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Circular Logistics in the Construction Industry

An exploratory study based in a Swedish context

Master's thesis in Supply Chain Management

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Gothenburg, Sweden 2022
www.chalmers.se
Report No. E2022:039

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SUMMARY

The construction industry faces great environmental challenges; the construction industry is one of the industries with the highest emission of greenhouse gases, as well as user of virgin materials. One way to reduce the environmental impact of the industry is through circular economy, which would reduce the need for virgin materials. In order to enable circular economy in the construction industry, the logistical system of the industry must be adapted. This study aspires to determine how circular logistics should be used in order to facilitate for circularity. As a result, interviews have been carried out with people who have experience from either circularity, sustainability or logistics in the construction industry. From these interviews, a network has been presented that is designed to describe the building blocks of a circular logistical network. Additionally, the main driving forces and hinders to work with circular logistics has been discussed.

The study concludes that the construction industry lacks logistical performance, as well as actors with the knowledge and competence to operate in a circular logistical system. Furthermore, a circular logistics network must be constructed with the focus of keeping the value as high as possible between two construction clients. In addition, the actors that operate within the logistical network has to facilitate for larger quantities of reused materials. Finally, it must be economically viable for construction clients to adopt a more circular approach.

Keywords: Circular Logistics, Circularity, Construction Industry, Environmental Sustainability

Acknowledgement

This report was carried out during our last semester at the master's program Supply Chain Management at Chalmers University of Technology. It was written together with the Swedish consultancy-firm AFRY, at the division of Industrial and Digital Solutions. Together, we hope that this report will affect the mindsets of people within the construction industry to work together in a more sustainable and circular manner.

Firstly, we would like to give our uttermost gratitude to our supervisor and examiner at Chalmers, Petra Bosch-Sijtsema. Thank you for contributing with your knowledge within our area of study, as well as for giving us constant feedback throughout the entirety of the project and for always being reachable and quick to respond to our questions and reflections. We also want to direct our gratitude to our mentors at AFRY, Jenny Olsson and Petter Wadmark. We appreciate your continuous support, your knowledge within construction logistics and your drive and encouragement to propel the project forward. Finally, we want to thank all the interviewees that used their time to contribute to our study. We are very grateful for the vast interest and support that we experienced from the participating respondents.

Andreas Andersson & Alexandra Söderberg
Gothenburg, May 2022

Glossary

Building Permit - Bygglov

Demolish - Riva

Dismantle - Montera ner

Inventory - Inventering

Key Performance Indicators (KPI) - Nyckeltal

Responsibility of producer - Producentansvar

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1 Introduction

The construction industry is facing a number of challenges regarding environmental sustainability, which includes the high levels of transportations and waste that are common in construction projects (Enshassi, Kochendoerfer, & Rizq, 2014). According to Josefsson and Saukkoriipi (2005), the average level of waste in a construction project related to resources adds up to more than 10% of the total construction cost of the project. Additionally, according to a report by Boverket (2021), emissions of greenhouse gases from the construction industry during 2019 represented more than 20% of the total level of emissions in Sweden. Since 1 January 2022 the Swedish Parliament has decided to introduce a requirement for a climate declaration which force actors in the construction industry to reduce the environmental impact from their operations (Boverket, 2022). It is possible to reduce this impact through the use of circular logistics, as this has the potential to reduce the level of "virgin materials" used (King, Burgess, Ijomah, & McMahon, 2006). This study will investigate how circular logistics could be used to lessen the environmental impact from construction projects.

This chapter gives a brief description of the background, aim and delimitations for this project. In addition to this, the research questions will be derived from the project's aim. These questions form the base, and the report aims to answer these questions.

1.1 Background

As of today, the construction industry faces great challenges regarding environmental sustainability. According to World Economic Forum (2016), the construction industry is the industry that globally uses the most virgin material. One way that has the potential to reduce the impact of the construction industry is the use of circular logistical flows. Today, there is a lack of existing flows and methods to facilitate circular logistics and recycling within the construction sector; it is estimated that between 70-80% of the waste within the construction industry is not recycled (World Economic Forum, 2016). In those cases where circular flows exist, there is often a lack of coordination between different actors. Moreover, an increase in circularity would create new challenges on both new and existing actors (Adams, Osmani, Thorpe, & Thornback, 2017). Incorporating a higher level of circular processes could increase the ability for the industry to be more sustainable (Barthrope, Robbins, & Sullivan, 2010). World Economic Forum (2016) argues that even small changes throughout the industry could have big impact on global environmental sustainability, as a result of the size of the industry.

The report will investigate what must be done from a logistical perspective in order to enable circularity in the construction industry. The report will map how circular logistical flows are designed today and look at what the client of a construction

project can do to enable these flows to be improved in order to reduce waste and improve sustainability. This mapping will be done with regards to the construction sector.

1.1.1 Circular Logistics and Construction Clients

To be able to identify a holistic concept that is relevant for the study, the definition of circular logistics has to be derived from various sources and closely related concepts. To start off, the broader term of circular economy must be characterized. According to Stahel and MacArthur (2019), circular economy is when a traditional linear economy is changed to create value from the products that are depleted in the view of the end-customer. These products can for instance be reused in the current state, refurbished or recycled. In addition to this, Kossila (2021) describes that a circular material flow is when the remaining value of a product, that has been used by a consumer, is captured in such a way that a new product assumes the value of the old one.

Traditionally, supply chains were focused on delivering products downstream, from producers towards consumers. In recent years however, the characteristics of supply chains have changed (Fleischmann, Dekker, Inderfuth, & Wassenhove, 2004). Even though the main focus of supply chains is still to deliver to customers, supply chains have increased the focus on the reversed flow of goods, from the consumer back to the producer. Fleischmann et al. (2004) describe that in the practice of reverse logistics, the products that are returned to the producer still have sufficient value to be able to be used in a different supply chain.

Based on the concepts that have been presented in this section, circular logistics will be defined as **"the logistical processes that enable value to be captured after a product has been used, in order to benefit new products"**.

The report will be rooted from the viewpoint of the construction client. Kamara, Anumba, and Evbuomwan (2002) describe that the construction client conceptualizes a construction project, meaning that the client stipulates the characteristics of the project. As a result of the construction client having mandate and authority to affect construction projects, it is practical and reasonable to approach the issue of circular logistics from the perspective of the client.

1.2 Aim

The aim with the report is to, from the perspective of a client within the construction sector, determine how circular logistics can be beneficial from an environmentally sustainable point of view. In addition to this, the report aims to determine which factors are essential for the client to enable a successful implementation of circular logistics.

1.3 Research Questions

As been described, there is a potential to increase environmental sustainability through the use of circular logistics. To get a better understanding how this can be done in the construction industry, three research questions have been formulated. These questions are formulated to investigate the issue from a client's point of view. First of all, an understanding of the current situation is required (RQ1). Secondly, what is needed to accomplish a sustainable circular logistic flow will be identified and analyzed (RQ2). The last research question (RQ3) aims to investigate the driving forces and hinders of using circular logistics in order to achieve a higher level of environmental sustainability from the client's perspective.

RQ1: What does the current state look like from the client's point of view regarding circular logistics?

RQ2: Which factors are needed to enable circular logistical flows in the construction industry?

RQ3: What are the driving forces and hinders of circular logistics from the client's point of view?

The research questions are derived with the intent to develop an understanding about how to design a logistical network in order to allow for circularity in the construction industry. They have been designed with the intent to specify for a construction client how circular logistics should be used in order to increase environmental sustainability.

1.4 Delimitations

In this section, a number of delimitations to the report are presented. The delimitations are designed to both make sure that the report provides relevant results with regard to the aim, but also to fit the time constraints that are applied on the project. As a result of that, the report will focus on environmental sustainability as the main driver for circular logistics. This means that the study first and foremost concentrate on how circular logistics affects the environmental dimension of a construction project. Even so, economic and social aspects may still be factors that are important for the client of the project, meaning that these dimensions may also be considered in the report, albeit not to the same extent.

The report is not discussing bulk-goods and very large goods like frames of buildings, as the logistical flows for these types of goods to some extent is different compared to other goods used for construction. These goods has not been discussed frequently in the interviews, and in cases where they have been discussed, it has been clear that the logistical operations in these cases have too little in common with other types of goods needed for the construction industry.

The aim with the report is not to develop new digital tools or solutions which could be used to simplify circular logistics for a client. Even so, development of current tools and solutions could be considered as an important factor to allow for better circular logistics and could therefore be a part of the solution.

Finally, the report will take place in a Swedish context. This means that the aspects of the project and the actors that will take part in the study all operate within the Swedish market. This does not limit the involvement of international actors though, since the Swedish construction sector frequently consists of several actors from different countries.

1.5 Outline

This master thesis consists of six chapters, with several subheadings (which also will be called sections throughout the report), with the following structure: The first chapter gives a broad overview and understanding of the challenges the construction industry faces from an environmental sustainability perspective. The second chapter, theoretical framework, present relevant literature that will be used as a support both when it comes to structure and plan the interviews but also to analyze the result and provide a good basis for the discussion. The third chapter, methodology, gives a deeper understanding of the working process and applied methods that have been chosen to reach insights that can further leads to answers and conclusions to the research questions. The fourth chapter will present the results, followed by a fifth chapter consisting of the discussion. Finally, the sixth and last chapter present the conclusions of the thesis.

2 Theoretical Framework

In this chapter, relevant theory will be presented with the aim to give a brief background of the subject together with theory that later will support the discussion and contribute to relevant conclusions. The chapter will start with a section presenting where the construction industry is today, the different phases of the construction industry and some important definitions. This will be followed by a section containing some framework grounded in sustainability that will contribute to a deeper discussion. The third section will explore the concept and definition of circular logistic and lastly, a section of network perspective will be presented.

2.1 The Construction Industry

Fundamentally, the construction industry deals with designing, constructing, maintaining and repairing buildings and infrastructure (Behm, 2008). The construction industry differs somewhat across different countries. Since the report has a Swedish focus, this section will primarily consider the characteristics of the Swedish construction industry. Primarily, this section will focus on how the logistics around a construction project are designed.

In this report, the construction client's (sometimes just called client) perspective is the main focus. To make the report less unambiguous, the client as a concept will be defined. Since the report is set in a Swedish context, the Swedish concept of "Byggherre" will be used as the definition of a client. The concept is translated by the Swedish industry organization "Byggherrarna" to "construction client" (Byggherrarna, 2019). According to Swedish law, a construction client is someone who for their own sake carries out, or lets someone else carry out, a construction project such as building, demolition or groundwork (Sveriges Riksdag, 2010). A client could either be a physical person or a juridical person, such as a company or a municipality. The client is responsible for that the processes that are carried out during the construction project follows the laws and regulations that are in place for the concerned area.

One of the main features of the construction industry is its complexity. Brockmann and Kähkönen (2012) describe that the approach to a project can be vastly different in terms of what resources are needed depending on the projects level of complexity. This implies a high level of uniqueness regarding the selection of processes that are involved; Barthrope et al. (2010) describe that there is often an ad hoc-attitude within construction projects. Koskela (1999) compares the construction industry to a car manufacturer, and argues that a car manufacturer has a number of workstations, where each is dedicated and optimized for a single task, whereas in a construction project, all tasks must be carried out at a single site.

2.1.1 Construction Phases

Even though construction projects differ, and the sets of actors varies, there are a few stages and parts that will remain the same in the construction process. Generally, the construction process can be divided in four phases: the initiation phase, the design phase, the construction phase and lastly the closeout phase (Projektledning, 2018). This is visualized in *figure 1.*

Figure 1: *Construction Phases, modified from Projektledning (2018)*

The initiation phase contains estimations of which experts that are necessary to be able to highlight the different challenges and risks that may occur related to the project (Klinger & Susong, 2006). This phase is about gain insight of the project and map all possible challenges to foresee eventual problems that can contribute to delays and overheads. Through the experts, surveys and suggestions for measures can be made (Klinger & Susong, 2006; Projektledning, 2018).

In the design phase, it is first of all necessary to select a project manager to be able to carry through the phases at the best possible way (Projektledning, 2021). In the initiation phase, all the needed data are gathered, and is subsequently in the design phase used as a basis for requesting quotations from external partners. In the design phase, drawings and documents about the project are developed (Klinger & Susong, 2006). The design phase gives both the property owner and the customer the information they need regarding the project in order to be able to further take decisions about the project design and implementation. During the design phase, several decisions are made based on the documents that have been produced. This may, for example, be about the construction design and technical standards (Projektledning,

2021).

The construction phase consists of several parts beyond the actual construction itself, as the administrative work around the project, inspections, financial parts, cost calculations and review of documents etc. When the construction has been carried out, the closeout phase remains. This phase consists of handing over documents, drawings and instructions of care and service (Projektledning, 2018).

2.1.2 Construction Logistics

The construction industry place special demands on a logistical system. Janné (2020) describes that there is a continuous demand for construction projects with the increasing urbanization that currently is ongoing. Conversely, the increased urbanization also reduces the remaining available land in the city, meaning that a new construction project has to rely on ever smaller spaces for unloading trucks and storing material. In addition to this, environmental laws and noise pollution are factors which may limit the use of transportation to and from the construction site (Henke & de Serves, 2007; Lumdsen, 2007).

Ying, Tookey, and Seadon (2018) describe that the construction industry is based on projects, which means that each construction project is at least to some extent unique. The logistical system must as a result be adapted to fit the special conditions that each project requires. Therefore, there is also often an impromptu attitude to logistics; since most projects often differs and are not the same, the logistical attributes are often tailor-made for that specific project. Barthrope et al. (2010) highlight the importance of planning and designing a plan for the execution of construction logistics for a specific project at a early stage; even though the material flows in a construction projects only are present during the construction phase, the success of these flows are usually decided by the calibre of the logistical planning during the phases prior to the construction phase.

Traditionally, Just-In-Time deliveries have been a central part of construction logistics (Barthrope et al., 2010). Akintoye (1993) describes the complexity of Just-In-Time in the construction sector; a high number of components and parts are needed to complete a project. Some components are assembled in a factory to create prefabricated sections. Other components and parts are used with the intent to be used in a manufacturing process directly at the building site. Additionally, Akintoye argues that several other factors also affect the complexity of the Just-In-Time deliveries; ordered quantities, the supplier of materials and the distribution system of material are also important factors.

Sundquist, Gadde, and Hulthén (2017) argue that the construction industry is lagging behind other industries from a logistical point of view. Sundquist et al. mean that the industry is lacking in productivity, and that the lack can partially be explained with a low efficiency in material flows. Additionally, Adams et al. (2017)

argue that the uniqueness of projects is a factor that lowers the logistical efficiency within the industry.

According to Sundquist et al. (2017), storing capacity at construction sites is an issue, as construction projects often take place in an environment with limited space. Furthermore, Sundquist et al. argue that sometimes, more material than necessary are ordered to cover for potential shortage of materials, which consequently leads to more space on the building site being used for storage, as well as a higher risk of damage of materials. Sundquist et al. (2017) describe that to solve these issues, the industry has to become even better at planning and be more efficient at material handling, as this could reduce the need for ordering too much material. In addition to this, Barthrope et al. (2010) argue that by using consolidation centers, the impact of some of the logistical problems can be reduced. Instead of delivering directly to the construction site, the trucks transport the goods to the consolidation centre. The centre does also operate as a storing facility for materials that are not yet needed at the construction site. Additionally, by using a consolidation center, the number of deliveries to a construction site are reduced, as materials from different sources are delivered together (Dreischerf & Buijs, 2021). This reduces the pressure on the unloading facilities of the construction site. Since the consolidation centre will be used for storing material, less materials need to be stored at the construction site, which frees up space and makes it less likely that goods are damaged at the construction site (Barthrope et al., 2010).

Another subject that needs to be addressed is the issue regarding waste management. The waste can both origin in demolition work of older buildings and as residual material from the project (Liyin & Hongping, 2011). Overall, the construction industry generate high level of waste; Nowak, Steiner, and Wiegel (2009) describe that the construction industry produces between two and five times more waste than all European households combined. Barthrope et al. (2010) describe that in construction, there are often numerous types of wastes that are required to take care of. Some materials, like wood and paper, can be recycled, whereas other materials cannot. In addition, certain materials used are classified as hazardous, meaning that special care needs to be taken while handling these. The fact that different conditions apply for different materials means that a company that handles waste at a construction site has to be flexible and able to handle different materials. Since projects usually do not look exactly the same, the waste management of each construction project will be at least to some extent tailor-made to fit the materials and the layout of the construction site.

2.1.3 Legislations regarding Circularity

In recent years, a number of changes in various laws have been made by the Swedish government within the area of construction logistics to promote environmental sustainability. After the year of 2020, it became mandatory to sort out and recycle

a minimum of six different fractions in a construction project (Sveriges Riksdag, 2020). These fractions are wood, minerals, metal, glas, plastics and plaster. It has also been stated that these materials have to be kept and transported in different containers, and that the sorted materials is not allowed to be incinerated. Additionally, in 2010 it was decided that when a demolition is carried out, the construction client is obliged to carry out an inventory of the materials of the building that is to be demolished (Sveriges Riksdag, 2010). The client is required to identify which materials in the building that is supposed to be demolished that can be reused. Furthermore, it must also be stated how these materials are supposed to be taken care of.

As a mean to try and reduce the environmental impact of a number of manufactured goods, the Swedish government has stipulated a number of laws regarding the responsibility of the producer of these goods. The laws are different depending on what type of material that is regarded, but it is common that they demand the producer of a product to be responsible for the collection of used products and for making sure that the products are taken care of in an environmentally correct manner (Kossila, 2021; Maja Larsson, 2006). As of today, the materials traditionally used for construction are not covered by any laws regarding responsibility of the producer, even though discussions on the subject have been proposed in the Swedish government (Naturvårdsverket, 2022; Riksdagen, 2018).

2.1.4 Building Permits

In order to carry out the majority of larger construction and renovation projects in Sweden, a building permit is required. The application for a building permit is sent to the municipality in which the construction project is taking place and it is the building committee of the municipality which approves the application (Gustafsson, 2015); (Sveriges Riksdag, 2010). The committee takes a decision based on a number of factors, which includes how the building fits in the city and the environmental impact that the building has (Rasmusson, 2018). The application should contain information necessary for being able to make a decision regarding the application (Sveriges Riksdag, 2010).

2.2 Sustainable Development

In the 1980s the Norwegian Prime Minister Gro Harlem Brundtland defined sustainable development as *"Meeting the needs of the present without compromising the ability to future generations to meet their own needs."* This means that companies should always strive to operate in ways that secure economic performance in the long-term by avoiding short-term behavior that contribute to environmental waste and socially detrimental effects (Porter & Kramer, 2006).

An important part of the sustainable development is *Circular Economy*, which partly

is seen as a solution to the different challenges to achieving a sustainable development (Geissdoerfer, Savaget, Bocken, & Hultink, 2017). A circular economy or economic system that strives to minimize the use of resources to reduce the amount of waste, emission and energy will result in a reduced environmental impact (Geissdoerfer et al., 2018). According to Geissdoerfer et al. (2018), an important aspect of the circular economy is to transfer and involve private business to a more sustainable system and create a network with extended value. One key for organizations to successfully accomplish these changes, transfer from private business to a network system, is with the help of a business model.

According to the European Commission (2014) a circular economic system preserves the value in the product as long as feasible and tries to reduce waste. This results in that the resources is kept within the economy and can be reused even when the product has reached its life span. As mentioned earlier, this is achieved by minimise the consumption of resources which is done by recycling of materials and energy to avoid leakage out of the system. This is also highlighted in the butterfly diagram by Ellen Mcarthur Foundation (2013) which will be presented further in the following section, *section 2.2.1*.

2.2.1 The Butterfly Diagram

Ellen Mcarthur Foundation (2013) discusses the circular principles which describes how to reduce unnecessary exploitation of resources and maintain the value within the raw materials and resources used. The different ways of keeping the value and extend the resources lifetime is by Ellen Mcarthur Foundation symbolized in a butterfly diagram, *figure 2*. The purpose with the diagram is to minimize the "leak" that occurs, since the leakage represents a loss of value that was previously contained in the system. As a result, this lost value will have to be replaced by new raw materials.

The central part of the butterfly diagram, *figure 2*, is in essence a traditional linear economy; raw materials enter the system at the top, from where they are used to manufacture parts and components. These parts and components are then used to create products, which are delivered to customers through service providers. Each of these steps requires energy and resources in order to add value to the product (Kossila, 2021). This means that the closer the product is in regard to the consumer, the higher is the value that can be attributed to the product, and a lower level of energy is required to transform it from its current state to a finished state (King et al., 2006). In a traditional linear economy, it is not uncommon for the products to be deposed after being used by the consumer. In a circular economy however, the product is in one way or another reused to capture its remaining value. Ellen Mcarthur Foundation (2013) expresses that the two "butterfly wings" in *figure 2* represents the two ways that material can be reused in a circular system. Since energy is needed to add value, it is more preferable to use a smaller cycle where

materials do not need to go through more value-adding steps in order to be able to be used by a consumer again (King et al., 2006).

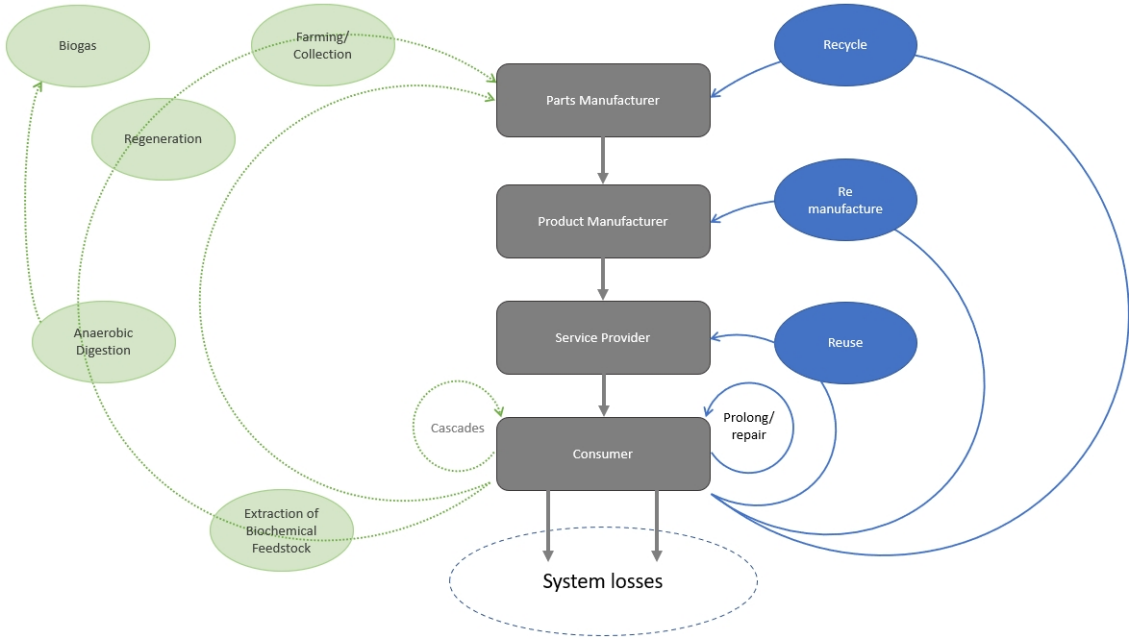

Figure 2: *The Butterfly Diagram, Modified from Ellen Mcarthur Foundation (2013)*

The left side of the model describes the cycle of biodegradable materials. This section of the diagram will not be used in this report and is therefore transparent in *figure 2*. The right part of the diagram describes the technical cycle, which contains of materials that are not biodegradable, such as different types of metals and plastics (Ellen Mcarthur Foundation, 2013). These materials can be reused in several different ways. In the diagram, it is more beneficial to follow a smaller circle, as this is more energy-conservative as a smaller number of value-adding operations need to be carried out (King et al., 2006). On the right-hand side of the diagram, the smallest loop represents operations that aim to prolong and repair products during within the scope of a single owner. Following this, reusing a product creates the second smallest loop, as no value-adding operations are necessary between two different users of a product; the product is used in the same state by both users and the only operation that needs to be carried out is the transportation and reselling of the product.

The next way to reuse non-biodegradable materials is through re-manufacturing (Ellen Mcarthur Foundation, 2013). Compared to repairing and prolonging actions that creates the smallest loop in the diagram, the process of re-manufacturing requires more energy and resources, meaning that it is preferable to do maintenance in a preventive cause to avoid re-manufacturing in as large extent as possible (King et al., 2006). With this said, a re-manufactured product requires way less energy than a new one; Southern Waste Region (2021) argues that, for construction products, roughly 50-80% less energy is needed to re-manufacture a product compared to the

energy required to make a similar new product.

The final loop on the right-hand side of the Butterfly Diagram, *figure 2*, is the recycle-loop. Out of all the methods available for regenerating non-biodegradable materials, recycling is the one where the material has the lowest value when it re-enters the system, and therefore requires the most energy to make it utilizable in a new product for a consumer (King et al., 2006 & Ellen Mcarthur Foundation, 2013).

To summarize, the butterfly diagram is used to display and categorize the various ways that materials and products could be circulated (Ellen Mcarthur Foundation, 2013). The diagram describes how value is kept within a system. Through the usage of the diagram, it is possible to distinguish how the life of resources should be extended, and how leakage in a system is minimized.

2.2.2 Circular Business Models

A business model takes its starting point from the core of the company and how it creates value for its customers. It describes how the company is structured and how it should create revenue, produce a product and be able to deliver to the customers (Kossila, 2021). The development from a traditional business model to a sustainable business model includes a more long-term perspective from a sustainable point of view. Here, a sustainable point of view means that the company starts to identify the value it creates for its environment and its step towards a circular business model. In a circular business model, the company start acting in the sense of securing that the products contribute to the reduction of the use of resources (Kossila, 2021). How the different states of business models relate to each other are visualized in *figure 3* by Geissdoerfer et al. (2018) and is later used in the literature by Kossila (2021).

In this framework, *figure 3*, the development to reform a business model towards a sustainable business model is categorized by three elements, sustainable value creation, more proactive management of a more comprehensive set of stakeholders and a long-term perspective (Geissdoerfer et al., 2018). Sustainable value creation starts by reviewing the sustainability in the business and its activities. It could for example be to search for an opportunity to decrease the number of transports with the aim to reduce emissions. The other two elements aim to increase the awareness of how the business and activities influence the environment and what value it creates for the society in which it operates. Nevertheless, the two latter elements are done on a more long-term perspective and a proactive approach is applied in consideration to more stakeholders (Kossila, 2021).

Geissdoerfer et al. (2018) describe how the concept of circular business models came from the combination of challenges with implementing circular economy into the real world and the practice-oriented strategy of business model innovation. Circular business models are often used to describe business models that are in line with the circular economy by incorporating elements that narrows, slows, and closes resource

loops, which is visualized in *figure 3*. This means that the company makes sure that the used material continues to circulate through resource loops to extend its life span. A circular business model is built on resource loops that maintain the value of materials and resources (Kossila, 2021). Closing loops comprises measures aimed at enabling recycling, while narrowing loops represents measures taken to increase efficiency. Additionally, slowing the loops is equal to extension of phases in a circular economy. These loops refer to the biological and technical cycles of the circular economy by Ellen Mcarthur Foundation (2013) & Geissdoerfer et al. (2018). It is important to develop a value network with stakeholders that are driven and have the motivation to contribute to environmental benefits, economic viability and social concerns to be able to have a successful circular business model characterized by value creation (Geissdoerfer et al., 2018).

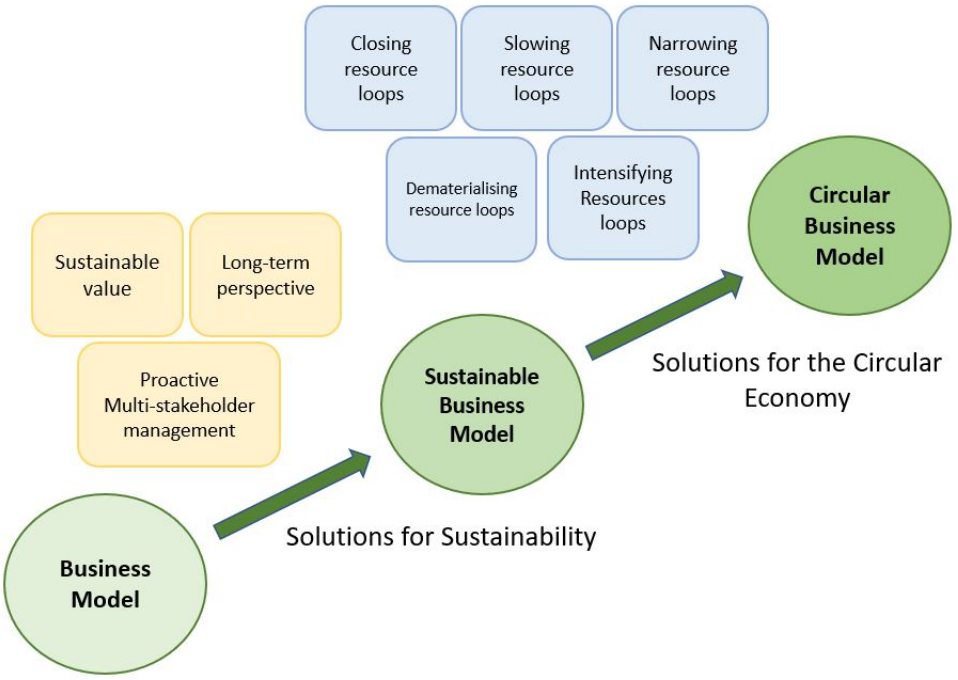

Figure 3: *Business Models, modified from Geissdoerfer et al. (2018)*

The driving forces to move from a traditional business model towards a more circular business models where the company adopts circularity differs. According to Kossila (2021), an early adoption to a circular business model could be a driving force for the company to become a role model at the market. It could also be about open up new business opportunities, economic benefits, requirements from customers or the ability to secure the assets to valuable raw materials.

As illustrated in *figure 3*, a circular business model can be defined as a sustainable business model which also aims at establishing solutions for sustainable development by creating monetary and non-monetary value. This is done by pro-active management consisting of several stakeholders and incorporating a long-term perspective that strives for circular economical solutions through circular value chains

(Geissdoerfer et al., 2018).

2.2.3 Circularity in the Construction Industry

Andersson, Moberg, Gerhardsson, and Lindholm (2021) argue that, even though the construction industry has started to look at and discuss issues regarding circularity, there is still a lot to be done; only about a third of the potential of circularity in the construction industry is actually exploited today. Admittedly, Andersson et al. (2021) argue that the potential for circularity is very high; by incorporating circularity in the construction industry, companies are not only able to decrease their level of waste and greenhouse gases, but also have a positive impact on the brand of the company. However, the authors argue that there is plenty still to be done to increase circularity and that actors in the industry need to be educated in order for them to realize the full potential of the benefits of circularity.

Andersson et al. (2021) argue that there are a number of practical issues that must be addressed when working with circularity in the construction industry. Firstly, Andersson et al. argue that it is important to have a clear structure on the construction site and that the material flows are clear for everyone. Additionally, the authors argues that the division of responsibility between different actors at a construction site is key and that it should be very clear who has the responsibility for certain processes or materials. Connected to this is also the question of material handling; the materials should be handled with a methodology that is aimed at not destroying or damaging materials within the circular processes and that all concerned actors, both in terms of dismantlers but also transporters and other actors, are synchronized in order to reduce the risk of damaging materials. Finally, actors should be aware of the time aspect of circularity and that there might be a substantial time until there is demand for a specific material. This puts special demands on actors that keep materials in storage.

Ajayi et al. (2015) present a number of actions to take in order to be able to decrease the waste within the construction industry, which can be seen in *figure 4*. Firstly, Ajayi et al. (2015) argue that it is important to take the entirety of a building into consideration when planning for waste reduction. They argue that buildings should be designed in order to allow for being able to be dismantled, in order to reuse the material from the building and in such way reduce the waste at the end of the life of a construction project. This can be contrasted by the argumentation by Munaro, Tavares, and Bragança (2020), who argues that, as of today, there is a lack of incentives to design buildings in order for them to be able to be dismantled at a later stage. Following this, Ajayi et al. (2015) describe that BIM-models could be used to decrease the levels of waste in a construction project. BIM, or Building Information Model, is a model used to represent and visualize objects within a construction project (Jongeling, 2008). Ajayi et al. (2015) argue that the construction industry is shifting ever more towards BIM-models, and that waste management solutions

therefore must be more compatible and integrated with BIM-models.

Another way to reduce the need of waste is through legislative measures; Ajayi et al. (2015) describe that a frequently used measurement by governments around the world is to make companies liable for their waste by introducing fees that corresponds to the level of waste that a specific company produces. Additionally, law makers could design a system where waste reduction as a concept must be incorporated in the design phase of a project, which according to Ajayi et al. is a stage where a lot can be done regarding reduction of waste. Munaro et al. (2020) agree that lawmakers has a great responsibility and argue that law incentives are crucial when moving towards circularity. Additionally, Ajayi et al. (2015) argue that waste can in many cases be erased during the planning phase of a construction project. For instance, standardisations of buildings and processes could be used in order to reduce the ability of having material that are not optimized for specific construction projects, and therefore reducing the risk of waste in the form of off-cuts.

In addition to this, Ajayi et al. (2015) also argue that researchers have a vital role in the reduction of waste; there has to be more R&D carried out into strategies regarding waste management. Subsequently, the knowledge of these strategies needs to be communicated to actors in the industry, meaning that there is a need to increase the education within the industry. Finally, Ajayi et al. (2015) describe that it is important for the usage of circularity to be economically viable, meaning that the economic benefits that reducing waste provides should be greater than the additional cost that comes with waste minimizing. Practically, this means that actors in the industry would strive towards waste reduction, as they would see economic benefits from reducing waste.

Sezer and Bosch-Sijtsema (2020) mentioned a number of issues that may occur in the process of refurbishment in the construction industry. One issue mentioned by the authors were the limitations of space that is common at construction sites, especially in densely populated areas. This lack of space hinders the easiness of sorting recycling, as the containers and equipment may not be available to the extent needed as they require space. Additionally, Sezer and Bosch-Sijtsema argue that there is a lack of standardised approaches to refurbishment, as the differences in refurbishment processes may vary to a great extent. The lack of knowledge of construction clients could be a factor that limits the refurbishment process in the construction industry. Lack of knowledge meant that clients did not make specific demands for refurbishment to a great extent, which makes it hard to gain an understanding of the requirements of the client in terms of refurbishment (Sezer & Bosch-Sijtsema, 2020).

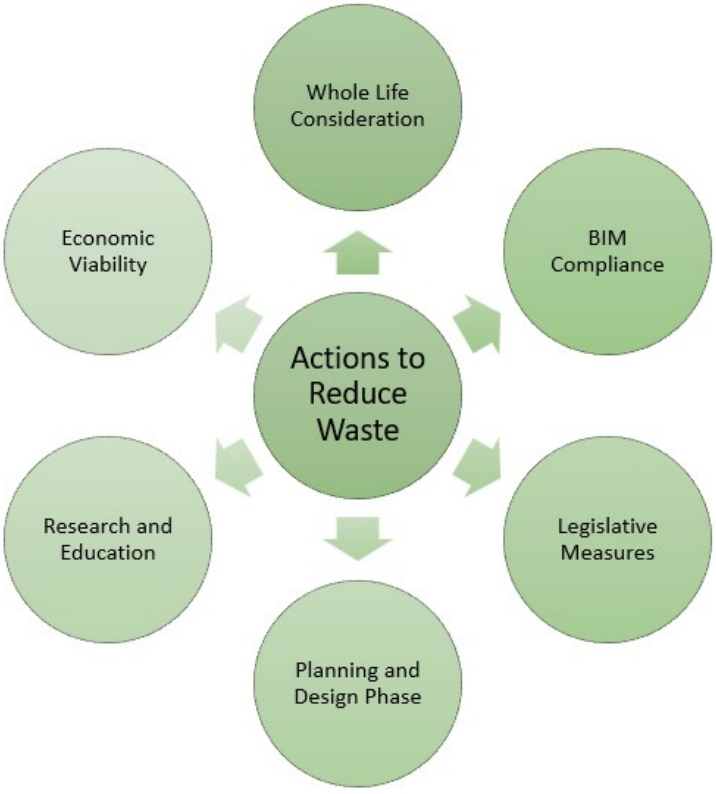

Figure 4: *Actions to reduce waste, modified from Ajayi et al. (2015)*

Kovacic, Honic, and Sreckovic (2020) argue that digitalisation can have a positive impact on circularity in the construction industry from various perspectives, which includes BIM-models, material passports containing specific information about a material and data from inventories. Furthermore, Benachio, do Carmo Duarte Freitas, and Tavares (2020) argues that it is beneficial to store data about material in specific passports, where it is stated how a material has previously been used, which could help to incorporate the material in future projects. In addition, Konietzko, Bocken, and Hultink (2019) describe that, in order to increase circularity, it would be beneficial to introduce a digital platform where supply and demand from buyers and sellers could be met. This would slow down the speed of resource loops, resulting in reduced need for virgin material.

2.3 Circular Logistics

In *section 1.1.1*, circular logistics has been defined as "the logistical processes that enable value to be captured after a product has been used, in order to benefit new products". This section will first present some of the concepts related to circular logistics that exists today and the difference between them. The last part of the section will focus on the logistical processes behind the definition of circular logistics and how they enable circularity.

A common building block of circularity in logistics is the concept of reverse logistics. Bernon and Cullen (2007) describe that the importance of reverse logistics was highlighted as online retailing grew bigger. Additionally, shorter product life cycles and changes in return policies are also factors that increased the usage of reverse logistics. Bernon, Tjahjono, and Ripanti (2018) argue that reverse logistics may also be used as an enabler for circularity. To allow for this, it is important to involve values and ideas of circularity in the reverse logistic process; actions that permits circularity, such as processes aiming at refurbishing and reusing products, can be incorporated directly in the reverse logistics-flow (Ripanti & Cullen, 2019).

As of today, two frequently used terms are Supply Chain Management (SCM) and Circular Supply Chain Management (CSCM). Supply chain management is dependent on the organization's network since the resources and skills are spread out on several actors in the network. From a sustainable perspective, a strong collaboration network tends to be crucial when it comes to improve the sustainability performance. Therefore, it is an important part of the organizations business model and are crucial in the transformation towards a circular economy (Geissdoerfer et al., 2018).

Geissdoerfer et al. (2018) define the concept circular supply chain management as the term that contains configuration and coordination of the supply chain to close, slow, narrow and dematerialize the resource loops. Both supply chain management (SCM) and circular supply chain management (CSCM) aim to achieve operative effectiveness and efficiency and strives for the competitive advantages. Circular supply chain management, unlike supply chain management, also aims to minimising the input in form of material and energy meanwhile waste and emission leakage are reduced. (Geissdoerfer et al., 2018).

2.3.1 Gap Exploiter's Role in Circularity

As circularity involves more than one user to have a sequential possession of a product, or for a refurbishment in the middle of a person's ownership of a product, there is a need for an actor to take the intermediator-role (Kossila, 2021). A Gap-Exploiter allows for the remaining value of a product to be increased or transferred to a new user (Harjula, 2016). This means that a product which was discarded by a user can be circulated and used by another user, instead of being disposed.

In *section 2.2.2*, the various ways that a product could be reused were presented. The Gap-Exploiter is usually specialized at one of these roles; the Gap-Exploiter may for instance refurbish a specific type of product, or provide a platform for reselling products (Kossila, 2021). The purpose with these operations is to increase the value of a used product to a level where it could be reused by the next product owner. However, no matter if a product can be resold or if it has to be repaired, someone has to intermediate between the previous and following user. In *figure 5*, the role of the Gap-Exploiter is presented (the Gap-Exploiter's role is here represented by the

dashed square).

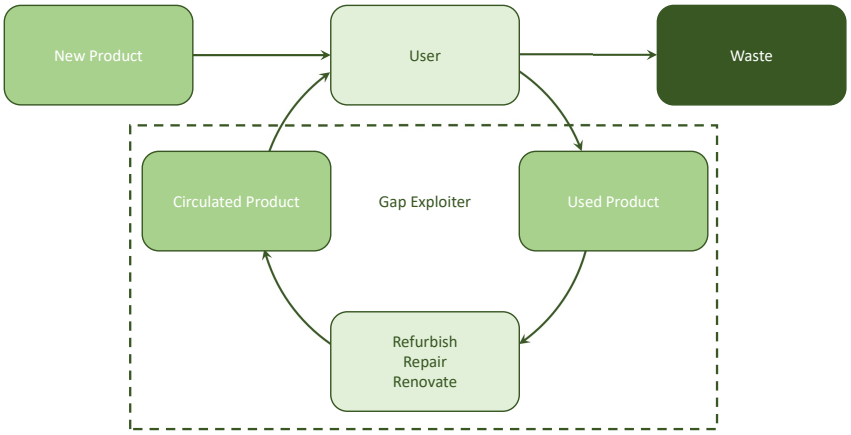

Figure 5: *The role of the Gap-Exploiter, modified from Kossila (2021)*

2.4 Network Perspective

To be able to systematically analyse the logistical characteristics of the construction industry, a network perspective is used. More specifically, the network perspective will be used for analyzing how the logistical network should be created in order to enable circularity in the construction industry on a larger scale.

The aim of an industrial network approach is to analyze how the different elements are connected. Networks consists of several relationships which are connected to each other in different ways and the intermediation between them are acknowledged as crucial for the interrelations among the elements (Sundqvist, 2014). Gadde and Håkansson (1993) argue that a change in one relationship could also affect other relationships that are not connected to the changed relationship directly. This means that a single relationship can have a great impact on many actors. On the other hand, Gadde and Håkansson describes that the complexity of networks gives different actors multiple ways to impact and affect other actors, as there often are more than one way that two actors are connected.

2.4.1 Characteristics of a Business Network

Sundqvist (2014) highlights today's business reality where all firms are at least to some extent intermediary, as all companies have a high number of connections to business partners and their respectively resources and activities. This means that all companies in the network are supplier to some actors, while they simultaneously are customers to others. Every actor have several connections to other actors which in turn have their own connections to further actors.

Håkansson (1987) describes that the design of a network may actually hinder the development of new solutions and offers. Håkansson expresses that the relationships create dependencies between actors. A change in the offering towards a customer from an actor may require that specific actor to get access to new resources, which may demand other resources than what can be acquired in the current network. Therefore, the network might have to be changed. Håkansson (1987) describes that changes in relationships always comes at a cost. Consequently, actors could be reluctant to do changes which have too much of a costly impact. The same type of cost could for instance also emerge if changes in interlinked activities occurs, since a high level of linkage in activities can create an interdependence.

2.4.2 The ARA-model and Network Analysis

According to Gadde and Håkansson (1993), the industrial network approach is used to describe the characteristics and design of an industrial network. One method used to map a network is the ARA-model. This model provides three components that a business network consists of, namely activities, resources and actors. A business relation is created when these components are interlinked, which can be seen in *figure 6*. In this report, the model will be used to create a mapping of how a logistical network would be designed to promote circularity in the construction industry.

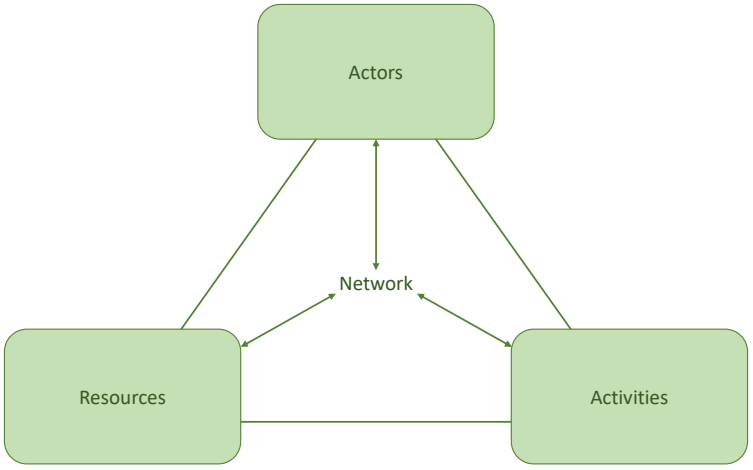

Figure 6: *The ARA-model, modified from Håkansson (1987)*

Firstly, the model consists of activities. An activity is carried by actors, either individually or in collaboration with other actors (Gadde & Håkansson, 1993). In

production, numerous activities are generally interlinked to create a chain used to add values to specific resources. Resources are also used as an instrument to carry out activities.

The resources in the model are controlled by actors. Resources can be of many different versions; Axelsson and Håkansson (1979) present five types of resources, namely technical resources, input goods, personnel, marketing resources and capital. These resources are combined to create more values to certain resources. Resources can either be controlled internally or controlled by another actor, in which case a linkage is required to that actor in order to gain control of the specific resource (Gadde & Håkansson, 1993). With time, the structure of what resources are favorable to control within the company, and what resources are best to get from other actors, changes. This means that companies must be able to change their industrial network when other resources are required. Resources are also classified as heterogeneous; the value of a resource may vary depending on how it is used and which actor that is using it.

The final component of the ARA-model are actors. As been previously described, actors are in control of resources (Gadde & Håkansson, 1993). Resources can either be controlled by a single actor, or jointly between numerous actors. The actors uses these resources in order to carry out activities and the different actors are specialized at carrying out different activities. With these three layers (activities, resources and actors) it is possible to map and analyze the function of a logistical network.

To conclude, the ARA-model is a way to map a business network and its attributes (Gadde & Håkansson, 1993). In this repoer, it will be used to display how the logistical network could be designed in order to facilitate for circularity in the construction industry.

3 Methodology

For this report, a study has been carried out which has been classified as qualitative. A qualitative methodology is generally used in non-numerical studies where a handful of cases which contains a high number of variables are studied (Wilson & Sharples, 2015). Bell, Bryman, and Harley (2019) describe that within qualitative research, it is more common to accentuate words rather than numbers in the data used in the study. A qualitative methodology allows for a study where reasoning of respondents are in focus, meaning that the way that the respondents expresses themselves regarding the asked questions is a central part of the results.

In addition, the research carried out in this study has been classified as exploratory. Exploratory research is primarily used to gain fundamental knowledge regarding topics where there are limited previous studies made (Wallén, 1993). This means that exploratory research is used to gain an understanding of the main building blocks of the subject that is researched. According to Wallén, it is common practice to use an inductive method when carrying out exploratory research. When doing an inductive study, general conclusions and findings are derived from the collected data (Bell et al., 2019). Thus, theories can be built from performed research. An inductive study can be contrasted to the deductive study, where a hypothesis is formed from the current knowledge. An inductive methodology is sometimes criticized though; Bell et al. argue that the conclusions and findings presented are strictly based on the empirical data that is collected, and that the collection of data can limit the result of the study.

3.1 Collection of Data

The data used to answer the research questions is in the shape of interviews, which were carried out with interviewees that are considered to have relevant experience for the study. In this section, it will be explained how the data collection was carried out. The data collection process can be seen in *figure 7*.

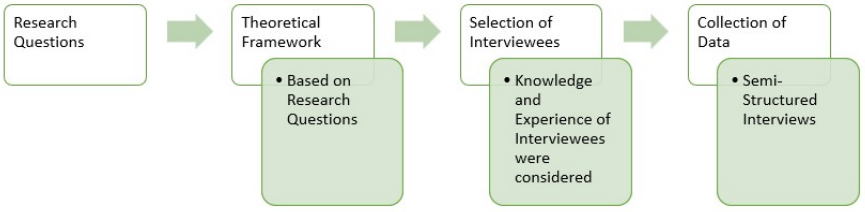

Figure 7: *The Data Collection Process*

Firstly, to complement the collected data from the interviews, and to create a base for discussion, a theoretical framework was created. The literature that was presented in the theoretical framework was derived from the research questions of the report

to make sure that the selected literature is adequate for answering the research questions. As the study was of a exploratory nature, some literature was also added after the completion of the interviews, as it was hard to estimate exactly which areas the respondents would consider to be important.

Subsequently, the second part of the data collection is a semi-structured interview study. According to Bell et al. (2019), a semi-structured interview study uses a set of questions that are used as a framework in the interviews with all of the interviewees. It should be stated though that there is a level of flexibility to the interview process, as the questions that are used for the interviews are primarily a guide. This means that the interviewer has the possibility to ask other questions that may arise as a result of the answers that the interviewee gives. Nonetheless, even though different interviewees may receive dissimilar additional questions, the main questions are the same. This assures that the answers from the interviewees are sufficiently related to be comparable and analysable; Bell et al. (2019) describe that there has to be some level of structure to guarantee a comparability between different cases.

When analysing the process of collecting data for each of the research questions, it can be seen that the first research question (RQ1) aims to get an understanding of the current state of circular logistic from the client's perspective. The main tool for answering this question will be interviews with experts within areas suitable for answering the question. In addition to this, the literature study will be used to complement the results from the interviews. With the current state in mind, the second question (RQ2) aims to identify the different factors needed to contribute to a sustainable circular logistical flow. Similar to the case with the first research question, interviews with different actors were determined to be important. The interviews were used to further identify the different activities and resources that affect the circular logistical flows in a sustainable way. Parallel with the identification of activities and resources needed for circularity, the driving forces and hinders to work with circularity will also be identified, which refers to the third research question (RQ3).

3.1.1 Interview Process

The interview guide used for this study started of with a selection of questions that intended to illustrate the previous experiences and the expert areas of the interviewee. Following this, the main section of questions asked were structured with regard to what research question or questions they aimed to answer. Finally, there were some additional questions for a specific selection of interviewees. These additional questions relates to a specific case or a specific experience that some interviewees have and which were perceived to be beneficial in order to get a deeper understanding for some of the research questions. The primary interview guide can be seen in *appendix A*.

All interviews were carried out with both team members present. One of the team member acted as the the main questioner, while the other one took extensive notes. The one taking notes was not limited to only note though; both team members were able to add questions during the interview in case they had relevant input. Bechhofer, Elliott, and McCrone (1984) claims that, with the use of more than one questioner, it is possible to get a broader discussion, where not only one person is trying to come up with suitable follow-up questions. In addition to this, having more than one questioner helps with creating an atmosphere which opens up for a discussion, meaning that it may allow the interviewee to feel more like having a conversation than being interviewed.

As one of the team members took extensive notes during the entire interview, the main ideas and aspects presented by the interviewees were picked up already at this state. In addition, the interviews were recorded, meaning that a verbal transcription of the interviews were created. The reason for not doing a real transcript was that the authors considered that the time this process would take would cannibalize on time dedicated to other parts of the study, as the time frame of the project creates demand for certain compromises in the work process.

The interviewees selected for the study are persons that are considered to be able to add useful insights to the report; some interviewees have taken part in projects which have attempted to incorporate circularity, while others have a more holistic view of the subject. The interviewees have different roles, presented in *table 1*, which will contribute to a broad view and enable for covering different perspectives on the research questions and the different challenges. The different roles are divided into three categories: project oriented, company oriented and sustainability oriented interviewees. The aim with this categorization is to understand the perspective the respondents answering from. This means that a project leader and manager are answering from their perspective from a specific project, while interviewees within the company-oriented category answer from a more holistic and extended perspective, meaning that they are not discussing the issue from the perspective of a specific project, but rather from a more central view within the company. Finally, the different roles within the sustainability category are respondents who are mainly operating within the interface between sustainability and the construction industry.

Table 1: *Role List*

Role List		
Project Oriented:	***Company Oriented:***	***Sustainability Oriented:***
Project Leader	CEO	Environmental Strategist
Project Manager	Growth Manager	Environmental Specialist
	Business Developer	Coordinator of Sustainability
	Logistic Developer	Business Area Manager
	Head of Sales	Unit Manager
	Sales Manager	Lecturer and Professors

Table 2, shows the different companies and institutes that the interviewees represent. The interviewees have been sorted into categories depending on what type of actor they are and market they operates in. The interviews carried out with LogiPlan and Logeco, as well as the interviews carried out with Linköping University, were carried out in groups. This created a possibility for the interviewees to complement each other and opened up a platform for discussion. The duration of the interviews were between 45 and 90 minutes.

Table 2: *Interview List*

Interviewee	**Company**	**Date**	**Type**
Category:	***Public Construction Clients:***		
A1	Norra Djurgårdsstaden	2022-04-21	Teams
A2	Municipality of Gothenburg	2022-03-24	Teams
A3	Municipality of Umeå	2022-04-04	Teams
A4	Municipality of Helsingborg	2022-04-06	Teams
A5	Akademiska Hus	2022-03-28	Visit
	Private Construction Clients:		
B1	JM	2022-03-24	Teams
B2	Platzer	2022-03-25	Teams
B3	Vasakronan	2022-03-28	Teams
	Digital Tool-providers:		
C1	Myloc	2022-03-21	Teams
C2	LogiPlan & Logeco	2022-04-01	Teams
C2	LogiPlan & Logeco	2022-04-01	Teams
	Research Institutes:		
D1	IVL Svenska Miljöinstitutet	2022-03-11	Teams
D2	RISE	2022-03-23	Visit
D3	Linköping University	2022-03-18	Teams
D3	Linköping University	2022-03-18	Teams
D3	Linköping University	2022-03-18	Teams
	Gap Exploiters:		
E1	Återbruket Mölndal	2022-03-30	Visit
E2	Återbruket Göteborg	2022-03-21	Visit
	Construction Companies:		
F1	PEAB	2022-03-10	Teams
F2	Derome	2022-03-22	Teams

The first category are actors in the public sector that act as construction clients. These actors represents public entities, which in this case includes municipalities and companies owned by municipalities. The actors have been chosen on the basis

that they have at least to some extent worked with or been involved in construction projects that has incorporated circularity. In addition to the interviews carried out with actors in the public sector, interviews were also carried out with construction clients located in the private sector. These actors were, just like the actors from the public sector, selected for being involved in projects that have incorporated circularity.

The next group of interviewees are actors that provides digital tools designed to plan, handle and increase the efficiency of the logistical processes in construction companies. These companies were selected for their extensive knowledge about the processes and limitations of digitalisation within the construction industry. In addition to this, these actors have been working in close co-operation with companies that carries out logistical activities within the construction industry, which means that they have accumulated knowledge in this area.

Additionally, representatives for research institutes that have done studies within circularity and construction logistics have been interviewed. These institutes were selected based on the research that they had made within the subject area; all of the selected institutes have explored the combination of the construction sector, logistics and circularity to at least some extent.

The final category of interviewees, Gap-Exploiters, contains companies that distributes reused products and materials. The companies that were interviewed here were created and driven by municipalities. The purpose for having these interviews were to gather deeper knowledge on how the market for reused materials look. Finally, interviews were also carried out with companies within the construction industry. These companies were chosen on behalf of their experience of sustainability and circularity work in the construction projects that they have carried out.

3.2 Analysis of Data

After the collection of data was completed, the data has been analyzed in line with the presented research questions (the data analysis-process can be seen in *figure 8*). The outcome of the data analysis created the basis of the result and analysis chapter, the analysis was done with a thematic analysis. The interviews were recorded, and extensive notes have been taken throughout the interviews. The recordings, in combination with the notes, created the foundation for a code-based summary for each of the interviews. The coding has been made into different categories, based on the subject that were discussed. Bell et al. (2019) describe that, when the data is collected, the codes will emerge with regard to the information and the collector's interpretation of the information. The codes used can for instance be based on a set of concepts or categories that are discussed in the interviews. Furthermore, codes do often have underlying sub-codes beneath, which can start to get clearer when the main code are set. This process is carried out until there is a saturation in the

number of codes, meaning that there are no further concepts or categories left to code.

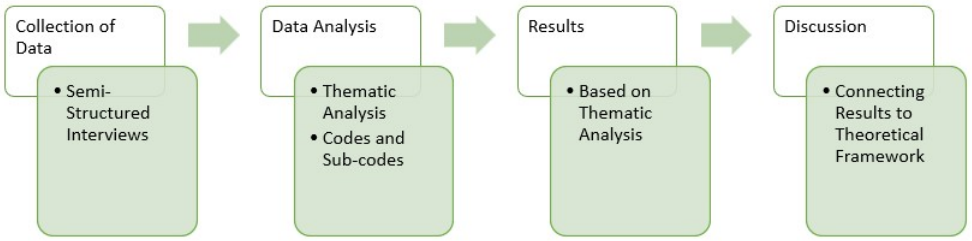

Figure 8: *The Data Analysis Process*

When the coding for all interviews had been carried out, the different subjects that the codes represent were turned into the foundation for the result section. The codes were categorized into different subject areas, depending on what field it covered. The opinions of each interviewee have been compared for each subject area and viewpoints have been mapped in order to create a holistic representation of the regarded issues. In addition to this, relevant quotations have been collected from the recordings. These quotations were selected to represent the general attitude and outlook of the interviewees, or to highlight a specific opportunity or hinder. Since the interviews were carried out in Swedish, the quotations have been translated into English by the authors and subsequently been approved by the interviewees.

Based on the result and analysis chapter have subsequently some of the most frequently discussed topics from the interviews been brought up for a deeper discussion by the authors in the discussion chapter. Admittedly, it was not possible to discuss all the subjects from the interviews that have been presented in the result and analysis chapter which meant that the authors needed to be selective with the subjects in the discussion chapter. The discussion was also supported by the literature presented in the second chapter, theoretical framework, to create credibility in the discussion and reasoning in order to later be able to draw realistic conclusions.

3.3 Ethical aspects of Methodology

One issue regarding ethics in an interview study is whether the interviewees are to have anonymity or not (Bell et al., 2019). It can be hard to tell the opinions and statements of companies and people while keeping the identity hidden. Furthermore, it is not uncommon with a divergence in what level interviewees wants to be public with their identities; some may argue that it could be advantageous to be public with their opinions in certain situations. In other cases, it could potentially be harmful to not be anonymous. With this in mind, the identities of the specific interviewee have not been displayed in this report. The name of the organization, as well as the role of the interviewee, is however not anonymous unless it was asked for.

In addition, the interviewees were able to decline to be recorded. This was done in order to assure the privacy of the respondents in the study. In a case where the interviewee were to decline, the notes taken would be used as the sole source of information. Moreover, in order to make sure that the respondents were not misquoted and that their opinions were presented correctly, all direct citations used in the report were sent to the interviewees for approval. Hence, the respondents were able to change their quotes, if they felt like the quotes should be altered.

3.4 Trustworthiness

Lincoln and Guba (1985) describe that trustworthiness should be in focus when evaluating validations of a qualitative study. From a trustworthiness point of view, there are four important factors to cover. The first factor is the credibility of the study, which is the legitimisation of the results from the respondents' point of view. In this study, the credibility were verified through having the quotations used being double-checked by the interviewees. In addition to this, information that were perceived as unclear were discussed again at a later point with a respondent, as a mean to assure that the interviewers have a correct understanding.

Secondly, Lincoln and Guba (1985) argue that in a qualitative study, the results need to be transferable to contexts other than the one in which the study took place. Nowell, Norris, White, and Moules (2017) argues that the researcher is unable to know which areas someone is seeking to transfer the results to. In order to enable this transfer though, the researcher should provide as much of a description of the results as possible. The third part of trustworthiness regards dependability (Lincoln & Guba, 1985). Nowell et al. (2017) describes that a high level of dependability is achieved when the study is logical and traceable for a third-party reader. In addition to this, Nowell et al. argues that audits can be used in order to achieve dependability. For this report, the result provided from interviews were discussed in close cooperation with the supervisors of the project to assure that the results were clear and logical.

The final aspect of trustworthiness according to Lincoln and Guba (1985) is confirmability. This aspect describes how the interpretations and analysis of the data has been derived by the authors of the report. Bell et al. (2019) describes that confirmability is achieved by making sure that personal values and opinions are left out through the report, meaning that only ideas and thoughts that can be derived from the collected data is included, even though it is impossible to achieve complete objectivity when carrying out qualitative research. In this report, to limit the impact of personal values both authors were allowed to independently analyse the interviews.

Lincoln and Guba (1985) describes that, in addition to the four presented aspects which together creates trustworthiness, authenticity is also an important factor when

validating a qualitative study. When analyzing authenticity, Bell et al. (2019) describes that one important factor to contemplate is the fairness of the representation of opinions that are brought forward in the study: does the selection of respondents represent different views regarding the discussed subject area? To achieve a high level of fairness in this study, the respondents that have been interviewed were selected from a varying background with the intention that they together can deliver a holistic picture of the subject area. In cases where it was needed, the supervisors of the study helped to suggest which interviewees to include in the study with the aim to capture a high number of perspectives. In addition to the issue of fairness, it is also important to allow for respondents to draw deeper conclusions and to receive knowledge from each other (Bell et al., 2019). To enable this, the results and conclusions that are drawn in this report were presented for all respondents who wished to take part of the results. The sharing of results took place in the form of a seminar, where the listeners were allowed to discuss the results with the authors.

4 Result and Analysis

In this chapter, the result from the interviews is summarized and presented together with some analysis. The interviewees represent a broad front of different roles and organizations in the construction industry presented in *table 1* and *table 2*. The interviews are analyzed with the aim to see patterns that represent the challenges and important insights within circularity in the construction industry. This chapter will also provide answers for the three research questions (RQ1-3) from different perspective due to the variance of interviewees.

The chapter starts with the challenges and obstacles, identified from the interviews, that the construction industry faces today. This is followed by a section with the prerequisites for enable circular material flows containing the producer's role in circularity. Subsequently, the different actors and their role within construction logistics, and how they contribute to increase and enable circularity, will be presented based on the interviews. Next section covers the level of digitalisation in the construction industry and how this affects construction logistics, especially focusing on the process to transfer from linear to circular flows. This section will be followed by the different driving forces that have been identified when it comes to circularity in the construction industry. The chapter ends with a section covered by a network perspective presenting the different actors and the different flows between them.

4.1 Challenges within the Construction Industry

The construction industry differs from other industries and is characterized by several challenges, which will be presented in the following sections. These characteristics sets the conditions for the requirements and opportunities to work with circularity in the construction industry.

One common area that was discussed and highlighted in all the interviews was the differences between the construction industry and other industries, such as automotive production. Some of the things that characterises the construction industry, and the challenges that are connected to it, are the generally **small spaces** of a construction projects where several actors, material flows and transports need to interact, coordinate and cooperate. These interactions generally take place in a **changeable environment** where weather conditions like rain, wind and snow can affect the working conditions. This has a major impact on the working situation in the construction industry since, compared to production in a factory, it is work that is predominantly performed outside and by humans, meaning that there is generally less involvement of machines. This means that more factors will affect the progress of the project, which according to a company-oriented respondent can affect different parameters while at the same time result in that it is harder to determine fixed measurement parameters compared to when the work is performed by machines.

According to a digital tool-provider, one of the major challenges that the construction industry needs to work with is to develop more fixed parameters, even though the industry operates within a changeable environment. The interviewees representing the digital tool-providers do not see this as an impossible challenge since their view of the construction industry is that every project is not as **unique** as most of the industry according to them want to claim. After several interviews with actors that have different perspective of the challenges, it was clear that there are divided opinions when it comes to the question regarding the uniqueness of each project.

Another area which was frequently discussed during the interviews was the **low level of digitalisation** within the construction industry; a number of respondents argue that it is far behind other industries. This affects the information flow between different actors which may result in logistical challenges. The issue of digitalisation will further be discussed in *section 4.4*.

4.1.1 Logistical Challenges in the Construction Industry

Regardless the level of uniqueness in each project, the construction industry has to depend on functional logistical systems in order to be effective. Several interviewees pointed out the issue of distributing enough time on the planning phase in order to make sure to have adequate logistical solutions. The overall perception from the interviewees was also that today, the industry does not spend enough **time on the planning phase** and that logistics sometimes is falling through the cracks between different actors and those responsible. A company-oriented respondent talked about the importance of someone owning the logistical questions, meaning that the logistical responsibility cannot be divided between different actors and persons which are also responsible for other areas. This was expressed among several of the interviewees: there is no framework for the logistical solutions and that the actors do not collaborate to a sufficient extent. This summarizes the overall view of today's challenges regarding the logistical issues; as of today, there are many **temporary solutions** and sets of actors for each project. The logistics are also often outsourced, which some interviewees saw as a way for organizations to escape responsibility.

4.1.2 The Human Factor in Construction

As been presented earlier in *section 4.1*, the construction industry is characterized by the fact that the work is mostly performed by humans. This does for example affect the conditions to develop fixed measurement parameters, which in turn makes it harder to measure development. The human factor means that elements like losses of key persons, sickness and human error may affect projects to a relatively high degree. Furthermore, since a lot of the work in the construction industry take place outdoors, external factors like weather conditions can also play a vital role in this case. Unforeseen events caused by the human factor can contribute to

complex challenges in the logistical chain which places relatively high demands on the **flexibility**. Between the respondents, there were different opinions to which extent the issue of flexibility affects the construction industry; some respondents argued that the construction industry is good to adapt to fast changes that could be present in a changing environment as in the construction industry. This perception came from the respondents with a logistical perspective, working with logistical questions and its challenges. On the other hand, respondents with a more research-oriented perspective had an opposing view, that the construction industry are not able to handle the changes within logistics successfully.

As of today, it is inevitable to notice different trends that influence the way humans think and act. A majority of the interviewees agreed that, even though trends come and go, the interest for more sustainable alternatives and solutions have increased in the last years. The consumers put more pressure on manufactures, property owners, carriers and other actors, which drives the work with sustainability forward and forces the market to change and act in a different way, compared to how it acts today.

Following this, a sustainability-oriented respondent also discussed the internal conflict that can arise due to trends regarding the perception of old and new goods in general. This could be perceived as a priority issue depending on whether the trend at the moment is to preserve old objects or not. For example, the people placed in a building which utilizes recovered material and which is decorated with old furniture may perceive the reason that they are placed here as something related to hierarchy or social class. This could also be a question regarding generation and culture, an elder generation could for example value things different from the new generations with a more sustainable thinking and eco-friendly perspective.

Related to trends and how it can affect humans' behavior comes the need of satisfaction after a choice. One project-oriented interviewee put it as:

"People want to feel that the choices they made are good"
– Interviewee B3

In the discussion, the interviewee quoted above was asked why the company the interviewee represents prioritized more environmentally sustainable choices in their projects even though the process was more expensive. According to the interviewee, it has been profitable since their customers value these choices; the company perceives that sustainability sells.

4.1.2.1 Lack of Knowledge and Competence One thing that was highlighted in several interviews was the lack of knowledge regarding circularity and recycling, which is in line with the fact that most of the interviewees described themselves as in the beginning of their work with sustainability and especially circularity.

However, this was not the only knowledge gap that was discussed, a sustainability oriented respondent expressed it like:

"There is a general lack of logical knowledge regardless the kind of flow"
– Interviewee D3

With this, it was meant that the challenge is not limited to the transition to circular flows. Instead, the challenge lies in the flows in general and that the logistical aspects often are missed in discussion about circularity. Their opinion is that the root cause is not reached when circularity is discussed: this only scratches the surface, which in the end will not lead to any major changes.

A sustainability-oriented respondent gave opinions from an educational perspective where the respondent wanted to highlight the importance of increasing the education and knowledge on a broader front. Architects need to be educated on how to make use of existing materials and not only learn to design productions with new material. Likewise, there is also a need for example craftsmen, electricians and plumbers to get education on how to preserve and renovate existing products and materials and not only how to install new ones. In line with this topic, most of the interviewees have brought up the importance of dismantling instead of tearing down and throwing away material. This issue is not only a matter of time and costs, but also a question about knowledge.

4.2 Prerequisites for Circular Material flow

Throughout the interviews, the issue regarding **wrapping and packaging** of material was frequently discussed. Material that has been used in previous projects, or material that has been ordered but not used, must be packaged sufficiently in order to not be damaged during transportation or storing. Additionally, it was argued that the material needs to be transported on **standardized load carriers** in order for material flows to be optimized. A Gap Exploiter argues that without proper packaging, the material is harder to sell:

"Without a proper way to package the reused materials, it is very hard for us to sell it. There has to be guidelines for how to package reused materials properly. Additionally, there has to be guidelines on how material is transported and stored, as materials today can arrive in various shapes and forms."
– Interviewee E1

Furthermore, the **return flow** of packaging and loading material after being used for reused products is today an issue. Some respondents argues that there are more or less hardly any existing flows dedicated for returning this material to where it is needed. This makes it hard to return this type of material on a large scale. In addition, load carriers are usually not designed for the return flow and are sometimes made to be used just once.

A commonly discussed subject from both construction clients and research institutes during the interviews has been the issue of **inventories** of material that is currently used in buildings that are ought to be demolished. The purpose with an inventory is for the client that owns the material to get a perception of which materials and which quantities of that material that could be reused in other construction projects. After an inventory has been carried out, the client that owns the material can decide upon what material to keep for future projects, and what material could be sold to other actors. When the inventory has been carried out, the next issue regards how to **dismantle material** that has been used in previous buildings, rather than just demolish the material. Throughout the interviews, there have been different opinions regarding to what extent it is possible to dismantle materials. Some respondents argue that dismantling at an industrial scale is not possible as of today; they mean that this is a process that mainly is feasible for do-it-yourself enthusiasts. Furthermore, some respondents see the costs connected to dismantling as an issue, and when weighing these costs against buying new material, there is no guarantee that the reused material will lead to a lower total cost. Instead, it has by some respondents been argued that it is generally more expensive incorporate reused materials in construction projects compared to the cost of only having new materials.

On the contrary, not all respondents agree that dismantling is that much of an issue. Some respondents argue that, even though the total cost may be higher when dismantling and reusing material, the environmental savings made weigh up for a potential increased economic cost. It has also been argued that there is a lack of knowledge in the industry about dismantling. Additionally, some interviewed companies have started to try this approach in their construction projects. One private construction client that has come rather far in this process has developed their own methodology for how to dismantle material:

"When dismantling materials, we had to hire craftsmen in the same way we hire consultants. We had a demolitioner employed who we had to convince to try methods for removing plaster boards without breaking them. The entire industry said that you can't dismantle plaster boards, but we have managed to do it. Following this, we employed a plumper, a ventilation assembler and an electrician with the same approach".
– Interviewee B3

Additionally, it has by some respondents been argued for that **standardisation** in building materials and methods could be a good approach for enabling an increase in circularity. When standardising, different projects are more similar in terms of what material is being used. Following this, materials are interchangeable at a higher level when standardising, which means that reused material have a higher possibility to be reused.

Even though standardisation is a facilitator for circularity, some respondents argue that it is not possible to standardise at a too high level. There are differences in requirements and desires between customers, as construction projects are not mass produced on an assembly line. Moreover, a logistics developer also mentioned that standardisation should not be seen as a limiting factor even though customers have different requirements. Instead, architects should try to achieve attractive and customized buildings with a high level of standardisation.

Throughout the interviews, it was stated that **storage** of reused material is a big problem in today's logistical system. There is no guarantee that supply and demand of reused material will match, meaning that material may be available at a time when there is no demand for it, or that there is demand for a reused material even though it is not available on the market. As of today, there is a lack of actors who can store material. Furthermore, material which are kept in storage does not contribute to environmental sustainability; the material must be used in another project for it to render an effect. This creates a balance act for the material owner: should the material be distributed to someone who needs it, or should it be kept until it is needed in one of the owner's own projects?

The issue of storing reused material will be further discussed in *section 4.3.1.*

4.3 Actors in Circularity

One of the characteristics in the construction industry is that it often involves several actors, which requires a lot from the logistical perspective. In most of the interviews, the importance of putting pressure and make demands on the actors emerged. If no demands are made, there will not be any changes at the market and in the way actors act and make decisions today. Most of the interviewees were united in the belief that the requests and demands regarding sustainability and circularity need to come from the construction client who orders the project. Since the sustainable options not rarely are more expensive, this is a decision that need to be anchored with the construction client.

A project leader at a public construction client is one of the interviewees which has begun to request and apply circularity in pilot-projects. Besides requiring climate-neutral transportations, they have also started to work with circularity in several pilot-projects where they aim for a higher percentage of recycled and reused materials. The pilot-projects are a good start, and it helps them to identify the existing challenges and what they need to do to increase the circularity. One common expression from the public construction clients was:

"We need more experience to be able to set clearer and more concrete goals"
– Interviewee A2

This was a general impression, that few construction clients had any concrete goals

or results since they have just started working on these issues and challenges. They were also generally united in the opinion that they must test to gather experience and insights and that there is no point trying to figure out reasonable goals when they have not yet identified their challenges and obstacles. A project manager at a public construction client believes that the municipalities have a responsible to lead by example, especially the larger municipalities. This means that the municipalities must take actions and start trying things to be able to influence the private construction clients.

A project manager of a public construction client depicted their vision about increasing the percentage of recyclable and reused materials in pilot-projects by practical exercise. A project leader at a private construction client was on the same page, actors need to try, dare to take risks and to be aware that they might obtain financial losses in order to achieve the insights needed to drive the development of circularity forward. Experts on specific materials can help and give their assessment or statement of the materials but in the end, it is the construction clients that needs to decide which way to go and take responsible of the quality and guarantee of the material. It is also important to convince the clients to not use new material and instead look for other alternative. This is something a project leader at a public construction client also brought up, the importance in asking the bolder questions, presenting other options and daring to be a little assertive. Otherwise, there will never be any difference; it is hard to break patterns and routines without starting to ask questions and collaborate between.

A project leader at a private construction client expressed the importance of large actors on the market to lead by example. The company puts pressure on their supplier to work with questions to increase the circularity and decrease the environmental impact. Furthermore, they take responsibility when it comes to quality assurance of materials and warranties with the help of various craftsmen, electricians and plumbers. Apart from demands between the construction clients and suppliers, requests and demands from private persons appears to be of importance since the public is becoming more and more environmentally conscious. A business developer at a private construction client state that the tenants definitely put higher pressure on environmental sustainability aspects like eco-certifications and energy consumption.

As the work to increase the circularity has arisen, the pressure on the planning phase has also increased. The interviewees emphasize that the work with circularity must start already back in the design phase and that the architects also have a responsibility to highlight their perspective and how they can preserve existing buildings and use more recyclable and reused materials to a greater extent.

4.3.1 Gap Exploiters

Among the interviewees, there has been a predominant consent regarding the importance of having Gap Exploiters that allows for reuse of material and products. As previously been discussed in *section 4.2*, there is a need to match supply and demand. To bridge this discrepancy, some type of storage activity is required. In the studied cases, this activity is usually carried out by a public entity. In addition, the public entity Gap Exploiters are rarely driven with the purpose to make an economic profit; their ambition is rather to maximise the environmental winnings by enable for a wider usage of reused materials.

"The idea is not that we should make a profit. We sell enough to cover our costs, meaning that it does not cost anything for the municipality for us to run this business".
– Interviewee E2

The interviewed Gap Exploiters do mainly have focus on reselling products in the condition that they received them. However, some value-adding activities, such as testing and refurbishment of selected products and materials, are occasionally carried out, even though these activities are comparatively rare; in the interviews, it has been stated that a vast majority of all material is resold in the material's current state. Furthermore, the Gap Exploiters interviewed do not verify the quality or leave warranties on products on a large scale, which is something that is required from many construction clients in order to use reused materials.

An issue discussed in the interviews was the lack of scale of Gap Exploiters in circular construction. As of today, a lot of reused materials that goes via the Gap Exploiters are both deposited and bought by individuals, meaning that companies only represent a small part of what is bought and sold. To be able to succeed in a circular construction project, there have to be actors which can handle and store larger quantities of materials. As been described earlier though, many Gap Exploiters are today not driven by economic profit and are usually driven as a public entity. To achieve circularity on a larger scale, more actors have to take the role as Gap Exploiters. Moreover, some respondents argue that current distributors and sellers of new construction material should expand to also selling reused material.

In order to allow for circularity on a larger scale, there is also a need for matching supply and demand to a greater extent. In the interviews, it has been argued that this should be done with a platform where buyers and sellers can be connected to simplify purchases. This type of service is used to a great extent in other industries, and some respondents would like to see this type of solution within the construction industry as well. As of today, there are a few platforms available for this, with the most discussed in the interviews being the platform created by CCBuild, which is an arena for cooperation to favor a circular construction industry. In the conversations with the respondents however, it has been argued that the existing platforms may

not be developed enough yet. The platforms have too low of a flow of materials and products and too low supply of material displayed at the platform in order to have a noticeable impact on the industry. In some interviews, it was argued that existing platforms are not convenient and accessible enough to create an adequate material flow.

In order for having a functioning circular logistical system, transportation of reused products is also required. However, it was mentioned in the interviews that the number of transportations to and from construction sites are already rather high today. Therefore, there is a need for transportations to be coordinated to not increase the environmental impact. It was also discussed that transportations could be connected to the material platform. In this case, transportations could be lessened by trying to only transport from the seller of a specific material that is geographically closest to the buyer.

From the construction client's point of view, a public construction client would like to see that there was a providing actor for every type of material in order to make reused material more obtainable. This actor would then either take care of the entire Gap Exploiter process themselves, or engage other actors to take care of the process:

"We would like to have an actor that would collect and test the material and then either sell it onward or sell it back to us. We would like to have a collaboration with an actor for each product category".
– Interviewee A2

4.3.2 Producer's Role in Circularity

During the interviews, the importance and role of the producer were frequently discussed. As of today, there is a lack of **warranties** for reused products; the producer cannot certify the quality of the material if it has been used in a previous construction project. Some respondents argue that for more construction clients to attempt using reused materials, there has to be some actor who assumes the role of testing and assuring the quality of reused material. Not all respondents saw the lack of quality certification as a problem though; in a few interviews, it was mentioned that warranties are no deal-breaker for using the material.

Moreover, a number of respondents argued that producers take too little **responsibility** in the recycling process of construction materials. Consequently, it was argued that there is a need for laws that stipulates the responsibility of the producers of construction material would benefit circularity. As of today, these laws of the responsibility of the producer exist for a number of materials and products in Sweden, though none of them regards typical construction materials (Naturvårdsverket, 2022). A law of this kind could define how construction materials would be recycled, and what responsibility the producer would have in that process. On the other hand, it was also argued that too hard regulations could potentially lead to

a situation where producers may suffer from losses in profitability, which could put producers out of business.

4.3.3 Information Flow between Actors

In a network built on different actors, the information flow between them is decisive for whether a collaboration is functioning or not. As expressed in *section 2.4.1*, all the actors are related to each other in some way and if one relationship is affected it will also affect other relationships between actors in the network. A digital tool provider stated:

"The delivery is not ready until the information flow also is complete - for this we need better systems to share information."
– Interviewee C1

The delivery is not only about handing over a physical product; it also includes information about the product. To increase the circularity in product- and material flows, the information flow must be seen as an important part in the process. It will facilitate the assessment of the quality of the products and give guarantees in case it is possible to go back and follow its life cycle. This will imply that the information is shared digitally and not physically on a paper or orally between persons. A digital tool provider also advocated that better information flows will enable the setup of more concrete goals and KPI:s (Key Performance Indicators), which will make it easier to put pressure on the suppliers and other actors on the market.

4.4 Digitalisation in Construction

In general, the respondents argued that the construction industry as a whole is less digitalised than many other industries. As of today, the digital systems that are used may be isolated to a specific actor or require manual processes. As a consequence, it has been argued that digitalisation has the potential to improve the supply chain and logistics of the construction industry, as digitalisation could increase communications and synchronize actors. In order for circularity to be implemented successfully in construction projects, many respondents argue that digitalisation and functioning digital processes plays a major role, where actors easily can create and share digital information.

Throughout the interviews, the concept of traceability has been frequently discussed. If material were traceable, this would for example give information about who manufactured the material, who the previous user of the material was and in what way the material previously has been used. This information could enable an owner of the material to assure the quality of the product. It would also help to get a deeper knowledge on how the material could be used in future projects.

Besides traceability, digitalisation could also be a tool when carrying out an inven-

tory, both in terms of material that is kept in stock and material that is currently used in buildings. As of today, some respondents have described that inventories are in some cases carried out manually without the help of any digital tools. With the help of digital systems, it is possible to carry out a more accurate inventory in a shorter period of time. A more accurate inventory could enable for a lesser need to order material or give a better understanding of the quantities of reusable materials that are used in current buildings.

As was discussed in *section 4.3.1*, a digital platform for matching supply and demand of reused products and materials is crucial in order to facilitate circularity in the construction industry. There has been argumentation for that these platforms need to be improved in order to be more efficient. However, some of the respondent claims that it is not mainly the digital platform that is the problem. The problem is that the existing platforms are not being used to the needed extent and that there are not enough reused materials and products circulating on the market today.

Another challenge today regarding digitalisation and the existing systems is synchronization between different systems. If the actors should be able to share information, it requires that the different systems can transfer information in between, unless there is only one system used by all actors.

Some of the respondents asked for systems that would provide digital twins within a few areas in the construction industry. For instance, some respondents argued that it would be beneficial to be able to have a virtual model of a building, where it is possible to go into detail about every piece of material that is used. This would provide information on how the material is used, and how it could potentially be reused in future projects. One interviewee with the same perception but from another category of actors was a respondent at a construction company that expresses the thoughts about digitalisation as:

"Digitalisation could be used to increase efficiency and reduce waste. This is because a digital copy of a building could show exactly how much material would be needed."

– Interviewee F2

Several of the respondents had the same perception, that digital twins would increase not only the circularity but also the productivity and decrease the waste. In addition to this, a company-oriented respondent discussed that digital twins would not only be useful in relation to buildings, but over the whole supply chain as well.

As discussed in *section 4.3.3*, a higher level of digitalisation is crucial for the information flow between actors. Sharing and transfering information in real time is a prerequisite for a supply chain in a dynamic environment where rapid changes are common. A digital tool provider mentioned that,

"Our biggest competitor is the whiteboard"
– Interviewee C2

This says a lot of where the construction industry is today and how some still are stuck in old patterns. With this statement it is not hard to understand that the information flow does not reach all the way through the chain which is necessary to achieve a successful logistical chain and network with all the different actors. They mean that this is also about to dare and challenge. Actors need to realize that they have to invest in digital tools to increase the possibility to share information between the actors and push the development forward. This means that money needs to be taken from the project budget to digital tools which is scary and often seen as a risk due to inexperience in the tools.

4.5 Driving Forces for Circularity

Related to one of the research questions, the following section will present the various driving forces for a construction client to work with circularity. This was discussed during the interviews, where most of the respondents expressed that they are only in the beginning of their work with circularity and that they therefore try to explore and discover how it can be used and utilized in the most environmentally sustainable way.

4.5.1 Economical versus Environmental Driving Forces

For many of the respondents, a big factor regarding circularity is the difference in cost between utilizing new material and reused material. Most interviewees argue that it is generally **more expensive** to incorporate circularity in a construction project today compared to a project which only uses virgin material. Hence, it was argued that the cost of buying new material and products is too low compared to the total cost of incorporating reused material.

The cost of reused material is down to a number of factors. For example, it is today rather expensive to dismantle material, compared to the cost of demolishing, as this requires a slower and more cautious process. Furthermore, material with the purpose to be reused may not be needed in a construction project for a substantial period of time, which implies high storage costs. Additionally, reused materials may not be able to involve as easily in current construction projects compared to new material, as the construction projects might have to be adopted to the characteristics of the reused material. Apart from this, products which are remanufactured or consists of recycled material may in some cases be more expensive than less sustainable products.

For some construction clients however, a **higher level of environmental sustainability** may be of more importance than an increased cost. More and more

customers demand higher levels of sustainability, meaning that clients can use sustainability as a marketing tool. For the clients, it is often a balance act between decreased costs and an increased level of sustainability.

Some respondents argue that a public entity-construction client may have other drivers and possibilities to work with circularity than other clients. A company driven by a municipality or a state for example may not have the same focus on making economic profit, which allows for a higher focus on environmental sustainability. In the municipalities interviewed, sustainability is an important factor which permeates a lot of the work that is carried out.

4.5.2 Laws and Regulations as a Driver and Hinder for Circularity

Throughout the interviews, the impact that laws and legal requirements have on the work with circularity has been discussed. The respondents are ambivalent regarding whether laws should be incorporated to force companies to work with sustainability, or if sustainability should be driven by the market. The argument for using laws as a driver for circularity is based on the reasoning that the market will primarily focus on the cost aspect; since the cost of incorporating reused material is in many cases higher than using new materials, customers will favour the latter. Not all respondents agree with the need of incorporating more laws; it was in some interviews argued that the laws and regulations that exist today are sufficient, and that the industry must make the change towards a higher level of sustainability through demands from customers and specific requirements on contractors.

A legal requirement that may be a hinder for circularity are building permits. Some respondents argue that these permits could limit the possibility to involve reused material in construction projects. One reason for this is that building permits do not allow for using other materials than what was meant to when the permit was applied for.

"If you design a house with reused materials, you may not for instance know exactly how a facade or a window will look. Therefore, there must be flexibility in the building permits, as you don't know exactly what material you will get access to"
– Interviewee D2

In some interviews, it has been argued that some regulations may not be constructed to fit the way the industry looks today. As the industry changes, environmental factors that connected the industry must be adopted in line with this. This means that there must be regulations that regards new types of operations that is carried out at a construction site.

4.5.3 Material Shortage as a Driving Force

As a consequence of recent crisis, namely the Covid-19 pandemic and the Ukraine-Russia war, there is a compulsion to change the market due to material shortage. In recent times, the prices have been accelerated and to transport material all over the world was not possible during the pandemic due to lockdowns and regulations. According to some respondents, this increased the significance of reusing material and reduced the habit of disposing used materials. One private construction client described it as:

> *"Increasing the level of circularity could reduce the supply risk."*
> *– Interviewee B3*

By this, they meant that in the current situation with present global crises, it is unclear whether the ordered products and materials will arrive or not. This means that by reusing material which are already in your possession, it may become less risky from a supply chain point of view. On the other hand, using reused materials implies risks regarding quality and guarantees which are not present to the same extent when using new materials.

5 Discussion

In this chapter, some of the main topics and insights will be discussed with the support from literature and results from the interviews. The aim with the discussion is to further be able to generate some conclusions in the last chapter and answer the three research questions. The first section will discuss the importance in planning for circularity and specially to early integrate it in the construction phases. To carry through this, integrate circularity in an early stage, there must be some incentives to do these changes. That is what will be discussed in the second section, the driving forces. This will be followed by a section of the potential within digitalisation and how it can enable for circular logistics. Lastly, the section that ends this chapter will discuss the network in the terms of actors, activities and resources and how different factors are important for the whole network to enable circularity.

5.1 Planning for Circularity

From the result and analysis chapter it was clear that circularity is something that needs to be planned for. Regardless of what kind of flow, it needs to be planned for in an early phase and not be left to take care of in a final stage. This section will discuss construction logistics and some of the key insights which concretises where in the construction process the planning for circularity needs to take place.

During the interviews, it was obvious that the perception on the capability to work with and solve logistical challenges in the construction industry differs. Some respondents with logistical focus were of the opinion that the construction industry overall is good to adapt to fast changes that can appear in a changing environment as in the construction industry. On the other hand, respondents with a more research-oriented perspective had an opposing view, that the construction industry is not able to handle the changes in logistics successfully. This can be contrasted with what Sundquist et al. (2017) argue; the authors mean that the industry is lacking in productivity as a result of a logistical system with low efficiency in its material flows. This might partially be down to a lack of flexibility in the construction industry.

It is clear that today all the different actors in the construction industry have their own agenda. They all have their perspective; challenges to tackle and obstacle to overcome. Different agendas, too low level of collaboration and lack of understanding of other actors' perspective contribute to a fragile network, since they all in some way and to some extent are connected to each other as described by Sundqvist (2014). Today's increased pressure on actors, mainly from legislation and customers, to take a sustainability responsibility will also increase the incentives to collaborate with other actors since actors in a network affect each other. Their agenda regarding environmental sustainability questions will hopefully be a common ground to increase the collaboration.

Most of the respondents expressed themselves as in the beginning of their work with circularity which explains why it was not possible to identify any framework or work processes to increase the circularity at a large scale. From a holistic point of view of this research it is rather possible to say that most of the organisations have a sustainable business model, where they are reviewing the sustainability in the business and its activities (Kossila, 2021). In its entirety, there is a lack of a circular business model in the construction industry today.

According to Brockmann and Kähkönen (2012), the difference in approach between construction projects is described to be very high; Brockmann and Kähkönen argue that each project is unique in its attribute. Additionally, Barthrope et al. (2010) describe that there is an ad-hoc approach to construction logistics. As been described in the result and analysis section, the perception of the uniqueness varies slightly between respondents. Most respondents agreed that construction logistics offers unique challenges for each project. However, in some cases there is a disagreement to the statements of Brockmann and Kähkönen; some respondents argued that the uniqueness is, even though it exists, not very substantial, while some of the respondents were of the opposite opinion. It is important to have in mind that it depends on the level of detail that is discussed. The different flows and processes in a construction project are mostly not unique, but on a more detailed level there are some uniqueness in each project. Depending on the role and interviewees position as project, company or sustainability oriented, the level of uniqueness from their perspective varies.

In the interviews, it was argued that it is important to introduce circularity as early as possible in a construction project. The first phase of a construction project is the initiation phase, which is where challenges are identified and where relevant experts are selected for the project (Klinger & Susong, 2006; Projektledning, 2018). Since it was argued from numerous respondents that circularity should be incorporated as early as possible, it could be relevant to take circularity into consideration already at this stage, by identifying challenges and incorporating experts of the area into the project.

The next phase of a project is the design phase (Projektledning, 2018). As been described in the result and analysis section, it is important to involve the architect in the process regarding circularity. This would predominantly be done in the design phase; Klinger and Susong (2006) describe that the design of the project, as well as the technical details of the project, are decided in this phase. Therefore, it would be suitable to start looking at what types of material should be used in this phase, especially when considering that the level of material that circulates in the construction industry is rather low. This goes in line with what Ajayi et al. (2015) describe, that a measure to reduce waste, and therefore increase the level of circularity, is to involve issues regarding waste in the design phase by designing

buildings to enable for dismantling at the end of the life of the building.

5.2 Drivers and Hinders for Circularity

As of today, it is in many cases more **expensive** to, even partially, conduct a construction project with reused material compared to constructing an entire building with new material. On the other hand, reused materials have the potential to **decrease the environmental impact** that a construction project has. Therefore, when carrying out a construction project with reused material in today's construction industry, it is in many cases a trade-off between an economic and an environmental winning. This means that first and foremost, it is the prioritisation of the construction clients and their customers that decides whether reused materials are used in the project or not.

The focus on the trade-off between economic and environmental aspects is not agreed upon from the literature to the same extent however. Kossila (2021) describes that there are ways to make economic profit by using a more circular business model. For instance, Kossila argues that adopting a circular business model could display a company as a forerunner and **role model**, open up new business opportunities and create relations with important business partners. These factors could **create a competitive advantage**, which in turn could result in an economic profit. Therefore, it could be beneficial for more construction clients to disregard the idea that there always is a trade-off between economical profitability and environmental sustainability in the construction industry, especially in combination with the increasing demand on environmental sustainability that some respondents are seeing today. Ajayi et al. (2015) acknowledge that economic factors are important for the decisions of a construction client; they argue that actions should be taken to make waste reduction economically viable, which in turn would reduce the impact of the trade-off between economic and environmental earnings.

Ajayi et al. (2015) argue that a factor that has great impact on waste-reduction is the usage of **legislations**, and that governments have the power and responsibility to reduce waste this way. Many interviewees agreed with this; from the interviews, it was argued by a number of respondents that laws that stipulates the responsibility the producer of materials would be beneficial as a driver for increased circularity. As of today, there are no legislations that focuses on the producer responsibility for traditional construction materials (Naturvårdsverket, 2022). On the other hand, there are laws that specify how material at a construction site should be recycled and sorted (Sveriges Riksdag, 2020). It should be kept in mind however that, according to Ellen Mcarthur Foundation (2013), recycling is the most energy requiring out of all circular loops. Therefore, it is more reasonable to discuss and formulate laws that are designed to help materials take a narrower loop, as this would be more environmentally sustainable.

5.3 The Potential of Digitalisation

An important and central factor when discussing circular logistics is how digital solutions are used. In order to have an efficient and seamless communication between actors, and in order to store and utilize information efficiently, it is inevitable to incorporate digital tools in the daily work. Since the construction industry suffers from a lower level of digitalisation compared to other industries (Sezer, Thunberg, & Wernicke, 2021), it is not hard to draw the conclusion that the industry would benefit from focusing on getting more digitalised.

One important area where digitalisation could vastly improve circularity in the construction industry is in the interface between a seller and a buyer of used construction material. To enable this type of trades, there is a need to create a platform where sellers and buyers could meet, and where supply and demand can be matched. This is confirmed by Konietzko et al. (2019), who argue that platforms have the potential of slowing down resource loops, meaning that less raw material is needed in the system. As of today, there are a few platforms designed for this purpose, with one of the most prominent ones is the one that CCBuild operates. However, the quantity of material that is bought and sold on these platforms are too low in order to enable for incorporation of reused material on a larger scale with more clients involving circularity in their business models. With a higher quantity of sellers, there is a higher availability of materials for sale and a greater variance in the types of available products, which is beneficial as this gives a buyer a broader range of products to buy from. As construction projects often are not fully standardised but instead customized to fit the demands of customers, a broad range of products could to a higher extent match the need of construction clients, as it is more likely that they find products that fits into their planned projects. On the other hand, a higher level of standardisation in the industry would enable a situation where actors require a smaller assortment of products, meaning that in this case, a fewer number of product variants would be required on the market of reused products. This viewpoint is amplified by Ajayi et al. (2015), who argue that standardisations reduce the risk of not having material optimised for a specific project, thus reducing the level of waste.

As been established, it is important to have a high number of actors accessing and using platforms designed for buying and selling reused material in order to increase circularity. Since there are a number of platforms designated for this already, the question must be raised why these platforms are not used to the extent that some respondents perceived to be necessary in order to be able to buy and sell material on a larger scale. The most obvious explanation is that the level of interest from construction clients is too low at the moment. As been explained, it is often more expensive for a buying construction client to incorporate reused materials, as this requires other processes that are not required when using new material. Furthermore, clients might not know how to incorporate reused material in their construction projects in a sufficient way. Likewise, selling clients are also required

to take care of, package and sell material, which most likely is not something that they are used to do. All in all, most buyers and sellers view these challenges to be greater than what they are able to accept in order for them to use circularity in an economically viable manner. As a result, this means that the demand from both buyers and sellers are low. From the view of the platform provider, it is in this case important to be informative about the benefits of circularity, and to promote educative work regarding how the processes needed in a circular business model should be carried out in a more efficient manner.

Another potential explanation for the low usage of these platforms could be that the platforms are not good enough to attract buyers and sellers. The paradox with a platform is however that in order to get buyers, there must be sellers; on the other hand, it is hard attract sellers to a platform with a low number of buyers. This means that the provider of the platform must market their business idea and their platform in order to attract more customers. Additionally, an issue could lie in the number of platform initiatives that exists today. By spreading material out over more platforms, it is much harder for buyers to find material that fits perfectly for their projects. If buyers and sellers could converge towards one platform, it could potentially be easier to achieve a higher number of sales.

Last but not least, Kovacic et al. (2020) as well as Benachio et al. (2020) describe that digitalisation also could be beneficial from a material data perspective, that it would be possible to store data about a material in a digital passport. This is something that has been frequently mentioned in the interviews as well, that data connected to a specific material could be positive for circularity. A number of respondents argued that the data could be used as a tool for enable traceability. Traceability of products would be a factor that would improve the ability to work with circularity for various construction clients. This means that products would be able to be traced on an individual level. By having traceable products, it is much easier to sell and reuse the products, as more information on how a specific product have been used in the past. With this information, a buyer can to a greater extent plan on how the reused products could be used in future projects, as the provided data can tell the buyer how the products have been used earlier. Additionally, if there are time left on a warranty for a specific product, the warranty could potentially be transferred to the new product owner, even though this would likely require changes in legislations.

5.4 Network analysis

In this section, a network that represents the ideal case in order to enable circularity for a construction client is presented. The network is based on the ARA-model presented by Gadde and Håkansson (1993). The network considers the **activities** that need to be done, the **resources** required for these activities, as well as the **actors** that need to perform these activities. The network is presented in two layers,

activities and resources, with the third layer, actors, being present in the other two.

All of this section of discussion is based on two figures. In *figure 9*, the activities that are judged to be most critical for successfully implementing circularity in the construction industry are presented. *Figure 10* shows the corresponding network level of resources. As a result, both models describe the same network, meaning that the only difference between them is what type of components they describe. These activities and resources are connected to actors. The models are seen from the perspective of two of the actors: a selling construction client, which has a supply of used materials to sell, and a buying construction client, which has a demand for reused products. The models are presented in three sections. The first section (*section 5.4.1*) focuses on the construction clients and the actors they are connected to, with the exception of the Gap Exploiter, which is presented in *section 5.4.2* (in *figure 9* and *figure 10*, the Gap Exploiter can be found in the central ellipse, whereas the construction clients are placed to the right and left of the Gap Exploiter). Finally, *section 5.4.3* discusses other actors which have no direct role in the material flow, but have an effect on the system in other ways (these actors are represented by the outer ellipse in *figure 9* and *figure 10*).

In figure *figure 9* and *figure 10*, different activities and resources are either coloured red or green. A red colour represents the parts of the model that have been discussed most frequently as an issue, or aspects that the authors regard as most critical for a successful usage of circularity. A green colour on the other hand represents areas that have not been discussed as frequently, or that are somewhat in place already today and therefore not as urgent to focus on.

It is worth noting that a construction client could do some of these activities themselves, or that some actors could have multiple roles in the network. Furthermore, it could also be that the selling and buying client in some cases are the same actor; it is not uncommon for clients to reuse their own material after it has been tested or refurbished by a Gap Exploiter.

In a real-world scenario, it is also not uncommon to have actors that represent construction clients in the relationship with other clients. For instance, a construction contractor may do the actual purchasing of reused products on behalf of a construction client, as the contractor may have a better understanding of what products could be used in a specific case. However, in order to not make the figures overcomplicated, this type of relation is not taken into consideration in *figure 9* and *figure 10*; instead, it is for the sake of explanation described as it is the clients themselves who have these relationships.

Finally, it is worth mentioning that in some cases, clients have ordered too high levels of material, meaning that they have more material in stock than what was required for the construction project. In these cases, there might be less of a need

to work with all of the actors in the model. For example, the material is generally in this case already packaged properly for freight and storage. Additionally, as the products are new, there is almost never a demand for refurbishing and quality testing these products.

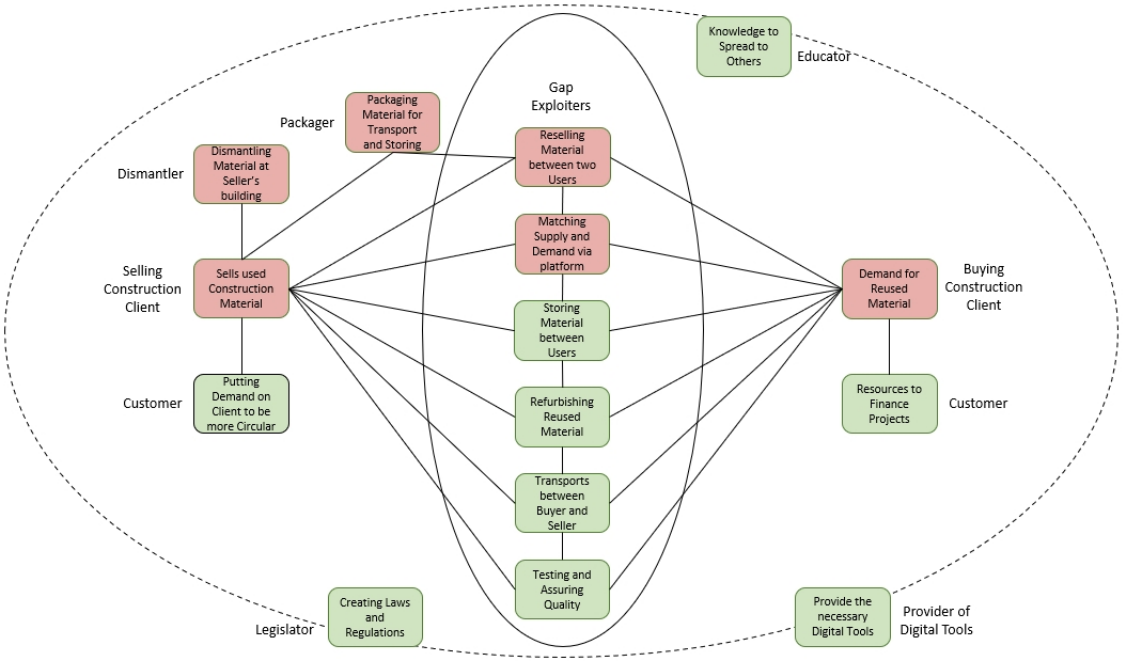

Figure 9: *Activities in an ideal network*

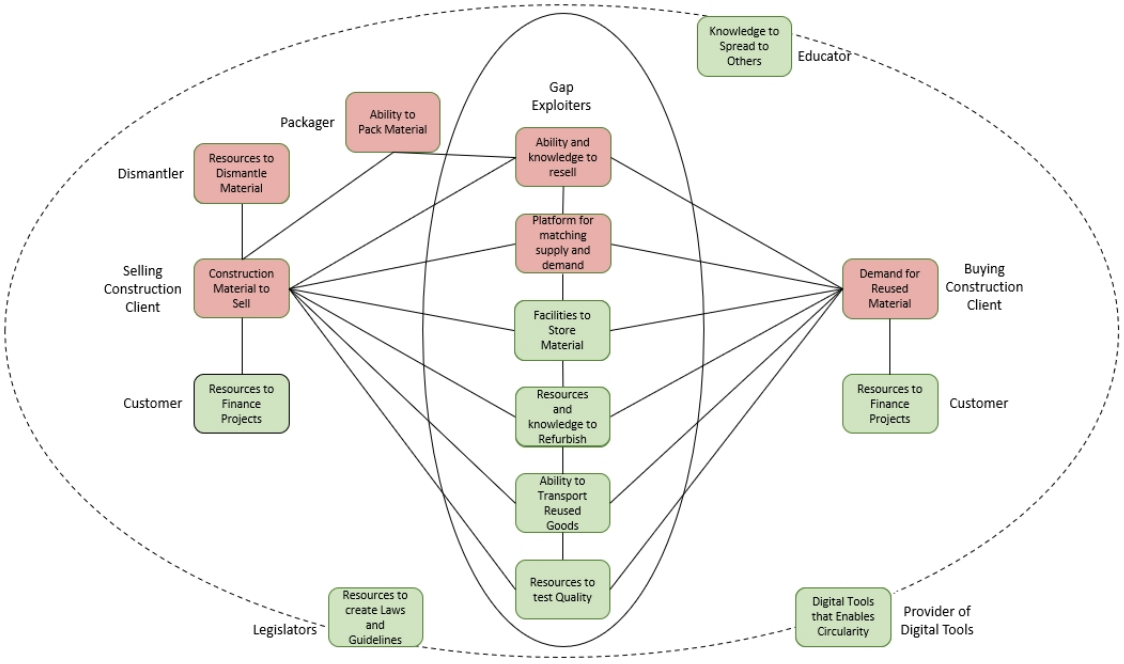

Figure 10: *Resources in an ideal network*

5.4.1 Construction Clients

The selling construction client needs to get access to activities and resources in order to be able to sell reused material without too much effort. Firstly, the selling client must have a relationship with an actor that can dismantle material in an efficient way. This confirms the argumentation of Ajayi et al. (2015), who described that dismantling is important to reduce waste and that buildings should be designed with dismantling in mind. This could also be connected to another issue regarding dismantling that was discussed among the interviewees, which is the issue of efficiently dismantling material without creating any damage to the material. An actor that dismantles must therefore have the resources and knowledge to both efficiently dismantle while simultaneously maintaining as much value as possible in the material.

In order to transport and store the dismantled material in an appropriate manner, it is important for the construction client to work with an actor which has the resources to properly wrap and package material. As of today, it is not uncommon for reused material to be packaged in a way that they risk to be damaged during transportation or when being stored. In order to do this better, it might be necessary to take inspiration from how new material is transported. Additionally, it could be needed to adopt to a system where the entire industry decides on a methodology for packaging. This point of view confirms what Andersson et al. (2021) argues, that methodologies have to be developed that stipulates how materials should be packaged.

In the figure, there are customers connected to both the selling and buying construction client. The customers are the main actor that could impact the clients to be more sustainable and incorporate more circularity in their construction projects. The reason for this is that the customers of the clients are the ones that could provide financing for the projects that the clients carry out; if the customers do not approve on the level of sustainability that the clients build their projects with, they will look for other buildings to buy or rent. This means that demands from customers are crucial in order to increase the will of construction clients to use a higher grade of reused products.

5.4.2 Gap Exploiters

There are numerous activities to carry out in the scope of the Gap Exploiter in *figure 9* and *figure 10*. The Gap Exploiter is in this case seen as one actor. However, the activities and resources of the Gap Exploiter are usually distributed between a number of actors which collectively represent the Gap Exploiter-actor used here.

As of today, the most common way that products are transferred between two construction clients is a transfer without adding value to the products. In the butterfly model by Ellen Mcarthur Foundation (2013), this is a way to achieve circularity

which is generally not very energy requiring. Furthermore, the products follow the trajectory that Kossila (2021) presented, meaning that they are recirculated with the help of Gap Exploiters, which passes a product on from one user to another. Quite often though, these do not handle enough number of products to provide the industry with sufficient levels of products; the Gap Exploiters are relatively few and the ones that do exist are often not driven by economic incentives and have no plans to scale up their businesses to allow for more products to follow the loop in the Gap Exploiter-model, *figure 5*. In order to increase circularity however, it is important that the Gap Exploiters are able to attract a higher number of both selling and buying construction clients. One way to increase circularity through Gap Exploiters would be if more stores would be driven with the purpose of making profit. It would in that case be in the interest of the Gap Exploiter to increase volumes of reused products, meaning that they could work with marketing, both towards sellers and buyers, on a higher level compared to today. On the other hand, unless there are high volumes of reused material on the market already, it could be harder to attract private actors.

Another important aspect of the role of Gap Exploiters is the activity of refurbishing products between users. Kossila (2021) argues that this would increase the value of the product for the next user, which could increase the will to work with circularity. Furthermore, Ripanti and Cullen (2019) argues that, from a reverse logistics-perspective, it is important to include value-adding activities directly in material flows. As of today, this is something that is not done very often in the construction industry. This does not go in line with the butterfly model by Ellen Mcarthur Foundation (2013). On one hand, Ellen Mcarthur Foundation do argue that adding more value to a product will also require more energy and resources. On the other hand, if value is not added to certain products, they might not be able to be reused again at all, which would lead to a demand for adding more raw material to the system. Ajayi et al. (2015) is on the same page, as the authors argue that a standardization of products would reduce the waste in the construction industry. Therefore, it is still beneficial to try to circulate products, even if the value has to be increased to be able to be used again. However, it could be hard from a resource perspective to develop a methodology regarding how to refurbish material in an effective way; Sezer and Bosch-Sijtsema (2020) describe that differences between various refurbishment processes make it hard to develop standardized approaches. As a result, Kossila (2021) argues that, depending on the condition of the product, different types of operations must be carried out in order to increase the product value for the next user. Therefore, more actors that focuses on specific operations to increase the value of specific products have to operate within a circular construction logistics system.

As it might not be certain that supply and demand between selling and buying construction clients can be instantly met, Gap Exploiters are required to stock hold

these products until the demand for them exists. As a client would look to buy rather specific products, and as the supply of material may be rather varying, both in types of products and in quantity, it is not unimaginable that some products might be kept in storage for a rather long time period. This point of view is also mentioned by Andersson et al. (2021), who describe that the industry must be aware of the demands that long storage time will bring forth. From a network perspective, this means that Gap Exploiters must have resources in terms of storing facilities where products can be easily stored for longer time periods without being too expensive, as added costs in the end could decrease the demand for reused products. In essence, it is possible to compare the storing activity of a Gap Exploiter to the storing activity of a consolidation center, which Barthrope et al. (2010) describes is a way to store material before it is used at a construction site. Furthermore, Barthrope et al. argues that consolidation centers is a solution to various issues, including transportations and space issues at construction sites. Therefore, it is reasonable to argue that a Gap Exploiter could operate at least to some extent similarly to how a consolidation center operates.

In order to be able to deliver goods between a seller and a buyer, it is also important to have a Gap Exploiter, in this case as a shape of a transporter, that is capable of transporting reused products. The fact that the products have been used in previous projects could potentially put special types of demands on the transporter; it is not certain that reused products are optimized to use in combination with conventional load carriers, as these products might not be very standardised or have unique challenges from a transportation perspective. Therefore, it might be necessary to develop special guidelines for transporting reused products. Andersson et al. (2021) is on the same track, and argues that it is important to transport products in a manner that minimizes the risk of damage. In addition to this, Andersson et al. describe that there has to be a clear division of responsibility between actors, where it is clearly stated who is responsible for making sure that products are transported in a feasible way without being damaged.

Admittedly, should the number of reused products in the construction industry increase, the number of transportations will also increase. This means that a solution that is meant to increase environmental sustainability requires more of an activity that is fundamentally bad from an emission point of view. Therefore, the construction clients must cooperate more with, and make more requirements towards, the transporters in order to try and increase the level of sustainability in transports. This means that the transporters might need to utilize their resources even better. For example, trucks that transport new material to a construction project could also be used for transporting reused products. This would incorporate flows of reused material into the more traditional flows, which might be necessary for circularity to not have too much environmental impact from a transporting point of view.

The activity of testing and assuring quality is something that needs to be carried out to a greater extent in order to elevate circularity. A user must, in some cases, know that the used products being bought can be trusted to be used again. There might also need to be a standard regarding how reused products should be tested and classified. On the other hand, the Gap Exploiter which tests products must also be able to analyse when testing is not necessary, as the testing process will increase the cost of a product.

5.4.3 External Influential Actors

In order to have a construction industry that incorporates more circularity, there are a few other actors that, through the resources they have and the activities they carry out, are able to influence the industry. Firstly, there have to be regulations that impact the industry positively from an environmental point of view. Ajayi et al. (2015) describe that legislators could use measures to reduce waste on a higher level than what is done today. One way to do this, which has been discussed in the interviews, is to include the construction materials that have the highest negative impact on the environment in the laws that stipulates the responsibility of the producer. This would mean that the producers of construction material would be required to make sure that the material they manufactured is recycled.

Another way for law makers to work towards more circularity in the construction industry would be to make some changes in the construction of building permits. As of today, the building permits stipulates the exact type and color of the material that are allowed to use when constructing a building. This could be a hindering factor for circularity, as it may not be known with certainty what reused material are able to acquire prior to the start of a construction project. As a consequence, some construction clients might be reluctant to attempt to use reused material, as there is a risk that the building permit will stop them. Therefore, to fully allow for the industry to make use of circularity, the design and scope of building permits might have to be investigated by law makers.

It is not only law makers that are able to affect the industry from the outside; different types of educators and researchers are also able to spread information and knowledge about circularity and how it is incorporated into the construction industry. By having these actors to research and inform about how circular business models should be used, and how products can be reused, more construction clients would get a better understanding och the subject. These considerations are in line with the findings of Ajayi et al. (2015), who argue that from a waste perspective, and therefore also a circular perspective, the industry would benefit from being more educated on circularity and waste management. Additionally, other actors may also benefit from receiving more knowledge about how they should adapt in order to be able to handle a more circular construction industry. For example, information on how materials should be dismantled and how it should be packaged during trans-

portations should be spread within the industry. In addition, it is also important to reach out to the clients' customers, as they have a considerable amount of influence on how the clients conduct their business.

Finally, to achieve an efficient material flow for reused material, it would be necessary to take a holistic approach regarding how the logistical flows of reused material should be designed. As of today, there are numerous guidelines and standardisations that are stipulated regarding the flows of new materials. In order to promote the use of circularity, the same type of documents must be established for flows of reused material. This means that there have to be guidelines on how reused material is transported, stored and taken care of in order to both increase the efficiency of the material flows and assure that material is not damaged during transportations or storing. Ajayi et al. (2015) agree with this and describe that it is important to create standardisations and guidelines for processes to reduce waste. Ideally, these guidelines should aim at incorporating the flows of reused material into the flows of new material, as this would require the least changes to the current material flows, which in its term would allow for using as many of the current resources in the material flows dedicated for new material as possible.

5.5 Academic Contribution of Report

The discussion is primarily aimed at contributing to the construction industry; the construction industry has a lot of potential to develop from a logistical perspective, especially in combination with circularity. In the discussion, the findings in the result are connected to the current challenges within construction logistics, as well as to the theory of circularity. Therefore, the contribution with the discussion is to develop a model for circular logistics in the construction industry. As of today however, there has not been done very much research in the field of circular construction logistics. Since the study is exploratory, the aim is to fill the void that to some extent exists in the interface between the construction industry, logistics and circularity.

6 Conclusion

The aim with this study was to investigate how circular logistics can be used and how it is beneficial from an environmental sustainability point of view with a perspective from the clients in the construction industry. The literature supports that circular logistic can be used to reduce the climate footprint and create a more environmentally sustainable society. The interviews have shown evidence of how clients in the construction industry managed to increase their circular flow through reuse of material in different projects. This reduces waste and saves virgin material, which in turn has led to a reduced environmental impact.

The following section will sum up some of the key findings related to the three research question that this study are based on.

RQ1: ***What does the current state look like from the client's point of view regarding circular logistics?*** As of today, there are numerous factors that limit the use of circularity from a logistical point of view. First and foremost, the construction industry is somewhat limited in the logistical performance by its characteristics: the small spaces at construction sites, a changeable working environmental and the uniqueness of each project may reduce the efficiency. Additionally, there are a lack of actors that have the knowledge and competence to implement a more circular approach to their logistical activities. Finally, the level of digitalisation is generally rather low, which reduces the ability to efficiently communicate in supply chains.

RQ2: ***Which factors are needed to enable circular logistical flows in the construction industry?*** In order to maximize the potential of circularity in the construction industry, the logistical network should be designed with the intent to preserve as much value as possible between a selling and a buying construction client. Additionally, the logistical system of circularity in the construction industry must be able to handle clients and materials on a larger scale compared to today, in order to make circularity economically viable. In the list below, the key factors for enabling circularity in the construction industry through logistics are presented:

- The value of reused materials must be kept as high as possible through the processes of dismantling, transporting and storing.
- There has to be a way that enables large quantities of materials to be sold between a high number of buying and selling construction clients, preferably through a digital platform.
- External actors, like legislators and educators, must be present and, through their activities and resources, guide the industry towards a higher level of circularity.

RQ3: ***What are the driving forces and hinders of circular logistics from the client's point of view?*** Generally, the biggest hinder for circularity is that it is more costly to incorporate reused materials compared to the cost of new materials in the construction industry. Therefore, many construction clients see a trade-off between being more sustainable through circularity and reducing the costs of a construction project. The clients that have reached further in the work with circular logistics however argues that the increased cost can be counterbalanced by increased revenues from customers, who in several cases demand a higher level of sustainability.

Some of the most prominent driving forces of circular logistics are:

- Decreased environmental impact
- Increased long-term economic profit
- Gaining a competitive advantage on competitors in terms of environmental sustainability
- Being a role model in the work with circularity

In contrast, some of the most mentioned hinders for circular logistics are:

- It is in many cases still more expensive for construction clients to incorporate reused material
- Laws and regulations are in many cases not optimised for facilitating circular logistics
- There are a lack of the technical knowledge and abilities required for facilitating circular logistics

6.1 Future studies

As of today, there is a discrepancy between the current laws and regulations and the laws and regulations that would be needed in order to favor circularity. Therefore, it would be necessary to do research on how legislators should design and implement laws in order to accommodate for sustainability and circularity.

In order to be able to dismantle material in a more efficient way, it would be feasible to develop methodologies and guidelines that stipulates the most ideal way to dismantle each of the most prominent materials in the construction industry. This would ensure that a high value is kept in the material, which means that they could be reused in a more energy efficient way.

Following this, the industry needs to develop more standards and holistic solutions regarding circular logistics in the construction industry. As of today, there is a lack of standards in a number of areas. For instance, it would be beneficial to depict a way of transporting and storing reused materials on a holistic level, in order to synchronize the usage of resources aimed for these processes. It would also be favourable to develop standards on how testing and assurance of quality should be carried out. Similarly, it would be necessary to create standards for how construction materials should be traceable, in order to facilitate the ability to reuse them. Finally, it would be advantageous for the industry to converge towards a single digital platform in order to increase trades of reused materials, meaning that there should be research done regarding how a platform should be designed in an ideal scenario.

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A Interview Questions

Standard Questions:

1. Is it okay if we record the interview?
   (a) Is it okay to mention the company's/organization´s name in the report?
   (b) You will remain anonymous in the report
2. Could we start with an introduction of you and your work position?
   (a) Name and organization?
   (b) Your role and responsibilities?
   (c) Your background and previous experience?

Current state (RQ1):

1. How would you describe construction logistics?
   (a) How do you work with construction logistics?
   (b) Which are the main actors from your point of view?
   (c) What are your biggest challenges within construction logistics?
   (d) What would be needed to overcome these challenges?

Circular logistic flow (RQ2):

1. What is circularity for you and how do you work with circularity in your construction logistics
   (a) Which actors do you need to collaborate with to increase the circularity?
   (b) How do you work with environmental sustainability?
      i. Do you see circular logistics as an enabler for a higher level of environmental sustainability? Why is that?
   (c) According to you, where are your greatest potential for improvement?
   (d) What kind of challenges can you identify and foresee?

Driving forces (RQ3):

1. What drives your organization to work with circular logistics (from a sustainable perspective)?
   (a) Where in your operations do you have the highest potential of improvement from an environmental point of view?

i. Do you work on these improvements? If not, why?

ii. Could circular logistics be used to improve these areas?

(b) Do you work with KPIs?

i. What kinds of KPIs do you have and are there some you prioritize more?

(c) Are laws and regulations a driving factor for sustainability and circularity?

i. Would you like to see more or less regulations from the government in order to increase circularity?

Residual Questions:

1. What role does digitalisation have for a successful implementation of circularity?

   (a) How have you used digitalisation in relation to circularity?

2. Do you think that standardisation enables circularity?

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