discussed, researching different solutions in prior can increase the possibility of for example implementing a CCC as the logistical solution in projects.

6.5 Reflection on the application of scenarios

The scenarios were based on findings from the theoretical and empirical study and aimed to function as a stepping stone in the early stages of implementing CCCs in all kinds of urban areas. The evaluation conclude that the scenarios are preferred for the public authority to use, due to the different ways of setting requirements that affected the design of the scenarios mostly, especially in scenarios 1, 2, and 4. Furthermore, by analyzing the prerequisites in an urban area or a development project, certain scenarios may be found more fitting than others. There are various amount of prerequisites that may influence the choice of scenarios, where factors such as desired outcome, project challenges, and industry incentives were brought up during the empirical study. Reflections on which prerequisites may be found more fitting to certain scenarios from the perspective of the public authority are discussed below.

In very logistically challenged urban areas a market for advanced logistical solutions already exists. Construction companies are forced to include logistical solutions to be able to construct the intended projects, leading to a big market for TPL-providers. In these areas, the need for the public authority to step in and establish their solutions, found in scenarios 1 and 2, is less ideal since municipalities do not want to compete with the industry. Simultaneously, the existing logistical solutions may be a CCC or in other ways leads to the public authorities desired outcome of climate and social benefits. If a CCC already does not exist, the public authority can instead promote the solution by, for example, setting a time-of-delivery restriction, while simultaneously inquiring for a CCC solution. This is in line with scenario 4 where a

CCC solution is promoted by the public authority by requirements. However, if the public authority specifically wants to include a CCC solution they may still choose to explore scenarios 1 and 2, but a recommendation is to discuss the possibility of utilizing the industry market first. Perhaps TPL-providers want to provide the solution and the public authority only needs to create a forum for the actors to meet.

If the public authority wants to use a CCC with the motive of climate and social benefits, but the incentive from the industry does not exist due to advanced logistical solutions are not deemed necessary, the public authority instead should start exploring scenarios 1 or 2. In this urban setting, extra logistical solutions may not be necessary, due to project sites in the area have enough space and good transportation possibilities exist. Leading to few TPL-providers existing on the market. For a CCC solution to be implemented, the only possibility may then be to force actors through mandatory requirements within a specific development area to use a CCC. In these cases, the empirical study leans towards the public authority needing to provide the solution. The public authority then covers the implementation costs and many of the risks related to the establishment of a CCC to ensure a good relationship with the actors operating and are connected to the CCC.

Overall, the selection of scenarios for CCC implementation is highly dependent on urban characteristics and existing TPL-providers. In areas where advanced logistics solutions and providers are already in place, public authorities might lean towards scenarios that promote collaboration with the industry, such as scenario 4, rather than establishing new systems. Conversely, in less logistically developed areas, scenarios 1 or 2, where the public authority plays a more active role in setting up CCCs, may be more appropriate. Ultimately, the choice of scenario should be guided by a thorough analysis of the specific context and requirements of each urban area, minimizing the need for extensive scenario evaluations.

6.6 Factors influencing the outcome of the study

The choice of method is critical to the outcome of this study. The methodological approach was chosen as its components synthesize into what this study aims to accomplish. Firstly, the theoretical framework provides a foundational platform for this study to build upon. In this chapter, the concept of construction logistics is investigated as a whole, with more emphasis on the CCC solution. Without this, there would be widespread interpretations of what a CCC is and seeks to accomplish, as both the theoretical and empirical studies have found that there are various interpretations of this solution. The aim of evaluating the benefits and barriers to this solution may have been affected in such a way that the interviewees selected were mostly positive about the solution, while they highlighted some drawbacks, they all acknowledged an overall positive view of a CCC. To gain more contrast and provide for a more holistic viewpoint, the same set of questions could have been asked to more conservative industry actors. This flaw has resulted in the report being pivoted to favor the positive parts of a CCC, while still raising some drawbacks, it begs to ask if there may be more undiscovered.

Continually, the method of evaluating the theoretical and empirical findings through a SWOT, flowchart, and Business Model Canvas was adopted and reconstructed through the method presented by Cordis (2022). The outcome of this decision was to have an already recognized method of evaluating the setting in the context of Gothenburg, and the final result of four propositions which then are evaluated further. While the parts of this methodological evaluation are recognized as managerial methods to investigate the feasibility and possibilities of scenarios, they have in the case of Cordis (2022) been applied to already existing CCC solutions, and not only the overall case of a city as this study seeks to accomplish.

Overall, the methodological approach that was conducted was determined as it was found most suitable and adhered to the aim and purpose of this study. However, when carrying out this study through this approach, various consequences must be considered. First is the overall wholeness of the study. To address this, various key steps can be made, firstly being the inclusion of conservative industry actors to provide a more critical perspective. Consequently, in more speculative terms, this may inflict the result in such a way that the suggested scenarios provided could be altered to serve a more conservative industry and perhaps emphasize requirements and regulatory measures even more to drive the solution forward.

7
Conclusion

In the following chapter, the conclusions of this study are presented by answering the research questions. Additionally, propositions for future research and development are being raised.

Who are the key stakeholders during the initiating phase of establishing a CCC and how can the responsibilities of these key stakeholders differ in terms of financial aspects, regulatory compliance, and operational management?

The key stakeholders that were identified in the early stages of CCC implementation include the public authority, contractors/developers, and TPL-providers, each with different possibilities to drive the establishment of CCC solutions. The public authority can play a crucial role in the initiating phase by setting requirements that force or incentivize the usage of a CCC in development projects. Additionally, they can fund the startup of the CCC in terms of providing land as well as certain operational necessities. In some cases, the public authority can also operate the CCC, although this was not preferred according to the interviewees. Contractors/developers are capable of driving CCC solutions in some cases, although they face challenges with the return on investment and upfront costs. Especially during bidding processes for single projects where including a CCC drives the price upwards. However, they remain an essential stakeholder as they are the primary users of the solution during project construction. TPL-provider, while directly involved in CCC operation, may face difficulties in establishing their own CCC due to financial constraints and high risks. Beyond establishing and operating CCCs they can also contribute as experts consultants and collaborators in promoting the CCC solutions within projects.

What are the potential risks and challenges associated with implementing a CCC and how can they be mitigated or managed effectively?

The risks and challenges that have been identified with a CCC implementation circulate the potential weaknesses and threats of the solution. Most prominently is the question of its financial viability, whether it is the most suitable option as well as the low flexibility of a static solution, prone to market fluctuations and varying utilization rates. To address and mitigate these, a recommendation in line with the findings of this study would be to facilitate a solution where the financial risk is motivated by societal gains, this is accomplished by the public authority taking a central position as a driving force in requesting this solution. It was found that this

request could either be stipulated through mandatory connectivity or regulations. This regulatory framework or mandatory connectivity secures a high utilization rate and if other parameters such as geographical placement are considered, it may be a viable option to alleviate construction transports on a long-term horizon.

How can the implementation of a CCC be introduced into a metropolitan context?

The scenarios that have been evaluated in this study range from being fully financially oriented to favoring societal gains at a financial loss. These benefit different stakeholders differently depending on what scenario is chosen but they all can provide for a basis of understanding of what to consider when investigating the appropriateness of the CCC solution. The first scenario raises the importance of societal gains with the public authority being the central actor in providing this solution. The second scenario has similarities, however, the key difference is how financial risk is distributed, with the TPL-provider as the operator of a paid-for facility. Through regulatory measures, it ensures customers and utilization while still favoring societal gains. The third scenario relies on market principles for its function, with the added productivity measures or construction projects necessitating such a solution to drive customers. As it is fully privately operated without request from the public authority it is difficult for it to take the societal gains that the solution offers into account unlike scenarios 1 and 2. Finally, the fourth scenario presents the private industry with the opportunity to capitalizing on the requirements stated by the public authority, driving customers through these requirements as opposed to fully relying on market principles.

Overall, the implementation of a CCC can often be introduced with a sustainability argument since it will improve the supply chain, leading to less transportation and consequently lower emissions and impact on the climate and environment. However, the largeness of the sustainability outcome differs depending on the motive of the actors.

How can lessons learned from CCC implementations in major cities be applied to the context of Gothenburg?

The lessons learned from experiences with CCC solutions offer valuable insights for a future establishment in Gothenburg. What was found when studying already existing CCC solutions is that there is a large emphasis on having a well-considered plan as well as a functional business model. An adaptable business model is crucial for meeting the ever-changing needs of construction projects and stakeholders, emphasizing a tailored approach based on market or public prerequisites. In public and mandatory CCC implementation early stakeholder engagement is essential for contractual understanding, as well as balancing operational costs with social benefits to ensure a financially stable CCC. Comprehensive planning and communication during CCC operation are important for efficient usage, especially during peak construction periods. Finally, long-time planning is essential to adapt to unforeseen

events, and it is important to recognize the fact that the lifespan of a CCC can affect its financial sustainability. Overall, applying these lessons learned to the context of Gothenburg requires careful consideration of the city's characteristics, goals, and needs, but also the specific project that the CCC solution will be applied to. By utilizing these lessons, Gothenburg can increase its construction practices and move towards more sustainable and efficient construction solutions.

How can the gathered information synthesize into proposed strategy for an implementation in accordance with the prerequisites of Gothenburg city?

The information gathered in this study shows that there are multiple strategies for implementing a CCC in Gothenburg. Presently, establishing publicly funded CCCs is favored due to significant incentives provided by the municipality's environmental and climate goals program. This enables the city to justify some of the implementation and operational costs of CCCs in light of the societal benefits. Simultaneously, many interviewees highlight a notable lack of motivation within the construction industry as well as the difficulty of financially justifying such an investment, spurring the need for public authorities to take the lead in such initiatives. Consequently, it is recommended that Gothenburg City explores scenario 1 and scenario 2 as potential strategies, alongside the exploration and planning of large development areas. Overall, there are various factors influencing which of the scenarios would be the most optimal, and even though these are the preferred from the context of Gothenburg another scenario may be found to be optimal when analysing specific projects. Finally, the scenarios and business models produced in this study are intended to be used as a foundation when exploring the implementation of a CCC solution in future projects.

7.1 Recommendations for future development

This study has highlighted the many challenges that the construction industry is facing and what the introduction of construction logistics can do to alleviate these. With the implementation of CCCs in carefully considered placements, the industry may see great benefits in terms of the reduced amount of construction freight and higher project productivity among many other desirable features. While the study is positive towards this solution, there is a large gap of understanding that needs to be acknowledged for this to gain traction and reach its full potential.

To further develop this study a suggestion would be to investigate the cost-benefit relationship of construction logistics to emphasize the impact of implementing such solutions. As recognized by the study, this estimation is a difficult task due to the construction logistics of a project being part of the contractors' daily tasks and the cost is often concealed. Consequently, the introduction of construction logistics and solutions such as the CCC materializes these costs and may pose a barrier due to the consideration of the steep cost, rather than the productivity increase, leading to cost-savings. One component in investigating the matter of CCCs fully is motivating

its cost-benefit relationship which should be sought to develop in future studies.

Finally, as stated by the purpose of this study, it aims to provide a basis for understanding the responsibilities of stakeholders in the initiating stages. For future development, this study can be used as a foundation to build a more in-depth analysis upon, which may yield more precise results. With the specific case of Gothenburg in mind, the city would be recommended to conduct specific analyses of the individual projects or development areas where the proposed scenarios can be the starting point from which to act. As with the cost-benefit situation previously described. To fully justify this kind of solution, further calculations would be recommended, to motivate the environmental impact and its alignment with municipal goals.

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Appendix 1

Sullivan et al. (2011) designed a flow chart to guide future application of a CCC in regards to choosing a suitable CC model see Figure A.1. The method follows the following flow chart which considers different factors, such as location and area of the site, to assist in the decision-process for clients or contractors interested in implementing a CCC solution. A degree of flexibility is however proposed to find the optimal solution since a hybrid of two CC solutions can be utilized as well. Sullivan's method was chosen since it generalize the types of CCC into three categorises which is suitable in our research since no predetermined CCC solution has been presented.

This flowchart is applied to large construction projects planned or already initiated since these are the type of projects most likely needing to incorporate a CCC in their logistical plan. Throughout the interviews it was described that the development area of Älvstaden which include Masthuggskajen as well as Lindholmen among other are to be a challenge in successfully addressing their logistical issues. Some key characteristics for the evaluated development areas and projects are that the location of the developing projects in the central areas are all in the inner city surrounded with commercial and residential buildings. Additionally it is in an area where most of Gothenburg's tram infrastructure passes through. The area is also in close proximity to the large infrastructure project Västlänken as well as commercial construction projects. Following the flowchart presented in Figure A.1 to make the decision what type of CCC would be most suitable for developing projects with these type of constraints, it was found that a collaborative consolidation center or a communal consolidation center were the suggested options. Projects in Lindholmen as well as Masthuggskajen results in the same outcome.

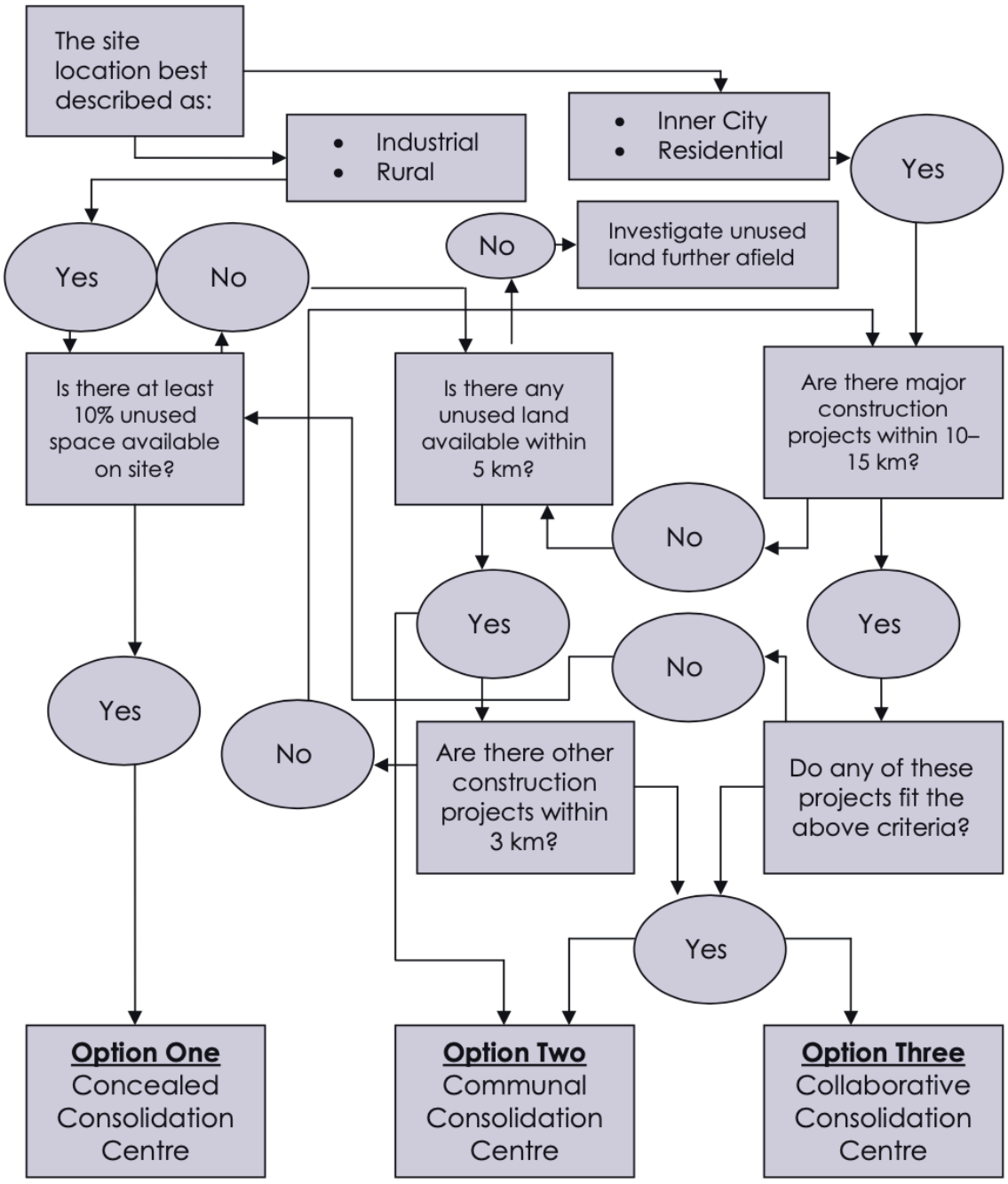

Figure A.1: Flowchart for deciding optimal CCC solution [Sullivan et al., 2011].

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